

UNDERGROUND INNOVATIONS

NEWS FROM ROBBINS



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COMPLETED: SOUTHEAST ASIA'S LONGEST TUNNEL

FROM THE RAINFOREST TO THE BIG CITY, a 44.6 km (27.7 mi) long tunnel will deliver water for a growing population. Malaysia's capital Kuala Lumpur and its surrounds are home to 6.9 million people and counting. To meet projected needs, the Malaysian Ministry of Energy, Green Technology, and Water (KeTTHA) commissioned a new tunnel. In 2014, three 5.23 m (17.16 ft) Robbins Main Beam TBMs played major roles in completing the Pahang Selangor Raw Water Tunnel, also the longest tunnel in Southeast Asia.

The massive tunnel passes through

the Titiwangsa mountain range under cover as high as 1,246 m (4,087 ft) and below hot springs.

KeTTHA selected Shimizu Corporation and Nishimatsu Construction of Japan, along with local companies IJM Corp. and UEM Builders Bhd. (SNUI JV), as the contractor for the complex job. Three TBM drives were proposed in combination with NATM to excavate highly variable conditions including hard granite up to 200 MPa UCS, multiple fault zones, and quartz dykes. The decision to use Robbins TBMs for the majority of

tunneling was a clear one for the JV: "The Robbins Main Beam TBM is number one in the world. I have used other machines, but this design is simpler and easier to use, and more powerful," said Mr. Nakano, Deputy Project Manager for the SNUI JV.

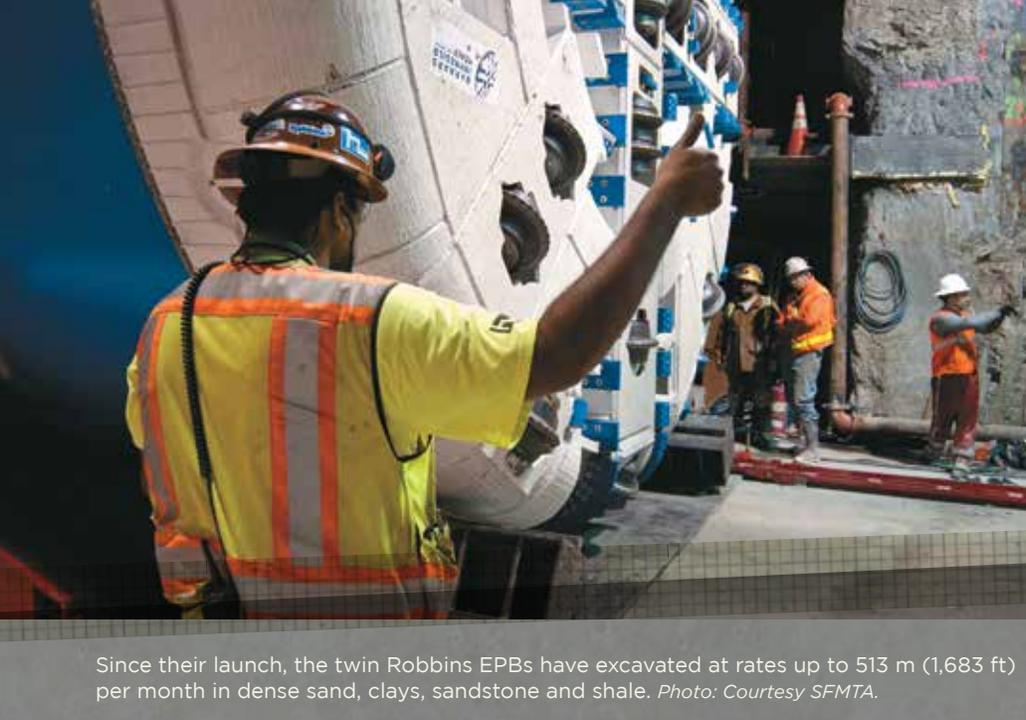
All TBMs recently finished: The first TBM excavated 11.2 km (7.0 mi), and broke through in March 2013, while the other two machines bored 11.3 km (7.0 mi) and 12.0 km (7.5 mi), meeting in the tunnel in mid-February 2014.

The machines maintained excellent advance rates of up to 657 m (2,156 ft) per month despite many challenges including fault zones, water ingress, high rock temperatures, and electrical storms that required machine stoppage.

"This is something we all look forward to in the tunneling industry," said Robbins Field Service Manager, Andy Birch. "We get through all of the hard work and eventually we break through. It's a great feeling, and I'm very happy for the JV and for Robbins."

The final two Robbins machines met in a chamber mid-bore in February 2014 at the Pahang Selangor Raw Water Tunnel in Malaysia. The first of the trio, seen here, broke through in March 2013.





Since their launch, the twin Robbins EPBs have excavated at rates up to 513 m (1,683 ft) per month in dense sand, clays, sandstone and shale. *Photo: Courtesy SFMTA.*

EPB COMPLETES TUNNEL IN 3 MONTHS

AN IMPRESSIVE RUN CAME TO A CLOSE

on January 13, 2014 with the breakthrough of a 6.15 m (20.2 ft) Robbins EPB in Beijing, China. In only three months, the machine for contractor China Railway Engineering Corporation (CREC) Bureau 5 excavated through 2.3 km (1.4 mi) of soft soils, clay, sand, pebbles, and highly weathered rock.

The breakthrough marks the completion of the last section of the Line 6 Phase II extension, adding to Beijing Metro's longest route. With a population of nearly 20 million, the extension was essential in sustaining growing transportation needs.

"The Robbins EPB is good and reliable," said Wan Ming, Mechanical Electrical Manager for CREC Bureau 5. Efficient excavation that led to advances of 125 m (409 ft) per week and 410 m (1,350 ft) per month was achieved with the help of field service support, and custom EPB design.

Features included a spoke-type cutterhead and shaft-type screw conveyor, as well as active articulation to negotiate curves down to a 1,000 m (3,280 ft) radius.

"We are proud that we overcame challenges through joint efforts by Robbins and CREC Bureau 5. This is the first time that an EPB on this project has excavated a tunnel so quickly," said Andrew Han, Robbins Field Service Manager.

SAN FRANCISCO'S TWIN EPBs ARE SMOOTH MUCK MOVERS

TWO EPBs GRIND THROUGH DENSE SAND

just 3.4 m (11 ft) below live rail tracks with strict settlement limits. That was the scenario facing contractor Barnard/Impregilo/Healy JV at the San Francisco Central Subway in California, USA.

The new subway was required to be driven below the existing Bay Area Rapid Transit (BART) tunnels. "It was a major technical undertaking, and many were skeptical that it could be done. The

were provided for the task, and to bore parallel 2.7 km (1.7 mi) tunnels with curves down to 137 m (450 ft) in radius.

Conditions included sand, clays, sandstone and shale. The machines were fitted with mixed ground cutterheads, as well as active articulation to prevent segment deformation in curves. Two-liquid backfill, consisting of cement plus accelerant, was also used, as settlement was limited to 13 mm (0.5 in).

The PB/Telamon JV performed extensive modeling to estimate the behavior of the BART tunnels during the crossing. An array of compensation grout pipes was included as a precaution. "Our hope was to cross under BART during a low usage time. But, the first TBM driving the southbound tunnel arrived at a different time than planned--the day before Thanksgiving. This meant we had to cross under BART on Black Friday, one of the busiest shopping days of the year," said Fowler. With careful excavation, minimal settlement was measured, and no compensation grouting was needed. A second machine completed an equally successful crossing in February 2014.

"The JV gets a lot of credit in making these crossings work, and the Robbins machines do too."

--Matthew Fowler, Project Manager, Parsons Brinckerhoff/Telamon JV

BART System couldn't afford to be taken offline," said Matthew Fowler, Project Manager for the Parsons Brinckerhoff / Telamon JV, who are responsible for the utility relocation and tunnel designs.

Two 6.3 m (20.7 ft) Robbins EPBs



A BIG WIN

FOR RECORD-SETTING MUMBAI MAIN BEAM

109 M (357 FT) BELOW MUMBAI,

a Main Beam machine broke through on January 21, 2014. The robust TBM completed one of the longest and deepest urban water tunnels in Asia, the Mumbai Water Tunnel. The 6.25 m (20.5 ft) diameter TBM achieved impressive advance rates throughout the 8.3 km (5.2 mi) bore, more than double the rates of previously bored tunnels in Mumbai granite.

Joint venture contractor Unity-IVRCL (UIJV) was pleased with the hard rock machine and the continuous support provided by Robbins during the project. Mr. Pravin Titare of Unity spoke to this, saying, "The Robbins TBM was good in hard rock, and we reached high rates of 870 m (2,855 ft) per month and 58 m (188 ft) per day, both records for TBM tunneling in India. We were able to achieve this due to the good performance of the machine and a conveyor system for muck haulage in place of conventional methods."

Robbins provided both the TBM and conveyor system for the project, as well as Field Service personnel to monitor the equipment and assist with daily upkeep and inspection. "The Robbins crew helped us commission and start boring on schedule, and the Robbins TBM operators did a great and skillful job

maintaining tunnel alignment. Because of this, UIJV received a good reputation towards our client Municipal Corporation of Greater Mumbai (MCGM)", said Titare.

Although the machine was ultimately a success, it did experience its fair share of challenges during the 21-month bore. Difficult ground, including basalt rock, fractured ground, and water inflows, was encountered throughout the tunnel.

"The TBM was very safe in adverse geological conditions. The rock support and ring beam erector reduced downtime."

--Mr. Pravin Titare, General Manager, Unity Infrastructure

Mr. Bipin Arey of IVRCL spoke about overcoming such challenges, saying, "The geology was particularly bad at times. Our team took all precautionary measures and advanced slowly." Ground support, from rock bolts to ring beams, played a critical role in the TBM's success.

Now completed, the water transfer tunnel will provide Mumbai's approximately 20.5 million residents with a consistent flow of clean drinking water.

TOUGH TBM TO EXCAVATE HAWAIIAN SEWER TUNNEL

The Aloha State's Kaneohe-Kailua Wastewater Conveyance Tunnel in Honolulu is all about efficiency. A new tunnel and pump station will relieve overtaxed, aging force mains.

In 2013 the City Council of Honolulu awarded the Southland/Mole JV the contract for a 5.0 km (3.1 mi) tunnel through basalt rock. The JV chose a 4 m (13 ft) diameter Main Beam TBM, refurbished with some components from Southland's recently completed Jollyville Tunnel.

In order to move the tunnel away from populated areas, designers introduced an isolated curve in the tunnel alignment of 500 ft radius, requiring the TBM to be specially designed. Operators will also follow a procedure of 1/2 strokes while navigating the curve.

Scheduled for factory acceptance in August 2014, the TBM will then be shipped to Hawaii for a December launch.

EPB TO BE ASSEMBLED ONSITE IN SEATTLE

The Northgate Link Extension is a key part of a massive light rail plan to revamp the city's traffic. In 2013, owner Sound Transit awarded a JV of Jay Dee/Colluccio/Michaels the contract for 5.5 km (3.4 mi) of twin tubes and two underground stations.

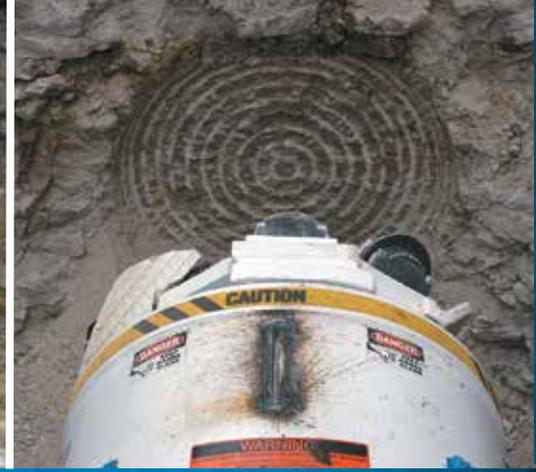
The JV selected a 6.5 m (21.3 ft) Robbins EPB that recently broke through in Singapore. The refurbished TBM will be designed for glacial till with silt, sand, boulders and clay. A camera will monitor muck inside the mixing chamber, while state-of-the-art foam and grout systems will be installed.

The TBM is scheduled for Onsite First Time Assembly (OFTA) in a shaft site near Northgate Mall in June 2014. The machine, once launched, will pass through two stations on its way to the University of Washington's Husky Stadium.



LEFT: The Beijing Metro EPB breaks through on January 13, 2014.
TOP RIGHT: A record-setting TBM bored the Mumbai Water Tunnel.
BOTTOM RIGHT: The contractor and Robbins celebrate a successful breakthrough on January 21, 2014.





LEFT: Robbins Small Boring Units (SBU-As) are capable of excavating hard rock up to and over 25,000 psi (175 MPa) UCS.
RIGHT: SBU-As are mounted with disc cutters in hard rock conditions and excavate by kerf cutting to fracture rock from the face.

SBUS BORE SOME OF THE TOUGHEST **ROCK TO CRACK**

BORING A SMALL TUNNEL IN HARD ROCK

is never an easy task, but when the rock is 28,000 psi (190 MPa) UCS, the term “hard” doesn’t begin to cut it. That was the obstacle facing sub-contractor Kruckenburg Services at a set of utility bores in Ashburn, Virginia, USA when they called Robbins. The contractor opted for a 36-inch (900 mm) diameter Small Boring Unit (SBU-A) with 9.5 inch disc cutters.

“Cut and cover was a problem with the rock hardness, as we had to go under a busy road. We also wanted casing under parts of the road that were planned to be widened,” said David Kruckenburg, owner. Utilities near the new sewer lines also limited options: We had a 36 inch (900 mm) water line, 10 inch water line and 10 inch (250 mm) force main sewer nearby. It had to be bored, not blasted.”

Buried lines were not the only cause for concern. “The pipeline will service 25 single family homes, as well as a historic Baptist church, built in 1835, that it passes within a few feet of,” said Casey Rafter of general contractor Metro Earthworks.

At a prescribed grade of 0.43%, the

contractor launched the SBU-A and Auger Boring Machine (ABM) from a pit 24 ft (7 m) deep, 40 ft (12 m) long and 16 ft (5 m) wide. The ABM provided both torque and forward thrust, while disc cutters mounted in the SBU-A chipped away at a rock face of solid diabase.

The crew averaged from 3 to 7 ft (900 mm to 2 m) per hour in the rock. “Our crew and in particular our foreman, John Kevin Beamen, were so important. We pulled the augers every 5 to 10 ft (2 to 3 m) to check alignment with a laser, and it required a lot of patience. The rock was harder on the bottom, so we had to watch for drift as the SBU wanted to raise up,” said Kruckenburg.

The SBU-A successfully completed the 210 ft (64 m) crossing in one month. Despite the challenges, Kruckenburg is a believer in SBUs: We own a 30-inch (760 mm) SBU and we’ve rented multiple SBUs since we used one on a bore back in 2002. I just finished another bore on this project using a 48-inch (1.2 m) SBU-A, and it did 140 ft (43 m) in five days. It ate that rock up. The thing is a beast.”

2014 EVENTS CALENDAR

Robbins will participate in the following trade shows:

ITA-AITES World Tunnel Congress
May 9-15

Iguassu, Brazil

Robbins Technical Sessions:

Mechanized Rock Tunneling

Rock TBMs for Variable Ground

Extreme Tunneling in Mexico City

Urban Tunneling in Singapore

Improving EPB Advance Rates

NAT

June 22-25

Los Angeles, California, USA

Robbins Technical Sessions:

The Future of TBMs in Mining

Urban Tunneling in California

Improving EPB Advance Rates

Lessons Learned from the Field

Tunnel Expo Turkey

August 28-31

Istanbul, Turkey

Australasian Tunnelling Conference

September 17-19

Sydney, Australia



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PLEASE CONTACT:**

Desiree Willis, Technical Writer
e willisd@robbinstbm.com
p +1 253 872 0500

The Robbins Company
29100 Hall Street
Solon, Ohio 44139 USA

p +1 440 248 3303
f +1 440 248 1702

www.TheRobbinsCompany.com