UNDERGROUND INNOVATIONS

NEWS FROM ROBBINS

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EPIC FINISH AT **OLMOS**

After four years of extreme excavation through high cover and volcanic rock conditions, TBM tunneling at the Olmos Trans-Andean tunnel is complete. The 5.3 m (17.4 ft) diameter Robbins Main Beam machine broke through to fanfare and an elaborate ceremony on December 20, 2011. Government officials, contractor Odebrecht Peru Ingenieria y Construccion, and the President of Peru, Ollanta Humala, were among those in attendance.

The 12.5 km (7.7 mi) TBM-driven section is part of a larger scheme that will transfer water from the Huancabamba River on the Eastern side of the Andes to drought-ridden areas on the Pacific Ocean Watershed. To complete the connection, the Robbins machine had to pass under cover up to 2,000 m (1.2 mi), which caused high rock stresses, resulting in more than 16,000 rock bursting events—17% of which were severe.

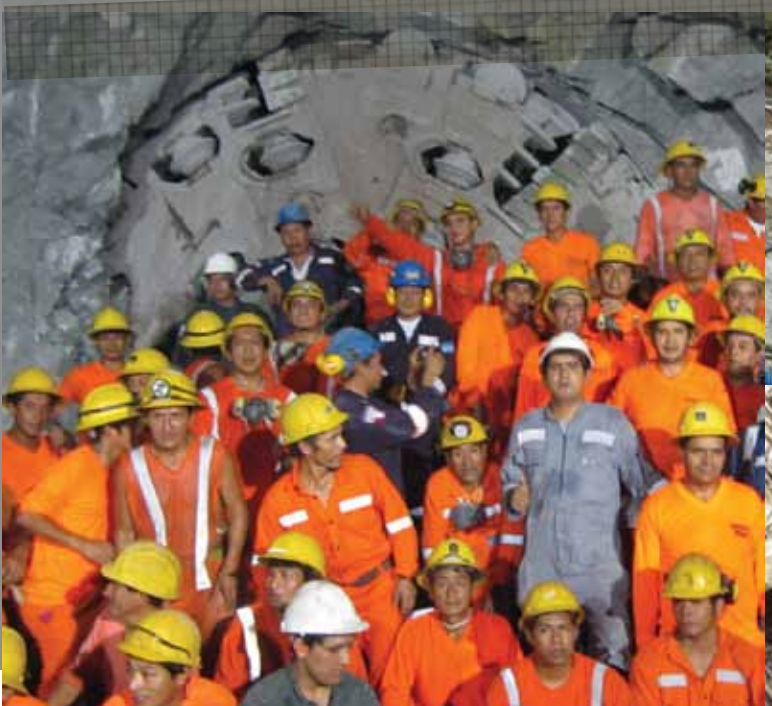
"I am satisfied with the performance of the machine, it was very powerful in the high-frequency rock bursting conditions," said Mr. Hiroshi Handa, Production Manager for Odebrecht.

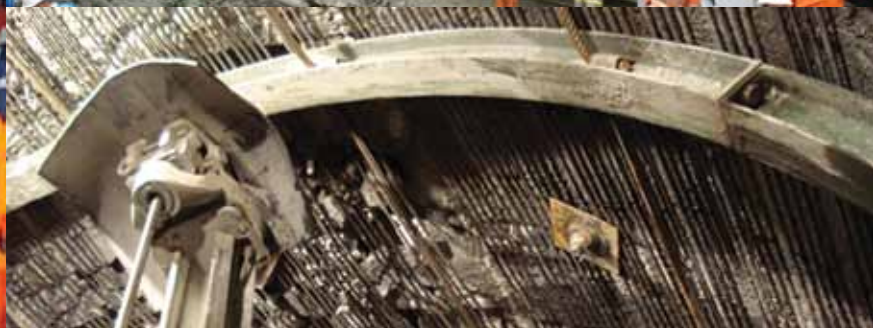
The extreme geology—andesite, dacite, tuff, schist, and pyroclastic breccias up to 250 MPa UCS—required in-tunnel machine modifications as rock bursting became more severe. Crews removed the roof shield fingers and installed the McNally Support System, manufactured by Robbins under license from C&M McNally. The system consists of steel slats anchored to the roof of the tunnel, effectively containing unstable rock while providing a safe working environment.

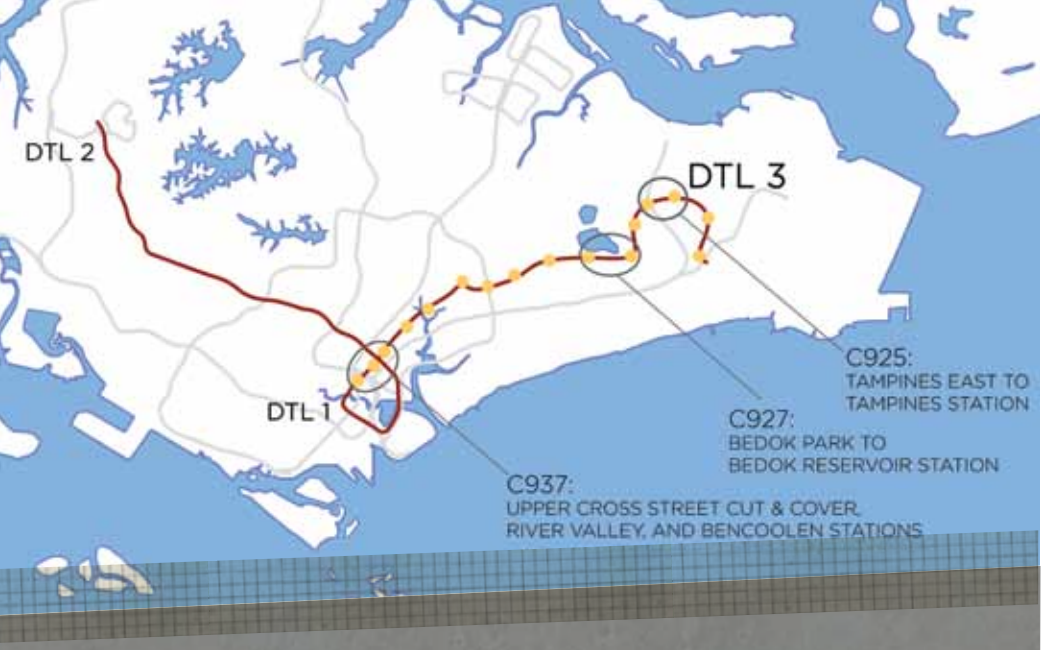
The modifications were successful, and no serious injuries occurred during continued rock bursting, in part because of Odebrecht's de-stressing policy. Workers bored ahead, and then exited the L1 area for a period of 30 minutes—the time when rock bursting was likely to occur.

Mr. Handa expressed praise of the crew: "I am proud to have an extraordinary working team—despite all of the difficulties and challenges they never lost confidence."

Clockwise from Left: The Odebrecht crew celebrate the Robbins TBM breakthrough; launch of the TBM in 2007; steel slats holding up loose rock in the crown.







Six Robbins EPBs will begin excavating three contracts along Singapore's new Downtown Line 3 (DTL3) in 2012 and 2013.

FLEET OF FAST TBMs TO FLY **BELOW SINGAPORE**

AS ONE OF THE DENSEST POPULATIONS ON EARTH, Singapore has invested heavily in its rapid transit system in recent years. The majority of metro construction is underground in the country's upcoming Downtown Line (DTL)--a 42 km (26 mi) long route with 34 stations that will serve about half a million commuters daily.

Six Robbins EPBs are currently being designed and built for various sections of the DTL excavation. The first of the machines to launch will be two 6.65 m (21.8 ft) diameter EPBs boring section C927 for contractor CMC di Ravenna of Italy. The machines will excavate parallel 1.35 km (0.8 mi) tunnels between Bedok Park and Bedok Reservoir Stations.

To excavate in mixed ground conditions, the TBMs will utilize mixed ground cutterheads with a combination of carbide knife bits and disc cutters. Removable grill bars will also be incorporated on the cutterheads should boulders or sections of hard rock be encountered.

Four more 6.65 m (21.8 ft) EPBs, one for contract C925 and three for C937, are being designed for contractor GS Engineering & Construction of Korea. The machines, similarly fitted with mixed ground cutterheads, are expected to launch between September 2012 and January 2013. The C925 EPB will excavate two sections of tunnel 891 m (0.6 mi) and 709 m (0.4 mi) in length, requiring the machine to be dismantled in a blind tunnel and relaunched to bore the second section.

Challenges for the EPBs include restricted boring hours due to the urban environment, as well as settlement minimization. In addition many buildings are supported using steel reinforced concrete piles in the bore path, which must be underpinned so that the piles can be removed.

More than 20 EPBs will eventually be excavating below Singapore for the new subway. The DTL, which will be the country's longest metro line, is scheduled to be completed by 2017.

JOLLYVILLE **TBM DUO**

CAVE-DWELLING INVERTEBRATES may not be on the minds of most tunnellers, but at the Jollyville Transmission Main they are a priority. The Austin, Texas, USA wastewater tunnel will travel through karstic limestone and dolomite formations below the Balcones Canyonlands, a protected wildlife preserve. A layer of cavities below the surface must not be disturbed by tunneling, as it is home to six species of endangered arachnids and insects.

Three TBMs, including two Robbins machines (one new and one refurbished), are up for the challenge. One machine for contractor Southland will begin excavation of a 1.4 km (0.9 mi) section of tunnel in January 2012. The first Robbins TBM, a new 3.25 m (10.7 ft) diameter Main Beam, will be built in Robbins' Solon, Ohio, USA facility and launched in May 2012 on a 6.1 km (3.8 mi) section.

Because of the karst cavities and risk of infiltration, pre-grouting ahead of the machines will not be permitted during the entire project. Instead, the Robbins machine is being designed with removable roof shield fingers and a version of the McNally Support System utilizing steel slats to control unstable ground. Oversized muck buckets and a large belt conveyor will aid in efficient muck removal while boring in varying conditions.

The second Robbins TBM, a Double Shield, is being rebuilt in the Ohio facility. The machine is being increased in diameter, from an original 2.9 m (9.5 ft) to 3.0 m (9.8 ft). A new back-loading cutterhead, gripper shield, telescopic, and tail shield are being added to the machine prior to its launch on a 2.8 km (1.8 mi) section of the pipeline in Spring 2012.

The Jollyville Transmission Main (JTM) is part of the larger Water Treatment Plant Number 4 in Austin, which sources water from nearby Lake Travis. Scheduled to go online in 2014, the JTM will carry up to 190 million liters (50 million gallons) of treated water per day to the Jollyville Reservoir.

EPBs BORE FINAL METERS IN ZHENGZHOU

ZHENGZHOU, CHINA IS ONE STEP CLOSER to becoming a national crossroads for rail traffic with the breakthrough of two EPBs. The 6.3 m (20.7 ft) Robbins TBMs have set a Chinese EPB record in the process, excavating up to 720 m (2,362 ft) in one month. The swift machines boring the Metro Line 1 holed through in October and November 2011—at least two weeks ahead of schedule.

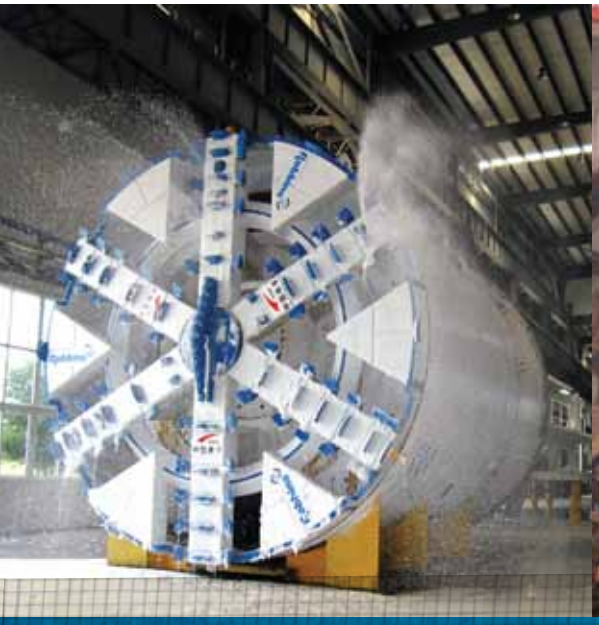
"The performance of the two machines was perfect, and the project owner has praised our excavation," said Mr. Zhao Donghua, Project Manager for contractor CRCC Bureau 11. The 11th Bureau and project owner Zhengzhou Metro Company held a grand ceremony for the final EPB breakthrough on November 16. The parallel 3.6 km (2.2 mi) tunnels were widely regarded as the most difficult section of the metro, with low cover of 7 m (23 ft) in a section of permeable, water-bearing soils below Xiliu Lake.

The Robbins machines were launched in November and December 2010, and achieved two intermediate breakthroughs into cut and cover station sites between Tongpai Road and Kaixuan Road station along the way. Ground for much of the tunneling was under approximately 8 m (26 ft) of cover in soft and powdery soils, and below building foundations and a highway interchange.

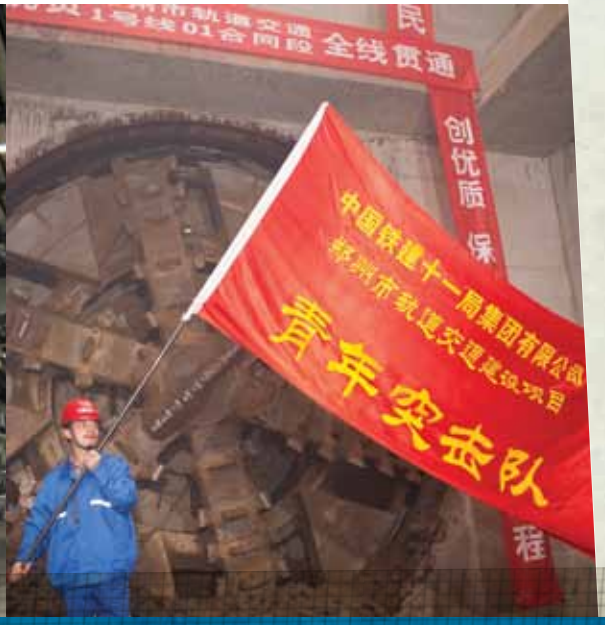
Daily advance rates as high as 23 rings (34.5 m / 113 ft) were achieved despite these challenges, including special measures below Xiliu Lake. Crews carefully maintained earth pressures of between 1.1 and 1.3 bar while boring at a low cutterhead speed of 1 RPM below the lake, reducing advance rates in this section. Settlement levels remained within limits during the entire drive.

CRCC Bureau 11 already has new projects lined up for the machines, which have been removed from the station sites. "We will utilize one EPB at the Beijing Metro project, the other machine will stay in Zhengzhou for future metro contracts," said Mr. Donghua.

Zhengzhou, a city of 7 million people, is planned to become a center for rail commerce. Up to four metro lines will be built in Zhengzhou, with national freight lines running from North-South and East-West intersecting in the city. By 2013, Line 1 of Zhengzhou Metro will include 26 km (16 mi) of tunnel and 22 stations.



The 6.3 m (20.7 ft) diameter Robbins TBMs achieved a Chinese EPB record in their size class, excavating 720 m (2,362 ft) in one month.



A crew member celebrates the early breakthrough of the final Robbins EPB at China's Zhengzhou Metro Line 1, on November 16, 2011.

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ROBBINS EPB TO MOVE MUCK BELOW CHINA'S CAPITAL

Beijing, China, with a population of nearly 20 million people, also has one of the most extensive metro systems in the country. Currently 14 lines extending 336 km (209 mi) cover the city, but rapid growth has necessitated their extension. In summer 2012, TBMs will begin excavation of what will be the capital's longest subway route when complete—a 12 km (7.5 mi) extension to Line 6.

A Robbins EPB is currently being built for Lot 3 on the extension, and will begin excavation through 2.3 km (1.4 mi) of soft soils, clay, sand, pebbles, and highly weathered rock. The 6.15 m (20.2 ft) diameter machine will feature a spoke-type cutterhead and shaft-type screw conveyor, as well as active articulation for smooth tunneling through curves. The machine, for China Railway Construction Corporation (CRCC) Bureau 5, will be launched from a 20 m (65 ft) deep shaft in July 2012.

The eastern extension of Line 6 will add seven new stations to the original 30 km (19 mi) line, which is currently under construction and scheduled to open at the end of 2012. A second western extension, planned for 2015, will make the entire Line 6 route 52 km (32 mi) in length.

LEFT: Contractor Midwest Mole, Inc. celebrates the breakthrough of a Double Shield Rockhead in Autumn 2011.
RIGHT: The Robbins machine excavated five tunnels, including a record 2,014 ft (614 m) bore, using a mixed ground cutterhead.

RECORD ROCKHEAD FINISHES

FIFTH TUNNEL

IN AUTUMN 2011, A SELF-PROPELLED TUNNELING MACHINE achieved a milestone in Cincinnati, Ohio, USA. The 72 inch (1.8 m) diameter Double Shield Rockhead, for contractor Midwest Mole, Inc., bored 2,014 ft (614 m) without intermediate access—a distance that appears to be a world record for a hard rock machine of this diameter.

The fifth and longest of seven tunnels at the Shayler Run Segment C Sewer Replacement Project pushes the limits of small diameter tunneling. "One of the only limitations on distance is tunnel ventilation. We can adequately ventilate 2,000 ft (600 m) tunnels, but we would need larger fans for anything longer," said Steve Abernathy, Vice President of Operations for Midwest Mole.

The distance of each bore is not the only challenge—the vertical alignment changes over the course of tunneling by 180 ft (54 m), resulting in soft shale and limestone at the outset that gives way to harder rock.

Robbins designed the unique Rockhead for these conditions, with a mixed ground cutterhead for five of the seven bores. A hard rock cutterhead mounted with 11.5 inch disc cutters was designed for the last two bores in harder rock.

"We finally had to change some of the 6.5 inch diameter cutters on the mixed ground cutterhead during this drive—we haven't had to do that for any of the other bores," said Abernathy of the fifth drive. After hole through, the crew switched to the hard rock cutterhead for the sixth, 1,315 ft (400 m) bore, which will be complete at the end of January.

As the machine excavates, crews adjust line and grade from an in-shield operator's console. The self-propelled Double Shield Rockhead allows installation of ring beam & board from within the tail shield. Even with liner installation, production has been as high as 70 ft (21 m) in a 12-hour shift, and 40 to 60 ft (12 to 18 m) per shift on average.

The entire 9,416 ft (2,870 m) pipeline is being constructed for the Clermont County, Ohio Water Resources Department in a USD $15 million project to upgrade an exposed sewer system.

2012 EVENTS CALENDAR

Robbins will exhibit at the following trade shows:

UCT
January 24–26
San Antonio, Texas, USA

George A. Fox Conference
January 24
New York City, New York, USA

SME Annual Meeting
February 19–22
Seattle, Washington, USA

Tunnelling Asia 2012
February 22–24
New Delhi, India

NASTT No-Dig 2012
March 12–14
Nashville, Tennessee, USA

INTERtunnel
March 27–29
Turin, Italy

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