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UNDERGROUND INNOVATIONS

The 6.8 m (22.3 ft) diameter Robbins Single Shield TBM broke through after excavating at instantaneous penetration rates up to 6 m (20 ft) per hour. Photo: Courtesy of NYCDEP

A STRONG FINISH

TBM COMPLETES DELAWARE AQUEDUCT BYPASS

ON TUESDAY, AUGUST 13, a 6.8 m (22.3 ft) diameter Robbins Single Shield TBM accomplished an epic feat of tunneling. The unique TBM, designed to statically hold up to 20 bar pressure, had bored below the Hudson River for 3,794 m (12,448 ft) over 582 days with instantaneous penetration rates of 6 m (20 ft) per hour.

The tunnel depth was a challenge, ranging from nearly 270 m (900 ft) deep where the TBM was launched in Newburgh, New York to over 180 m (600 ft) deep at the exit shaft. The water volume and pressure were also challenges.

"Things went really well. The machine did what it was supposed to do, the rock behaved, the learning curve for running the machine was reached before we hit any problems. We hit a curve, and the crew got used to it—we hit good limestone, and then harder rock. We also hit water, and we learned how to deal with that," said Ted Dowey, Portfolio Manager for the New York City Department of Environmental Protection (NYCDEP), project owner.

Successfully surmounting the obstacles required unique TBM design and skillful machine operation by JV contractor Kiewit-Shea Constructors (KSC). "There was the potential for high water pressures and inflows. We had a lot of interaction with the client and Robbins during TBM design. We had it set up correctly with dewatering, drilling, and grouting systems in place. We had the capacity to pump 9,500 liters (2,500 gallons) of water per minute. We were well set up with the TBM to encounter anything predicted," said KSC Tunnel Manager Niels Kofoed.

Difficult Ground Solutions (DGS), including powerful drilling, grouting, and water inflow control systems were incorporated into the machine's design to overcome the expected challenges.

Through a combination of rigorous pre-excavation grouting and dewatering, KSC were able to keep water inflows to 1,300 liters (350 gallons) per minute, well below the predicted 4,900 liters (1,300 gallons) per minute. Crews utilized water-powered, high pressure down-the-hole hammers to drill 120 m (400 ft) ahead of the TBM throughout the drive to verify ground conditions.

"It is a very powerful machine with tremendous thrust capacity based on high rock strength and potential for squeezing ground. Overall the TBM design worked out well and was able to advance through shale, limestone and more challenging sections," said Kofoed.

Despite challenging conditions, the Lot 4 TBM achieved a project record of 30 m (98 ft) in one day, and a high of 528 m (1,732 ft) in one month.

FINAL BREAKTHROUGH

ROBBINS EPB CAPS 62 KM OF TUNNELS AT TEO

A CELEBRATION WAS IN ORDER: On May 23, 2019, the last of six 8.93 m (29.3 ft) diameter EPBs had completed excavation at Lot 4 of Mexico City's Túnel Emisor Oriente (TEO), a feat marking the completion of ten years and 62.1 km (38.6 mi) of tunneling.

"We are proud of having successfully finished the excavation, despite all the adversities we faced, such as large inflows of water, hydraulic loads and constant changes in geology. We solved these by adapting the excavation mode according to each type of geology," said Hector Arturo Carrillo, Machinery Manager for Lot 4 contractor Carso Infraestructura y Construcción (CARSO). Despite multiple challenges, the operation achieved a project record of 30 m (98 ft) in one day, and a high of 528 m (1,732 ft) in one month.

It's a result that, Carrillo says, has much to do with the continuous conveyor: "It should be noted that our advance rates were achieved thanks to the great Robbins conveyor design. The tunnel conveyor was composed of the booster, vertical belt, curve idlers, and advancing tail piece, as well as elements on the surface. I think it is a great, admirable system that has helped us achieve the TBM's performance."

The breakthrough was the latest milestone for an urgently needed wastewater project that spanned some of the most difficult geology ever bored by EPBs. The 10.2 km (6.3 mi) long Lot 4, running from Shaft 17 to Shaft 13 at depths of up to 85 m (280 ft), included sections of basalt rock and permeable sands at high water pressure. "Our machines had to go through the worst geology, but they were designed for it," said Roberto Gonzalez, General Manager for Robbins Mexico, of the three Robbins EPBs and continuous conveyor systems used on Lots 3, 4, and 5.

"Robbins were always present giving ideas and contributing all their experience to solve any problems."

-Hector Arturo Carrillo, Machinery Manager for Carso Infraestructura y Construcción (CARSO)

THE NEWS IN BRIEF

IN BARDU, NORWAY

A specialized small diameter Main Beam TBM is boring the Salvasskardelva HEPP at rates of 100 mm (4 in) per minute in mica gneiss and schist rock.

IN GAZIANTEP, TURKEY

Crews are nearly 90 percent complete with tunneling in extreme hard rock at the Bahce-Nurdag Railway Tunnel using an 8 m (26 ft) diameter Single Shield TBM.

IN DALLAS, TEXAS, USA

Onsite First Time Assembly (OFTA) of a 9.9 m (32.5 ft) diameter Main Beam TBM for the Mill Creek/Peaks Branch/State Thomas Drainage Relief Tunnel is underway.

IN YAMAGATA, JAPAN

Crews are hard at work with more than one third of tunneling complete at the Tamagawa HPP #2, Lot 2 using a 4.5 m (14.9 ft) Main Beam TBM.

IN MUMBAI, INDIA

Two 6.65 m (21.8 ft) diameter Crossover XRE machines are now boring their second of several tunnel sections, achieving rates of up to 278 m (912 ft) in one month.

COMPACT TBM BORES LONGEST ROCK DRIVE IN SIZE CLASS

A MONUMENTAL ACHIEVEMENT

A SMALL TBM MADE A BIG IMPACT in August 2019. The 2.46 m (8.07 ft) diameter Robbins machine completed 3,475 m (11,400 ft) of boring with no intermediate access, making it the longest rock tunnel ever bored by a Double Shield TBM under 2.5 m (8.2 ft) in diameter.

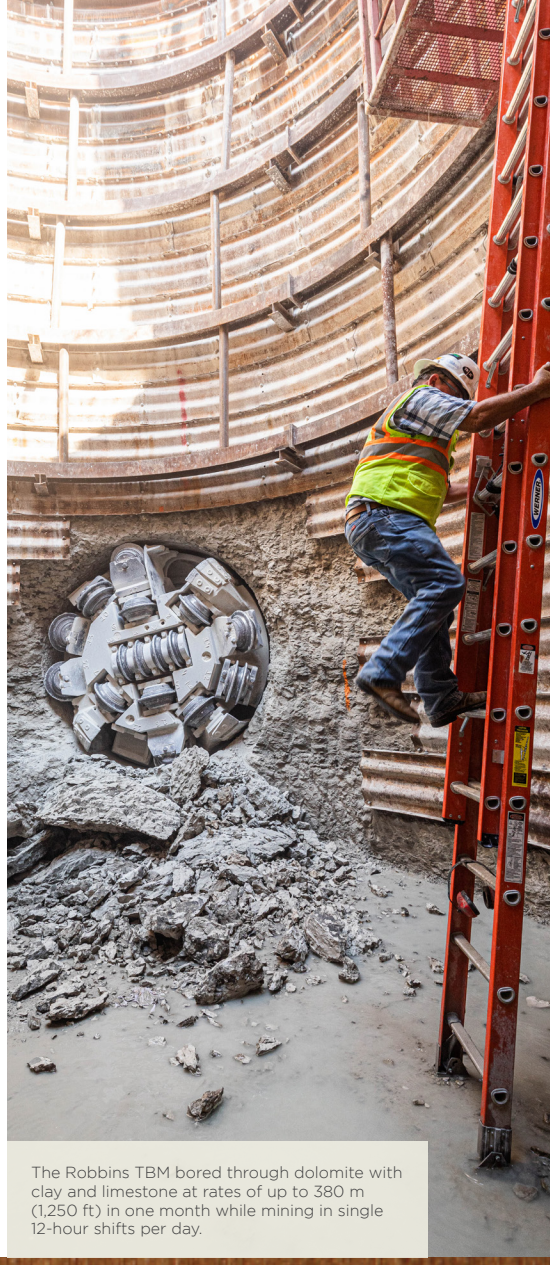
The machine completed the Parmer Lane Wastewater Interceptor in Austin, Texas, USA for contractor S.J. Louis Construction. Despite obstacles including two tight curves of 150 m (500 ft) radius and unexpected ground conditions that required modification of the cutterhead in the tunnel, advance rates were good. The machine reached up to 380 m (1,250 ft) per month while mining in single 12-hour shifts per day. "It was a hard rock TBM, and it performed better than expected through hard rock," said Zach West, Project Manager for S.J. Louis.

The challenges for the TBM and its crew were varied, explained West. "The pairing of this tunnel length, which is on the longer side, and the diameter, which is on the smaller side, is challenging. The survey in a small tunnel with tight radius curves and limited surface access for over two miles is very difficult." He added that the shallow tunnel depth, and the alignment to within a few feet of sanitary lines, high-pressure gas mains, and fuel tanks for gas stations, made TBM guidance critical. "I would say that I am most proud of our ability to guide the machine successfully through these obstacles and into our retrieval shaft within our expected tolerances."

The tunnel is located in an environmentally sensitive aquifer, with geology ranging from soft dolomite with clay to limestone from 13 to 68 MPa (2,000 to 10,000 psi) UCS. "While we tunneled through the softer material, our best advance rate was 0.9 m (3 ft) per hour. When we tunneled through the expected limestone, advance rates were over 5.2 m (17 ft) per hour. Our best day was 25 m (81 ft) in a single shift," said West.

> **"It was a hard rock TBM, and it performed better than expected through hard rock."**
>
> -Zach West, Project Manager for contractor S.J. Louis Construction

The Parmer Lane Wastewater Interceptor will allow two existing lift stations to be decommissioned, reducing operating costs for the City of Austin.



The Robbins TBM bored through dolomite with clay and limestone at rates of up to 380 m (1,250 ft) in one month while mining in single 12-hour shifts per day.

WORLDWIDE HIGHLIGHTS

+ In Indianapolis, Indiana, USA, a veteran Main Beam TBM is over halfway (27 km / 17 mi) complete with the massive 45 km (28 mi) long DigIndy tunnel project.

+ In Region del Maule, Chile, a 4.56 m (15.0 ft) Double Shield TBM completed tunneling the 12 km (7.5 mi) long intake tunnel for the Los Condores HEPP.

MONTREAL'S MACHINE

7.37 METERS

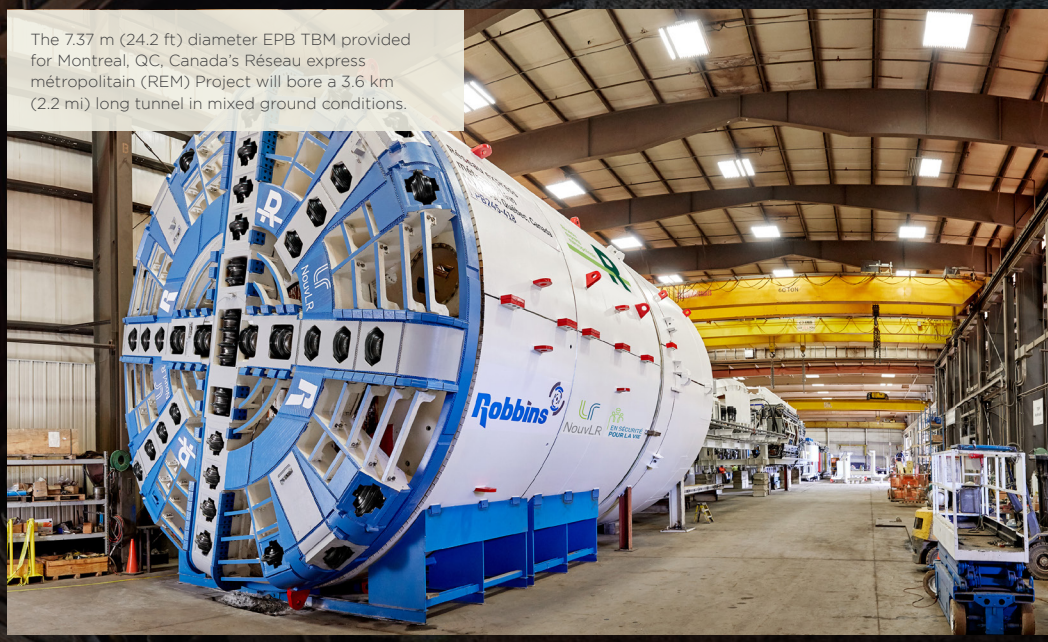
EPB TBM DIAMETER

MIXED FACE

TILL & LIMESTONE CONDITIONS

FEATURED PHOTO

The 7.37 m (24.2 ft) diameter EPB TBM provided for Montreal, QC, Canada's Réseau express métropolitain (REM) Project will bore a 3.6 km (2.2 mi) long tunnel in mixed ground conditions.



Hard rock can put your machine to the test, but proper TBM operation, optimization of penetration rates, and use of the right cutting tools can help.

FROM THE BLOG: 3 WAYS TO BORE

EXTREME HARD ROCK

WHEN THE ROCK SEEMS UNBREAKABLE, STRESSES ARE MULTIPLIED: The cutters must be stronger, the TBM more durable, and the operation optimized to keep equipment running smoothly. Once rock hardness rises beyond 180 to 200 MPa UCS, the limits of cutting tools are put to the test. Given the clear risks of excavating massive, hard rock, how can tunnellers set themselves up for the best possible chance of success?

Consider Your Cutting Tools

Robbins has developed Extra Heavy Duty (XHD) rings for projects where Heavy Duty (HD) rings are close to their design limit in terms of the thrust force required to break the rock. The XHD rings resist chipping, mushrooming, and other damage that can occur in very hard rock conditions, and they have a good track record: they've been put to the test at several jobsites, including Norway's Røssåga headrace tunnel bored in rock from 200 to 280 MPa UCS. At that tunnel it is likely that performance in very hard rock was improved by a minimum of 25% because of the XHD discs.

Optimize Penetration Rate

The overall goal in hard rock should be to operate TBMs as efficiently as possible to maximize production. This means increasing penetration per revolution while minimizing wear. The TBM Operator should therefore be looking for the best advance at the lowest RPM, because lower RPM reduces wear on the outer cutters and periphery of the cutterhead. Robbins has conducted tests at multiple sites over several years showing that a lower RPM achieves the same and often better penetration rates than a higher RPM in hard rock (e.g., reduce to 9.5 RPM from 12 RPM on a 5.2 m/17 ft diameter cutterhead).

Work with an Experienced Crew

Knowledgeable operators are key in hard rock: there needs to be a balance between cutterhead speed and thrust force. An experienced TBM Operator will be able to identify when ground conditions change and react accordingly. Dedicated maintenance is another key point, and especially critical for extreme hard rock operations. Crews should set aside time for maintenance, say four hours per 24-hour period, and keep this schedule throughout the project.

Read more on the blog:
http://www.therobbinscompany.com/3-ways-to-bore-hard-rock/

TRADE SHOWS & TECHNICAL PRESENTATIONS

+ ICUEE
Louisville, Kentucky, USA
October 1-3

+ ATC
Sydney, Australia
October 14-15

Technical Presentation:
On the Move: The Evolving Role of Continuous Conveyors in TBM Tunnels with Doug Harding

+ TUNNELING SHORT COURSE
Golden, Colorado, USA
October 14-17

Technical Presentation:
Applications, Design and Performance in Hard Rock TBM Tunneling with Dennis Ofiara

+ TBM DiGs
Golden, Colorado, USA
November 14-15

Technical Presentations:
TBM Tunneling in Extremely Hard Rock with Steve Smading

Effective Design and Operation of a Large Diameter Slurry TBM in Hard Rock Conditions with Matt Greger

+ CUTTING EDGE
Miami, Florida, USA
November 18-20

+ STUVA
Frankfurt, Germany
November 27-29

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