

UNDERGROUND INNOVATIONS

Autumn 2009

RECORDS RALLY AT GUANGZHOU METRO

After seven months of tunneling and more than 16 project records, two Robbins EPBs are pushing far ahead of schedule. The 6.3 m (20.5 ft) machines have completed initial breakthroughs into an intermediate station and are embarking on their final leg of tunnel. Both TBMs are more than a month ahead of schedule and on track for final breakthroughs in September and October 2009.

Records include a best month of 377 m (1,235 ft)—higher than any of the 16 TBMs that have worked on the Guang-Fo Metro Project. "The excavation speed of these machines has been praised by the project owner, Guangzhou Metro Company, many times. We believe the high rates are a combination of fewer equipment failures and efficient project management," said Mr. Ju Yicheng, Vice Chief Project Engineer for contractor China Communication Construction Corp., 2nd Navigation Engineering Bureau Ltd. (CCCC).

The two EPBs have operated at an average of 95% availability, in expected ground conditions requiring few cutter changes. As of August 2009, 66 disc cutters had been

changed on the first machine and 46 on the second, while no carbide bits had been changed on either of the TBMs.

Ground consists of weathered granite, coarse sand, and silt with earth pressures of up to 4 bar. Four independent foam injection points in the cutterhead are used to consolidate the face and create a smooth flow of muck in the mixed ground conditions. Active articulation systems have also allowed the machines to make curves down to a 200 m (820 ft) radius with no ring deformation. This type of articulation allows the front shield to turn independently of the machine's thrust cylinders, applying even pressure to each ring in tight curves.

The Robbins EPBs are boring parallel 2.6 km (1.6 mi) long tunnels for the Guangfo line of the new metro, which will connect the neighboring cities of Guangzhou and Foshan. The line is part of the Chinese government's Inter-city Rapid Rail Project, which aims to link up nine cities in Guangdong Province by 2015, including Shenzhen and Dongguan.



The first of two 6.3 m (20.5 ft) diameter Robbins EPBs broke through into the intermediate site of Xilang Station on August 15, 2009.



The newly designed operator's cabs feature large touch-screen monitors, etched stainless steel control panels, more storage space, and office-style chairs among other improvements.

DUAL EPBs TO EXCAVATE XI'AN METRO

Two 6.2 m diameter Robbins EPBs are on track to cut traffic times in one of western China's most ancient cities. The machines will excavate Lot 12 of Xi'an Metro Line 1 beginning in February and March 2010.

The contract was signed with China Railway 11th Engineering Bureau Group Limited in June 2009. Both TBMs will undergo assembly in a Chengdu workshop starting in November 2009. The machines are scheduled for launch in February and March 2010.

The machines will excavate parallel 2.3 km long tunnels, and are optimized for geology including sand, pebbles and clay with significant ground water. Spoke-type cutterheads and 800 mm diameter shaft-type screw conveyors will aid in efficient advance while maintaining a water-tight seal and balanced pressure.

The 26.4 km long metro Line 1 travels from north to south through downtown areas of the city. Currently reliant on surface transportation only, the new metro system is estimated to reduce traffic times across the city from more than one hour to 39 minutes. The line will pass nearby or directly underneath a number of ancient structures, including a bell tower and city wall dating back to the 12th century. Surface subsidence and vibration will be carefully monitored throughout excavation to avoid any structural disturbances.

REDESIGNED OPERATOR'S CABS OPTIMIZE FORM AND FUNCTION

Newly configured operator's cabs, also known as stations, are streamlining the process of TBM operation while keeping comfort in mind. Multiple 17 to 19 inch touch-screen monitors allow for integrated TBM monitoring, while an ergonomic console has been outfitted with etched stainless steel control panels. New structural features include a large countertop area, bookshelves, and storage space. Sliding doors allow for easy entry and exit in often narrow, crowded work areas.

"Our new cabs are visually and structurally superior to both older designs and the designs of other TBM cabs currently in use," said Mike Anderson, Robbins Sr. Designer.

Cabs are customized depending on the project, though standard models have been developed for different TBM size ranges, such as the 6.2 to 6.6 m (20.3 to 21.6 ft) diameters typically used for rail tunnels. "There is really no minimum diameter for the new cabs--we are currently drafting designs for stations that are

mounted on the back-up structure and are only about 1 m (3.3 ft) wide," said Anderson.

The structures are being designed with input from specialized cab manufacturers, and are undergoing assembly in the Robbins Solon, Ohio, USA manufacturing facility. "With the shell assembled, two people can generally outfit an operator's cab in about five days," said George Pfender, Robbins Electrical Supervisor. Technicians also outfit each cab with modular outlets that can be easily altered depending on the electrical requirements of the destination country.

Currently, the new designs are being used on several different projects in China, including five Main Beam machines ranging from 6.3 to 12.4 m (20.7 to 40.8 ft) in diameter for the Jinping Hydropower project, and the Chongqing and West Qinling metro projects. More cabs are in the works, with the goal of having standardized designs for several different diameter ranges in 2010.

ROBBINS SINGLE SHIELD ASSEMBLY COMPLETE



A 7.6 m (25.1 ft) Single Shield was completed in the Ohio, USA manufacturing facility.

In July 2009, assembly was completed on the 7.6 m (25.1 ft) diameter Single Shield TBM for the Theun Hinboun Expansion Project. The machine was assembled in Robbins' Solon, Ohio, USA manufacturing facility.

Geology on the project will consist of layered sandstone, siltstone, and mudstone--the machine will use an articulated cutterhead to compensate for changing ground conditions. The TBM, for contractor CMC di Ravenna, is capable of overbor-ing up to 100 mm in squeezing ground using shims and overcutters.

The Theun Hinboun Expansion Project will double generating capacity of the current Theun Hinboun plant from 220 MW to 440 MW. The project involves a 5.5 km (3.4 mi) long headrace tunnel on the Nam Theun River, a tributary of the Mekong located in Laos.



Left: The crew celebrates the intermediate breakthrough of a Double Shield TBM on China's Pinglu Tunnel in December 2008. Above: The 4.8 m (15.7 ft) diameter Double Shield set 15,000 rings, consisting of hexagonal segments, in July 2009.

DOUBLE SHIELD SETS 15,000 RINGS... AND COUNTING

Stretching over 200 km (124 mi), China's Yellow River Water Diversion project is one of the largest projects of its kind. The latest installment of the scheme, known as the Pinglu Tunnel, will be one of the world's longest tunnels excavated with a single TBM. On July 9, 2009, the 4.8 m (15.7 ft) diameter Robbins Double Shield TBM boring the waterway set ring no. 15,000, making the entire tunnel nearly three quarters complete.

The Sino-Austria Hydraulic Engineering Co. Ltd (SAHEC) is responsible for the 25.4 km (15.8 mi) tunnel, of which about 7 km (4 mi) were left to excavate in mid-July 2009. The machine has been boring since September 30, 2006 in mixed strata up to 50 MPa UCS.

"We've had high output in some very challenging ground conditions, from soil to often sticky, medium hard rock, to highly abrasive sandstone and traces of coal," said Paul Bargmann, Machinery Dept. Head for Alpine Bau GmbH, lead partner in the SAHEC JV. The machine broke through into a shaft chamber at the 13 km (8 mi)

halfway point in October 2008, and was refurbished before starting up again in December. The final breakthrough is scheduled for the end of April 2010.

The Robbins machine has been operating in China since 2000, when it was used to bore the 12 km (7 mi) long Lot 5 tunnel on an earlier section of the Yellow River Diversion. During the course of excavation, the machine set two world records in its size class of 4 to 5 m (13 to 16 ft): best month (1,855 m/ 6,085 ft) and monthly average (1,352 m/ 4,435 ft). Both records still stand.

The Pinglu Tunnel will connect to the North Main Line of the Yellow River Project, which additionally includes about 15 km (9 mi) of drill and blast tunnels that will transfer water to Pinglu, Shuozhou, and Datong areas.

Over 100 km (62 mi) of the South Main Line were excavated by five TBMs, including four Robbins Double Shields, between 1999 and 2001. The entire network will transfer water from the Yellow River to chronically dry regions of Shanxi Province.

ROBBINS EPB WILL DIG SANTO DOMINGO METRO

A 9.6 m (31.4 ft) diameter Robbins EPB is being readied for excavation of a new metro line in the Dominican Republic's capitol city. The contract, for Santo Domingo Metro Line 2, was signed with the Dominican Transit Reform Office (OPRET).

Assembly of the machine is currently underway at the Robbins EPB Division China manufacturing facility in Guangzhou. Machine commissioning and launch are scheduled for February 2010.

The custom-designed machine will feature a spoke-type cutterhead and two-liquid back-filling system to effectively excavate soft sands and soils while minimizing ground settlement. Two-liquid back-filling consists of cement plus an accelerant that are combined as they exit the EPB tail shield. The mixture hardens rapidly to stabilize tunnel walls behind segments as well as the surrounding geology.

The 22 km (13.7 mi) long, entirely underground Line 2 will travel from downtown Santo Domingo to Eastern parts of the city, connecting with the previously excavated Line 1. The first metro line, commissioned in January 2009, stretches 14.5 km (9.0 mi) and has 16 stations, transporting about 60,000 passengers daily. Four more lines are in the design and planning stages to ease traffic in southern and eastern parts of the city.

QUICK THINKING WITH SBU-A SOLVES PIPELINE BREAK

With a deadline of just one week, Tennessee, USA contractor Miko, Inc. needed a swift solution to fix a section of problem pipe. The contractor used a Robbins Small Boring Unit (SBU-A) and Auger Boring Machine (ABM) to bore a new crossing for an existing sewer line built in the 1970s. The 5 km (3 mi) long wastewater pipeline, servicing the city of Brentwood near Nashville, was suspected to have partially collapsed under a railroad, and the city was concerned about the potential for leakage into a nearby creek.

Miko bored the crossing for general contractor Civil Constructors, in order to replace a 30 m (100 ft) section of 1.2 m (48 in) diameter ductile iron pipe beneath the railroad. "The GC and owner were very impressed we got it done in a week, and that was without working on the weekend. We averaged about 6 m (20 ft) per day," said Mike Scates, Owner and President of Miko. The machine was launched on Tuesday, August 25, 2009 and holed through the following Tuesday.

The SBU-A is a type of trenchless boring attachment for use with standard ABMs. The SBU-A, in diameters from 600 mm to 1.8 m (24 to 72 in), consists of a circular cutterhead mounted with disc cutters. The disc cutters are capable of excavating rock from 25 to over 175 MPa (4,000 to 25,000+ psi) UCS. In mixed ground, the cutterheads are fitted with a variety of tungsten carbide bits and single or multi-row disc cutters.

In the launch pit, the machine is welded to the lead steel casing, while the ABM provides both torque and forward thrust to the cutterhead. Openings in the cutterhead called muck scrapers collect spoil from the face, where they are transferred to a full-face auger for removal.

Once the replacement bore was complete, ductile iron carrier pipe was laid inside the casing. "We were very impressed with the performance of the SBU-A and ABM setup--it worked by far better than traditional rock cutting heads like roller cone or Christmas tree heads. At the end of the bore you couldn't even tell the machine had been cutting through limestone," said Scates. The contractor has also used Robbins machines on a 70 m (230 ft) long water line beneath an Interstate Highway, and hopes to use the SBU on future projects.



Left: A section of pipe beneath a Tennessee, USA railroad needed to be replaced in just one week.

Middle: The 1.2 m (48 inch) Robbins SBU-A excavated the crossing at rates of 6 m (20 ft) per day.

Bottom: The SBU-A and Robbins 48-950 ABM excavated a 30 m (100 ft) crossing in limestone rock.



EVENTS CALENDAR

Robbins will exhibit at the following trade shows:

2009

ICUEE

October 6 - 8
Louisville, Kentucky, USA

National Engineer Civil Conference

November 10 - 13
Mexico City, Mexico

HKTC

November 20 - 21
Hong Kong

STUVA

December 1 - 3
Hamburg, Germany

2010

UCT

January 19 - 21
Tampa, Florida, USA

Bauma

April 19 - 25
Munich, Germany

