

UNDERGROUND INNOVATIONS

Special EPB Edition

AUTUMN 2008

ROBBINS EARTH PRESSURE BALANCE MACHINES

Robbins EPBMs were first introduced on the Channel Tunnel Project in 1987, and their design has since been honed for greater efficiency at the highest pressures and in complex geology. From “Smooth Flow” cutterheads that reduce friction to super-reliable back-filling systems and active articulation, Robbins has taken the traditional EPBM design to the next level.

This special edition newsletter highlights Robbins EPBM design features and the status of current worldwide projects. Robbins is working on many EPB projects in countries including the U.S., India, China, Turkey, Azerbaijan, and Mexico.

Each EPBM is specifically tailored to project conditions from soft clay to gravels to mixed ground with rock. Robbins EPBMs have garnered praise through unique design features that optimize the machine for the geology.

Open Cutterhead Design

For excavation in clay and silt, Robbins “smooth flow” spoke-type cutterheads are unparalleled. The cutterheads feature a large opening ratio, which means that more material can be excavated while still maintaining pressure and stability at the face. The open design requires less torque to turn the cutterhead, and results in less abrasive wear compared to the industry standard.

The Most Agile TBM in the Industry

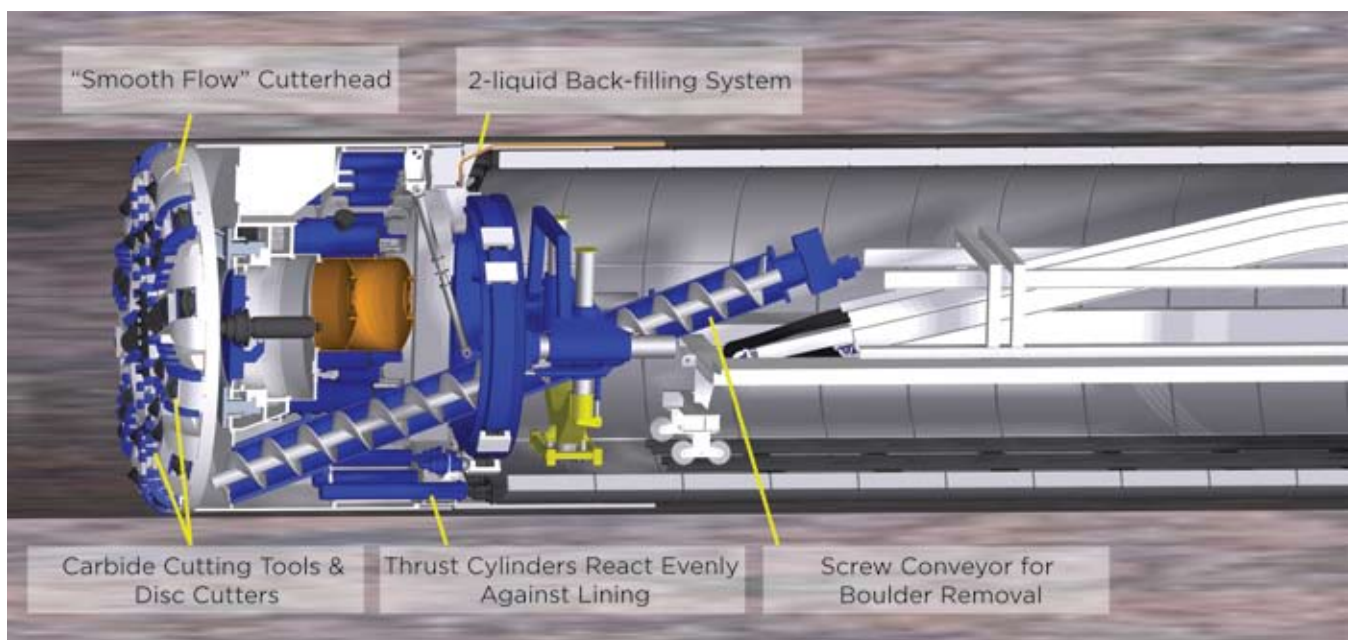
On curved drives, Robbins EPBMs are designed with active articulation, allowing the machine to tackle tight turns with ease. During active articulation, thrust cylinders react evenly against the entire circumference of the tunnel lining, regardless of the tunnel alignment. The machine thrusts parallel to the tunnel while the articulation occurs between the front and rear bodies, eliminating the problem of ring deformation.

The Urban Tunnelling Solution

Robbins has adopted a two-liquid back-filling system for a swift solution to safely tunnel in sensitive urban environments and permeable ground.

Other manufacturers utilize a concrete mixture to fill the temporary gap that exists between the tunnel walls and concrete segments. For EPBM projects this requires the use of concrete pumps at a very high pressure, making soft ground prone to settlement and upheaval at the surface.

The Robbins two-liquid back-filling system eliminates such problems by keeping two liquids separate and combining them in the tail shield. The liquids remain viscous, requiring only a normal pump with low pressure. Once combined, the two liquids (consisting of a cement mixture and an accelerator) harden rapidly to stabilize tunnel walls.



Robbins EPBMs feature unique designs to optimize each machine for the expected geology.



The 4.2 m (13.9 ft) Robbins EPBM will utilize unique PVC inner liner for a sewer project in Sacramento, California, USA

NEW ROBBINS MACHINE TO LINK UP MEXICO CITY

A new 10.20 m (33.5 ft) diameter Robbins Earth Pressure Balance Machine (EPBM) is planned to tunnel directly underneath Mexico City. The machine will be the largest diameter TBM ever to bore in Mexico.

Robbins signed the contract with the ICA consortium (made up of Empresas ICA, Cicsa, and Alstom SA) on July 29th, 2008 for the machine, back-up system, and cutting tools. The entire project is scheduled to be complete by the end of 2011.

The machine will excavate a 6.2 km (3.85 mi) long tunnel between Mexicaltzingo and Mixcoac areas in clay and sand, with boulders predicted up to 800 mm (30 inches) in diameter. A specially designed, 1,200 mm (4 ft) diameter two-stage ribbon-type screw conveyor will ensure efficient removal of the large boulders.

The TBM will feature active articulation for smooth boring around a curve with a planned radius of 250 m (820 ft). Active articulation will also prevent deformation of the segment rings on the curved portions of tunnel.

In 2007 the Mexican Federal District announced plans to build Line 12 of the Mexico City Metro--an entirely underground, 24 km (15 mi) long line with service to 22 stations. The Mexico City metro is one of the world's largest, with over 200 km (125 mi) of rail and nearly 4 million daily passengers.

SOFT GROUND TUNNELING A GO IN SACRAMENTO

An innovative EPBM is scheduled to make headway under the streets of Sacramento, California, USA in December 2008. The 4.2 m (13.9 ft) diameter machine will bore 5.9 km (3.7 mi) on the Upper Northwest Interceptor (UNWI) Sewer Project.

The EPBM, for the Traylor/Shea JV, is being manufactured and built by the Robbins EPB Division. The back-up system and continuous conveyor are being designed and built in the Solon, Ohio and Oak Hill, West Virginia, USA manufacturing facilities. All components will then be shipped to the jobsite for a December launch from a rectangular working shaft.

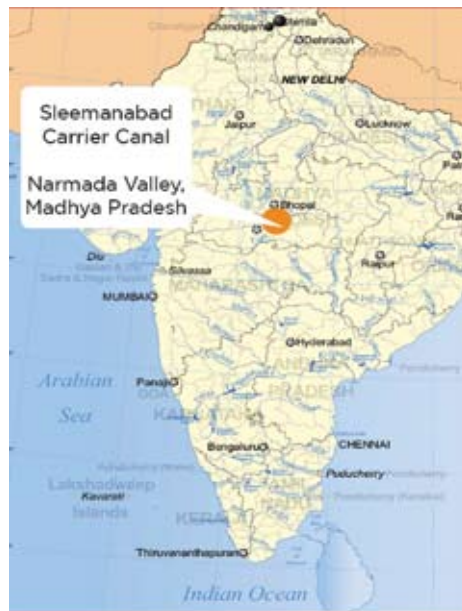
A mixed ground cutterhead will be initially fitted with carbide rippers to excavate through clay and running sand, though the rippers can be interchanged with disc cutters

if rock is encountered. The unique back-up system will enable installation of pre-cast concrete lining with an integrated PVC inner liner—the first time this type of liner has been used in the U.S. Once the tunnel is operational, the liner will protect the concrete from sewer gases and thus prolong tunnel service life.

A TBM was initially elected for the project due to the close proximity of residential areas. The method minimizes surface disturbances, which will be limited to the construction of 20 access manholes along the tunnel alignment.

The new sewer system should be complete by winter 2010. The project, for the Sacramento Regional County Sanitation District, is part of more than 190 km (120 mi) of new pipelines that will relieve current sewer systems nearing their capacity.

HYBRID EPBM WILL ADAPT TO CHANGING CONDITIONS



A 10.0 m (32.8 ft) diameter Robbins Hybrid EPBM will bore India's 12 km long Sleemanabad Carrier Canal in Madhya Pradesh.

Changeable depending on the ground conditions, a 10.0 m (32.8 ft) diameter hybrid EPBM has been developed for a project in Madhya Pradesh, India. Robbins signed the complete contract for the TBM, back-up, cutters, spares, continuous conveyor, and personnel in July 2008.

The 12.0 km (7.5 mi) long Sleemanabad Carrier Canal is a water diversion scheme located in the Narmada Valley. The geology in the tunnel area is highly variable, ranging from clay to gravel to mixed face rock (anywhere from 15 to 180 MPa / 2,200 to 26,000 psi UCS).

The hybrid machine has been designed for in-tunnel conversion between a standard TBM belt conveyor and a screw type conveyor depending on the ground conditions. The cutterhead also allows for switching out of cutting tools, from disc cutters to carbide rippers to clay spades.

The project, with Coastal Projects Pvt. Ltd, is scheduled to begin in summer 2009.



Left: The first 6.5 m (21.4 ft) diameter EPBM broke through on September 29, 2008. Above: The Robbins machine achieved advance rates of up to 19 rings per day.

EPBM SEES THE LIGHT IN DELHI

After five months of tunneling, a Robbins EPBM has completed its first bore in New Delhi.

The machine is one of two Robbins EPBMs boring parallel 2.0 km (1.2 mi) long tunnels for the second phase of India's New Delhi Metro Extension Project. A total of four machines are excavating a new 5.3 km (3.3 mi) line between the Udyog Bhawan and Green Park areas for the joint venture of Continental Engineering Corporation (CEC Taiwan)/ Soma Enterprise Ltd. (India).

The 6.52 m (21.4 ft) diameter Robbins machine was launched in May 2008 from Jor Bagh station and completed its first 1.0 km (0.6 mi) leg of the tunnel on September 29, 2008, holing through into the cut and cover site of Race Course Station.

"Advance rates were higher than anticipated—up to 19 rings were installed per day and the machine averaged over 90% availability," said Bob Moncrieff, Project Manager for CEC. Electric motors have contributed to the advance rates, by allowing the cutterhead to keep rotating in sticky ground consisting mainly of soft clays.

The machine will next be dismantled in a reception pit and transported

by road to the other end of the 318 m (1,000 ft) long Race Course site, where it will begin the second half of its bore to the contract boundary at Udyog Bhawan station. A second machine, launched later in the year, has advanced 50 m (160 ft) towards Race Course Station and recently began boring with all five of its back-up gantries on October 1.

Both Robbins machines feature several unique designs including a 55% cutterhead opening ratio to allow a smooth flow of muck and to avoid clogging during excavation. The machines are utilizing several types of tungsten carbide cutting tools to excavate ground consisting of clay, sandy silt, silty sand, and gravels with pressures up to 3 bar.

The parallel tunnels are part of more than 120 km (75 mi) of new rail being built for the Delhi Metro Rail Corporation (DMRC). Underground portions of the project involve deployment of 14 TBMs—a record for simultaneous tunneling in India. A tight schedule calls for all tunneling to be complete by December 2009, well in advance of the 2010 Commonwealth Games, which will bring an expected 5.5 million visitors to the city.

ROBBINS MACHINE WILL BE A FIRST FOR AZERBAIJAN

A 6.3 m (20.7 ft) EPBM will bore the first ever TBM-driven tunnel in Azerbaijan. Contractor Azerkorpu awarded Robbins the complete EPB boring system, including back-up, cutting tools, segment molds, segment manufacturing plant, rolling stock, spares, and operating personnel.

The Robbins mixed face EPBM will include both disc cutters and ripper teeth to excavate in clay and silty sand as well as mixed face rock. As the machine bores, it will line the tunnel with 600 mm (24 inch) thick precast concrete, universal type segments in a 5+1 arrangement.

Assembly of the machine is scheduled to begin in March 2009 in China, and will be supervised by the Robbins EPB Division. The TBM will be launched in May 2009 and is expected to bore for 8 to 9 months.

The Samur-Apsheeron Irrigation Project is part of a plan to rebuild the main canal, which provides the majority of water supplies to the capital city of Baku. The project consists of open canals and three TBM-driven tunnels totaling 5.7 km (3.5 mi) in length.

The network will convey water from the Samur River for both irrigation and a hydropower station, which will provide power to the Cusar District in Baku. Once the initial tunnel is complete, Azerkorpu plans to use the EPBM on several other tunneling projects in the country.

ROBBINS HYBRID EPBM A VERSATILE SOLUTION

A 3.1 m (10.2 ft) diameter Robbins Hybrid EPBM in Istanbul, Turkey can bore in two very different conditions. The hybrid machine can switch between hard rock and EPB modes, making it ideal in mixed ground conditions. The bored tunnel will be used to help clean up a sewer system for over 250,000 people living along Istanbul's Beykoz coastline at the Bosphorus.

Contractor NTF Construction Company is boring two mixed ground tunnels of 4.1 km (2.5 mi) and 3.0 km (1.9 mi) in length with the hybrid machine.

Geological conditions in the tunnel are highly variable due to Istanbul's location in a seismically active zone. Multiple fault lines exist at the tunnel site, and ground varies from silty clay to shale to limestone (rock varies from 75 to 100 MPa/ 11,000 to 14,500 psi UCS). Coral limestone found in preliminary geological tests also showed karstic features.

Specialized for mixed ground tunneling, the hybrid EPBM began excavating the Beykoz Tunnel in the first quarter of 2007. The machine is capable of boring with either 14-inch diameter disc cutters in medium to hard rock, or with tungsten carbide drag bits in soft ground. In hard rock mode, the machine operates using a standard TBM belt conveyor for muck removal. In soft ground, the machine operates as a non-slurry EPBM using a screw conveyor to transfer spoils to muck cars for removal. The machine is due to complete both tunnels in December 2008.

The Kavacik-Beykoz Wastewater Tunnels are part of a larger scheme by the Istanbul Water and Sewerage Administration (ISKI) to modernize Istanbul's deteriorating sewers. The two tunnels will convey untreated water via gravity from coastal areas to a new water treatment plant.

A 30 m (100 ft) deep shaft, lined with concrete segments, will allow water to be pumped from both the tunnels to the plant. Once the entire system is complete, it will treat approximately 575,000 m³ (1.5 million gallons) of water per day.



Left: The 3.1 m (10.2 ft) hybrid EPB can be converted depending on the geology

Middle: The circular back-up system (2.6 m / 8.5 ft in diameter) allows for maximum space of the muck hauling system.

Bottom: The Robbins EPBM is scheduled to finish both tunnels in December 2008.



EVENTS CALENDAR

Robbins will exhibit at the following trade shows:

2008

TAC 2008
October 27 - 28
Niagara Falls, Ontario, Canada

2009

UCT
January 20 - 23
San Antonio, Texas

NUCA
March 4 - 6
Phoenix, Arizona

ISTT
March 29 - April 3
Toronto, Canada

Intermat
April 20 - 25
Paris, France

World Tunnel Congress
May 23 - 28
Budapest, Hungary

