

The Robbins Company

The Most Trusted Name in Tunneling

2^{das} Jornadas sobre Tunelería y Espacios Subterráneos “Nuevos Proyectos y Avances Tecnológicos”

6 de Septiembre del 2012,
Centro Argentino de Ingenieros CAI – Buenos Aires

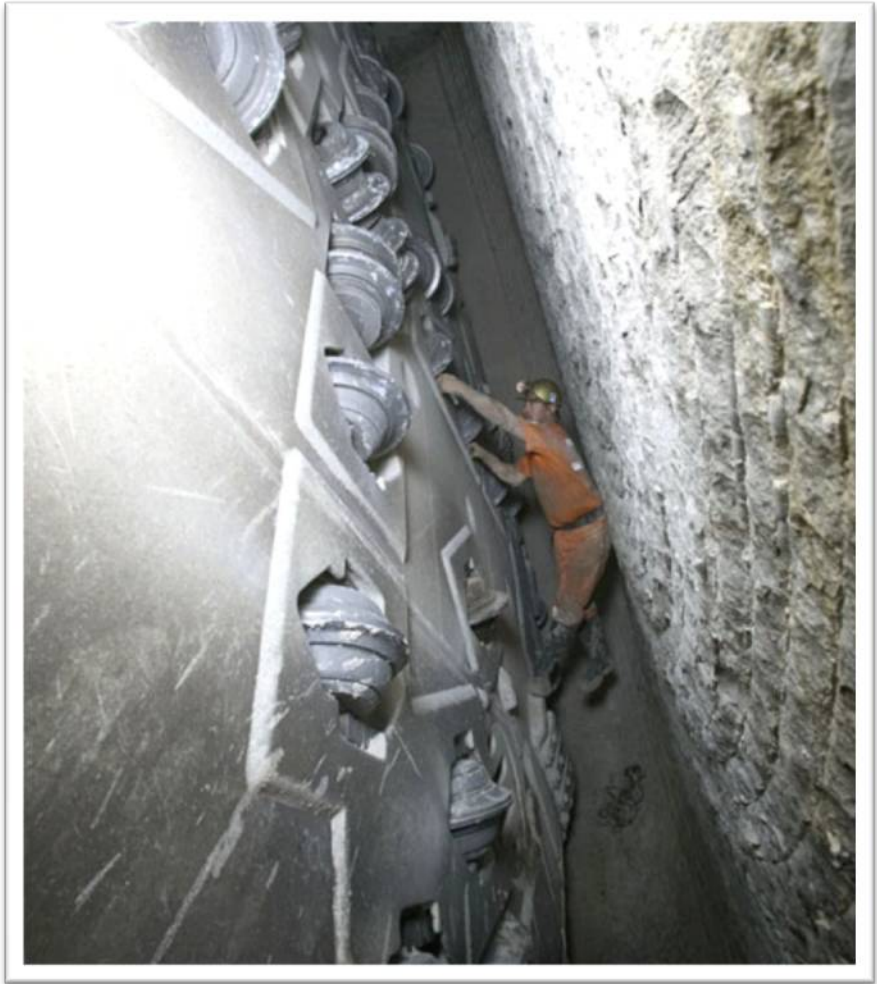
Robbins Products

- Tunnel boring machines
- Small boring units
- Conveyor systems
- Disc cutters
- Spare parts and service



Tunnel Boring Machines

- Main beam TBM
- Double shield TBM
- Single shield TBM
- Earth pressure balance (EPB) machine
- Slurry machine



Small Boring Units

- Standard small boring unit (SBU-A)
- Auger boring machine (ABM)
- Motorized small boring unit (SBU-M)
- Rockhead (SBU-RH)
- Small diameter double shield TBM (SBU-DS)



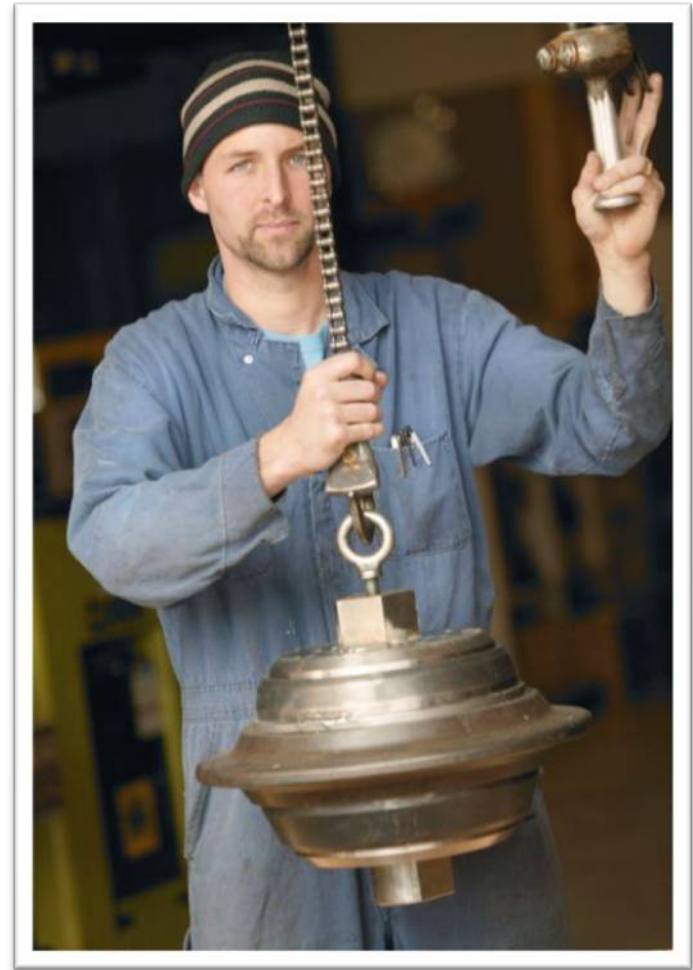
Conveyors

- Employed on more than 60 projects worldwide
- Custom conveyors are designed and manufactured for each project



Disc Cutters

- Wedge lock cutters
- 19" cutters
- Back-loading cutterheads
- 20" cutters
- Remote cutter monitoring systems



EPB Machines



CHANNEL TUNNEL



LOCATION

English Channel between the U.K. and France

EQUIPMENT TYPES

2 x 8.80 m (29 ft) EPB TBMs;
1 x 5.6 m (18 ft) EPB; 2 x 8.36 m (27 ft) Double Shield TBMs

TUNNEL LENGTH

39 km (24 mi)

GROUND CONDITION

Chalk Marl, Weak Sandstone, Stiff Clay

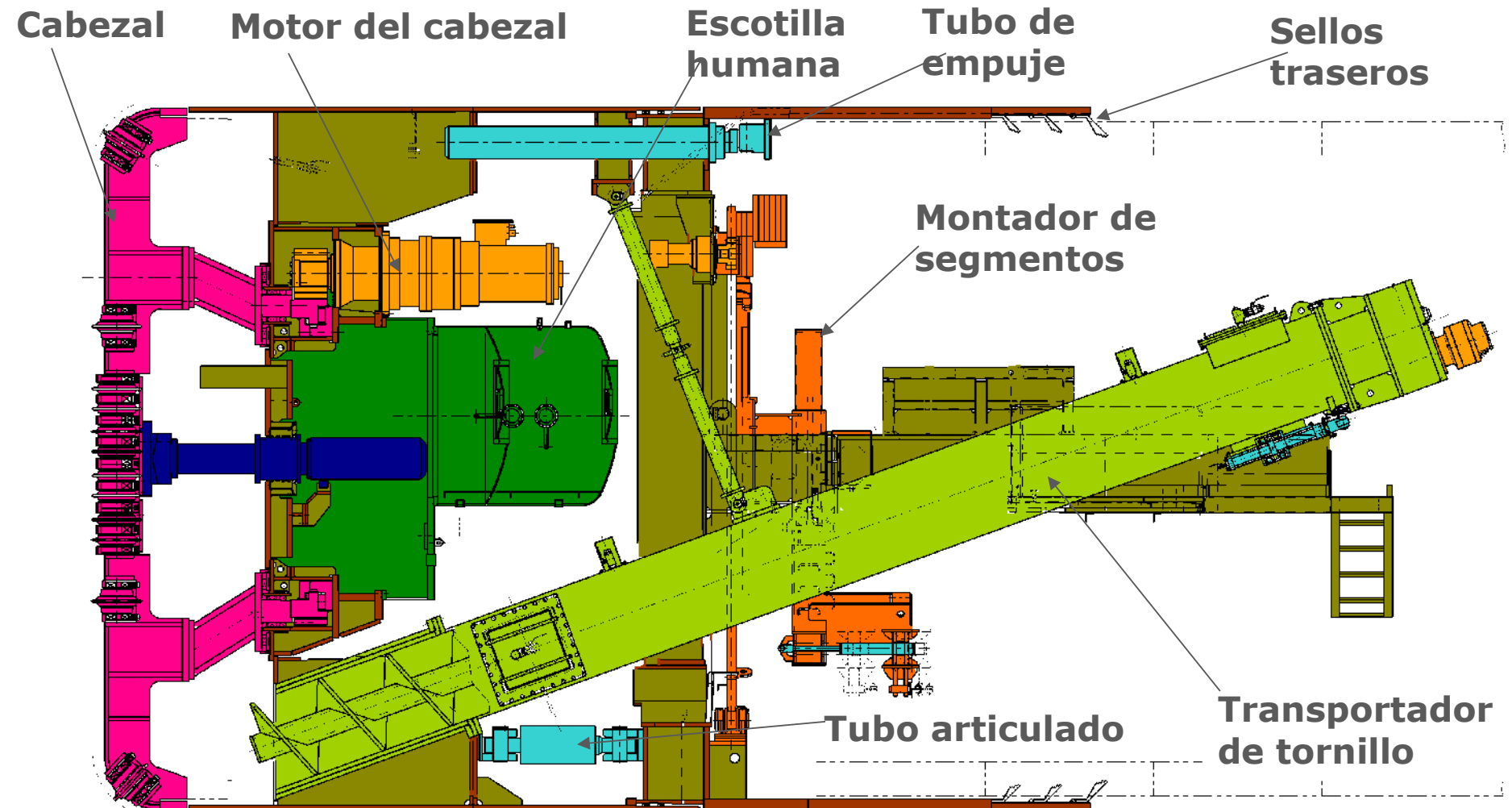
Channel Challenge completed by a Team of Robbins TBMs

- Two EPBs were launched on the French Side and two DS TBMs on the U.K. side
- One smaller EPB bored part of the service tunnel next to the main rail tunnels
- EPB design was unprecedented—sealed machines able to withstand 10 bar water pressure
- Four world records still stand for DS Machines—including 1,719 m (5,640 ft) in one month
- U.K. and French sides met on December 1, 1990

MÁQUINAS EPB



BALANCE DE PRESIÓN DE TIERRA (EPB)



BALANCE DE PRESIÓN DE TIERRA (EPB)



**Cabeza de corte
EPB típica para
suelo suave o
arcilla**

BALANCE DE PRESIÓN DE TIERRA (EPB)



**Cabeza de corte EPB
típica para roca
mixta y suelo suave**

BALANCE DE PRESIÓN DE TIERRA (EPB)



**Llegada a Nueva
Delhi**

Case Study Tunnel Emisor Oriente, Mexico City



EMISOR ORIENTE – LOTS 3, 4 & 5



LOCATION

Mexico City, Mexico

EQUIPMENT TYPE

3 x 8.9 m (29.2 ft) EPB TBMs

TUNNEL LENGTHS

9.2 km (5.7 mi), 10.2 km (6.3 mi), 8.6 km (5.3 mi)

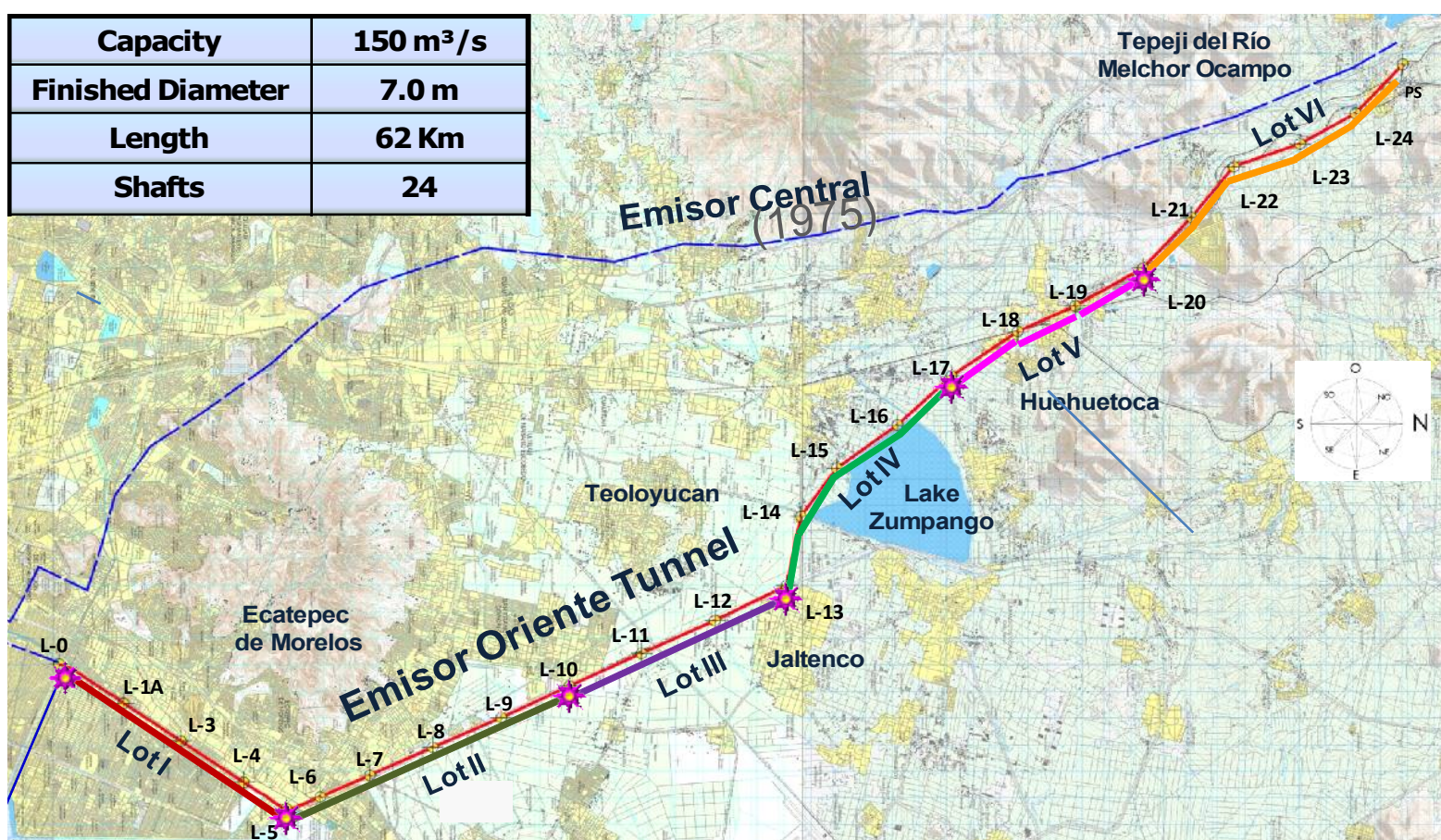
GROUND CONDITION

Mixed ground including basalt, volcanic rock, clay, tuff, and large boulders

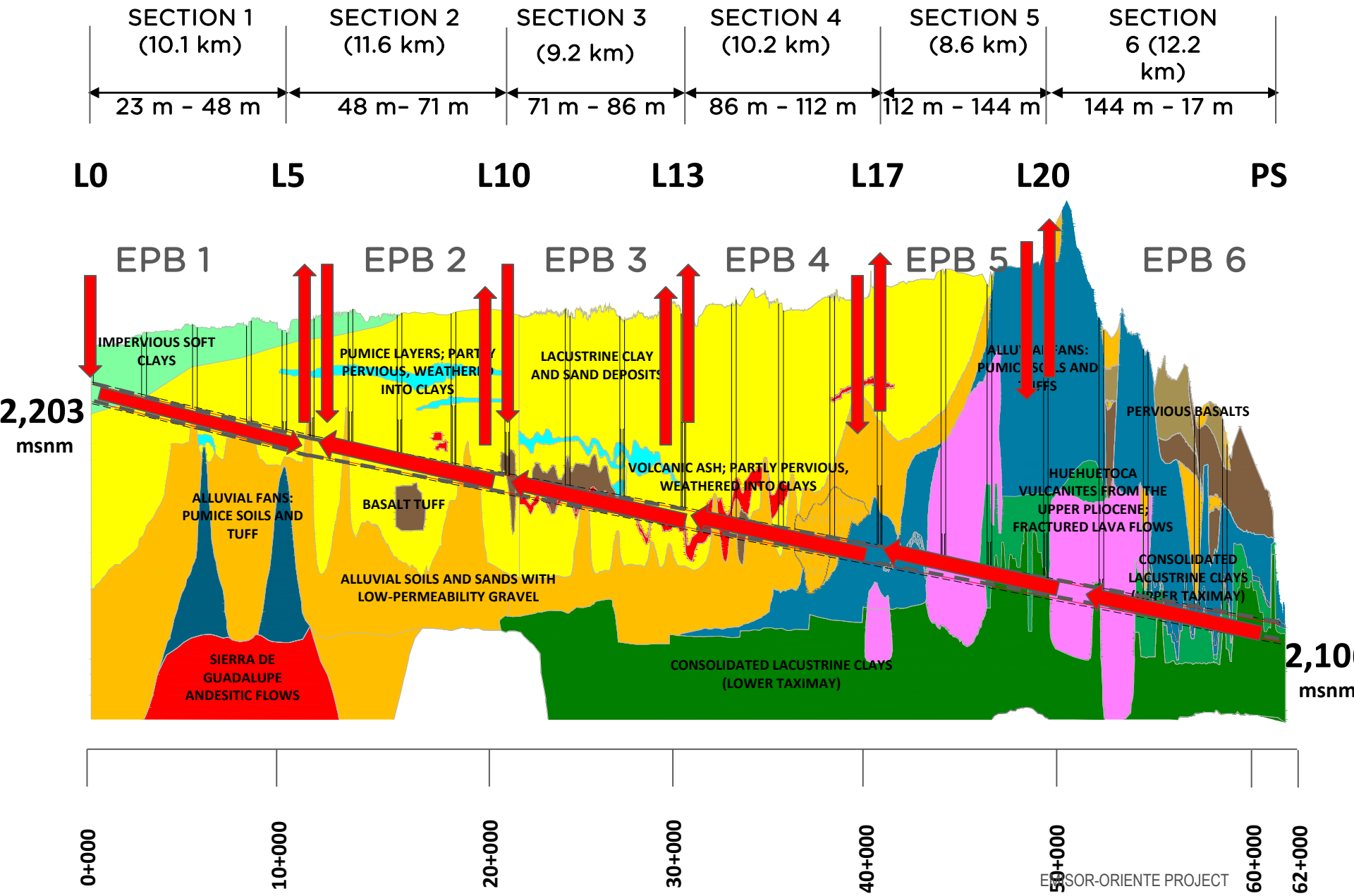
Mexico's Largest Infrastructure Project Will Halt Flooding in the Country's Capital

PLAN VIEW OF THE PROJECT

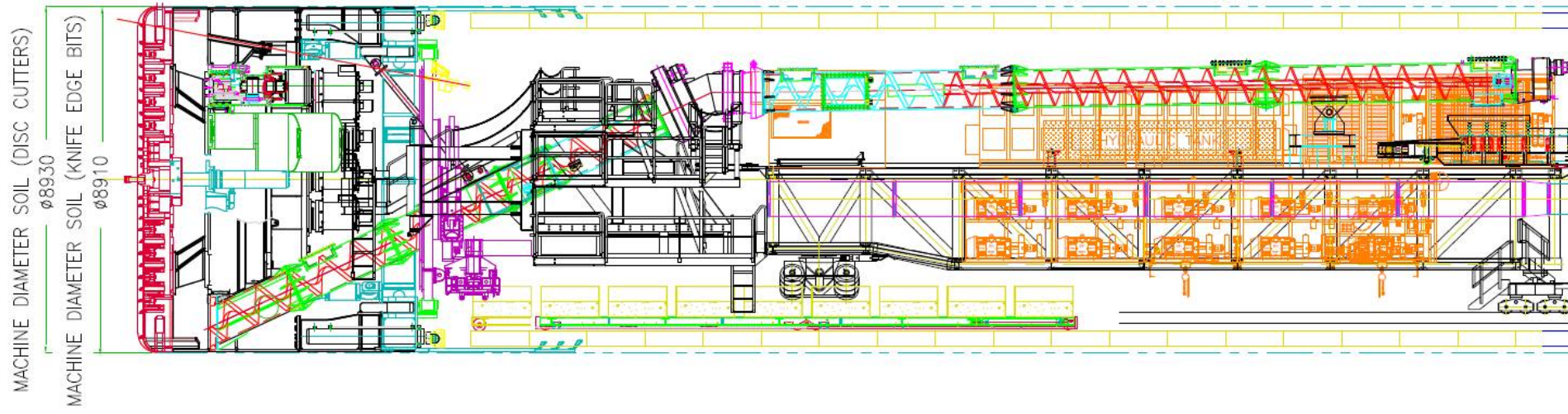
Capacity	150 m ³ /s
Finished Diameter	7.0 m
Length	62 Km
Shafts	24



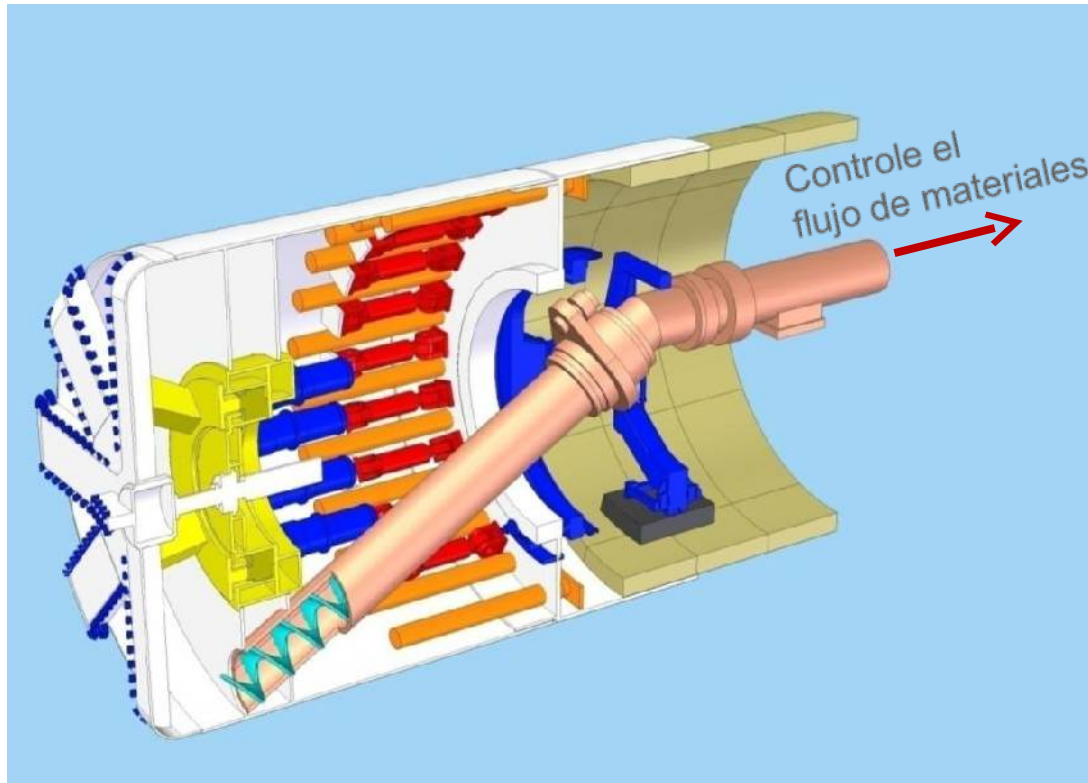
LOGISTICS



PROJECT APPROACH



BALANCE DE PRESIÓN DE TIERRA (EPB)



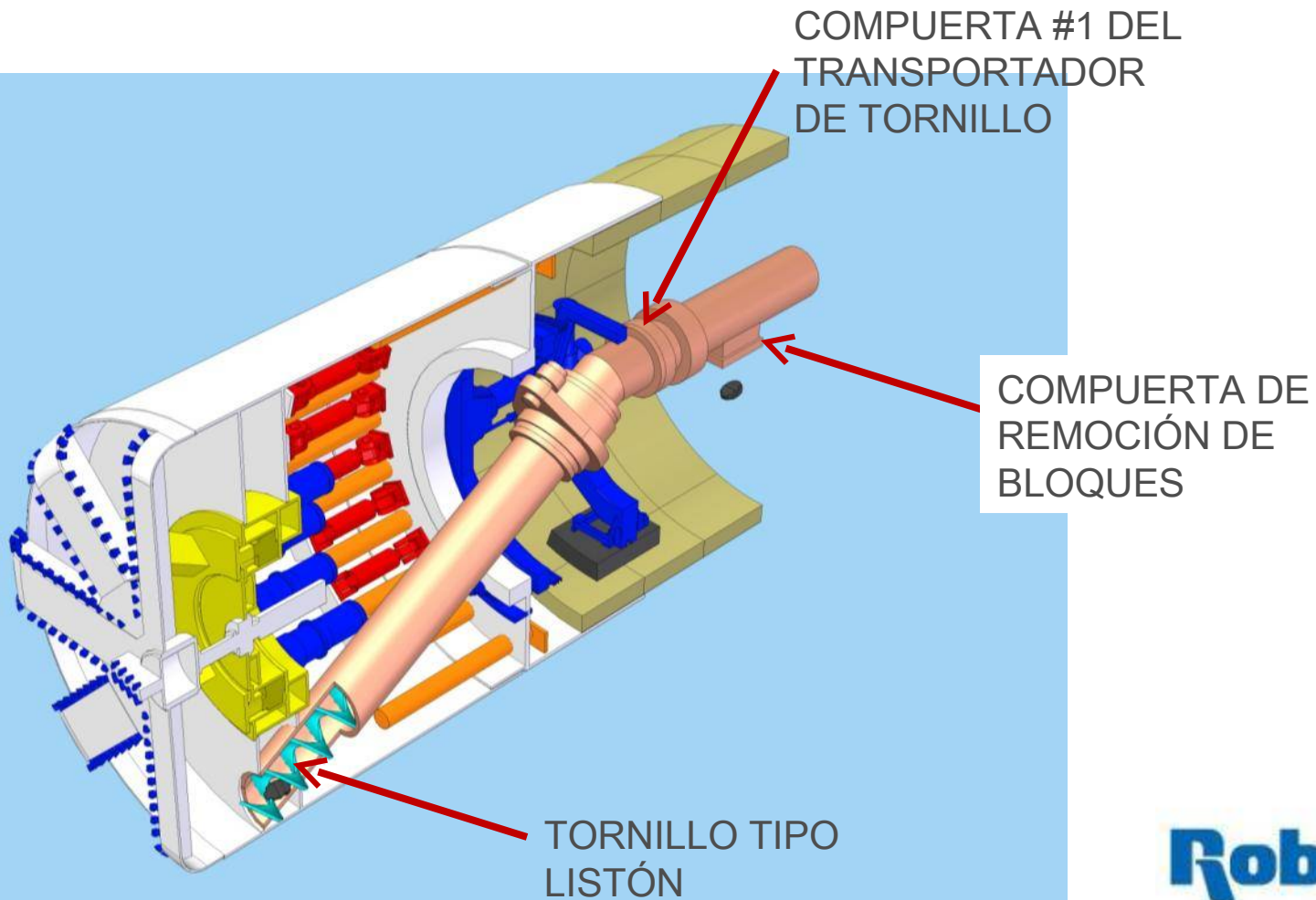
La presión por colapso del frente de corte se corrige :

- Aumentando la velocidad de avance
- Bajando la velocidad del transportador de tornillo

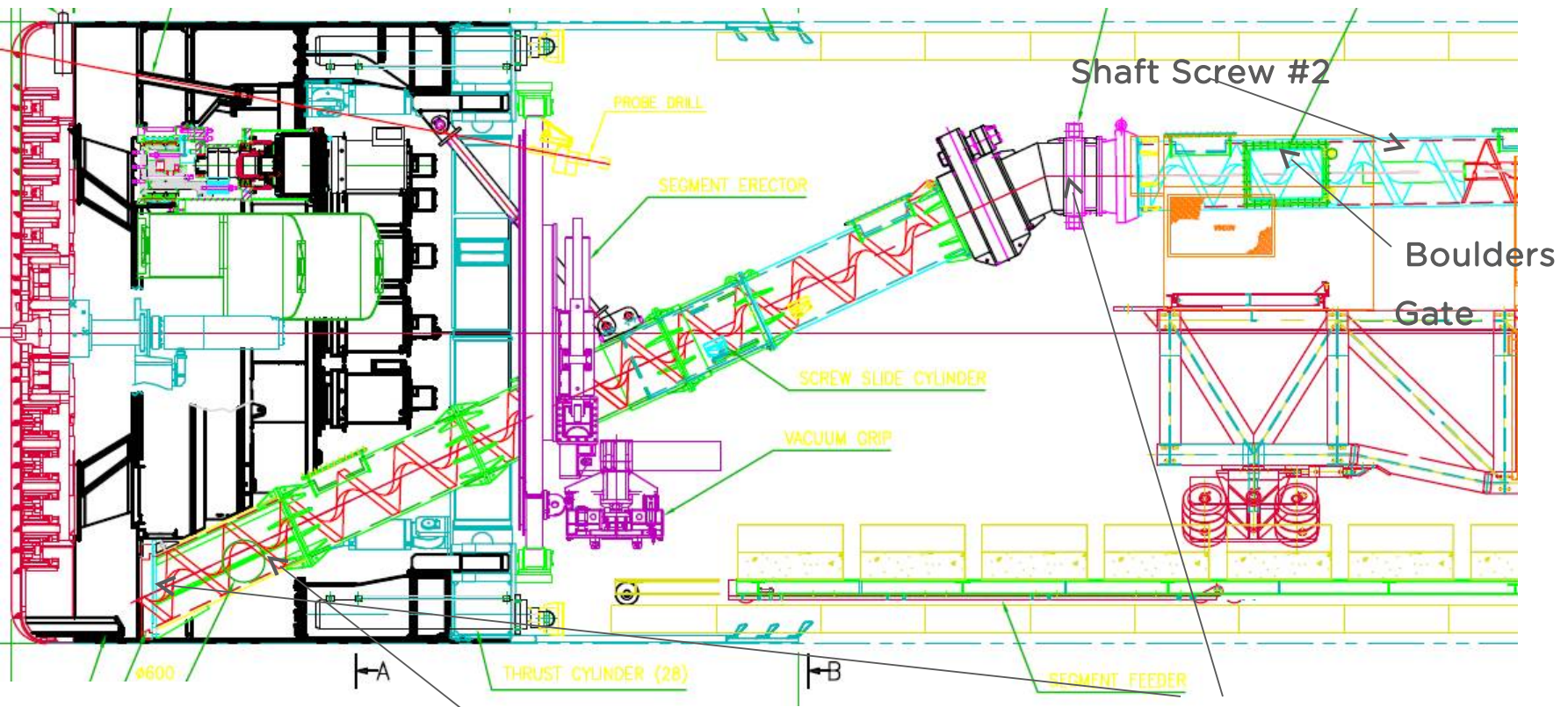
El aumento de presión en el frente de corte se corrige:

- Bajando la velocidad de avance
- Aumentando la velocidad del transportador de tornillo

BALANCE DE PRESIÓN DE TIERRA (EPB)



SCREW CONVEYOR



Boulders

600mm

Two Gates to control pressure

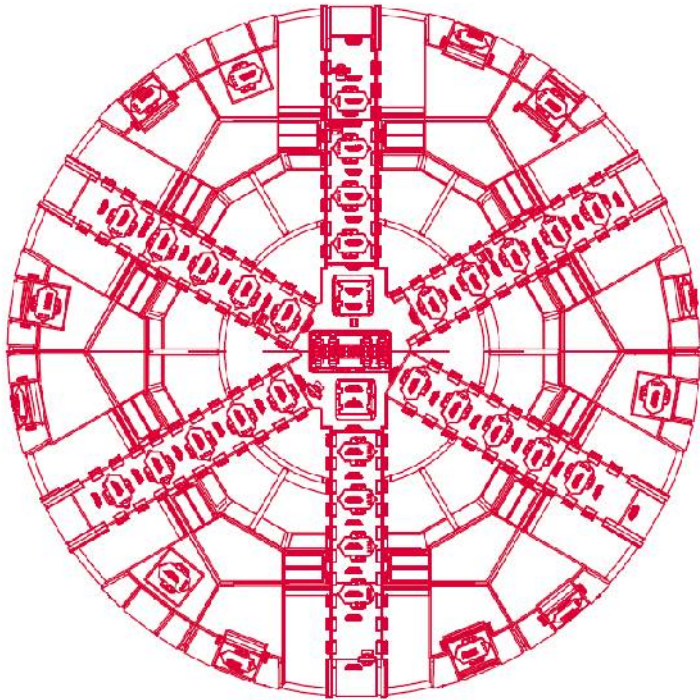
Ribbon Type Screw

PROJECT APPROACH

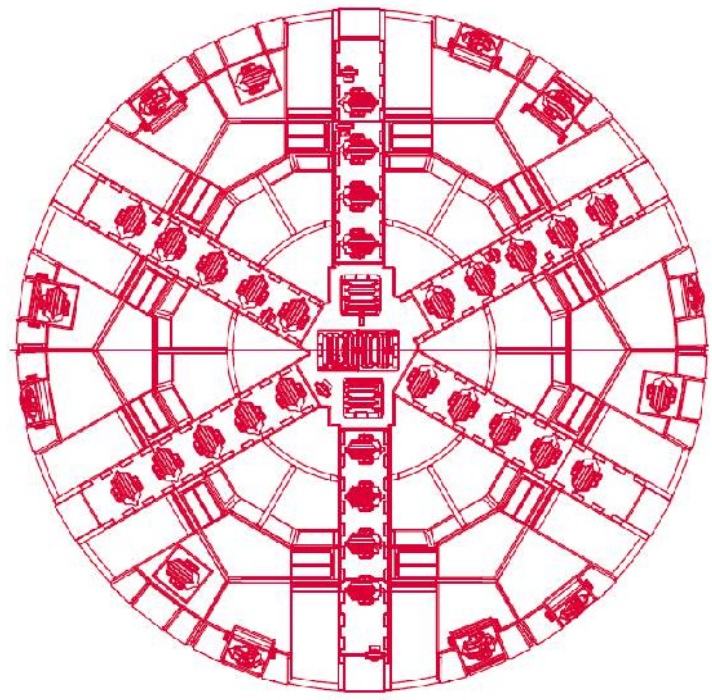
ROBBINS EPB SERIES 290 8.93 m Diameter EPB TBMs

Excavation Diameter	8,910 mm
Cutterhead for Soil	8,930 mm
Cutterhead for Rock	
Main Cutting Tools	Special knife-edge bit (soil) Single and Double-row Disc Cutters (rock)
Cutterhead Drive	Electric, variable speed
Cutterhead Power	1,900 kW
Machine Thrust	84,000 kN
Stroke	2,300 mm
Max Torque	17,900 kNm
Screw Conveyor #1	Ribbon type, 900 mm diameter
Screw Conveyor #2	Shaft type, 900 mm diameter
Articulation	Active
Segments	Reinforced concrete, 400 mm thick
Back-filling System	Two-Liquid Type

CUTTERHEAD



CUTTERHEAD FOR SOIL

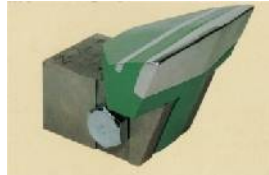


CUTTERHEAD FOR ROCK

CUTTING DEVICES



Special Knife
Edge Bit



Drag Bit
with Pin

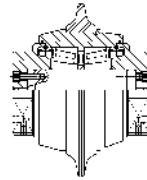


Drag Bit
Bolted

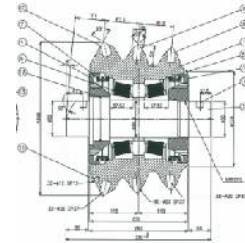


Used for soil and mixed ground

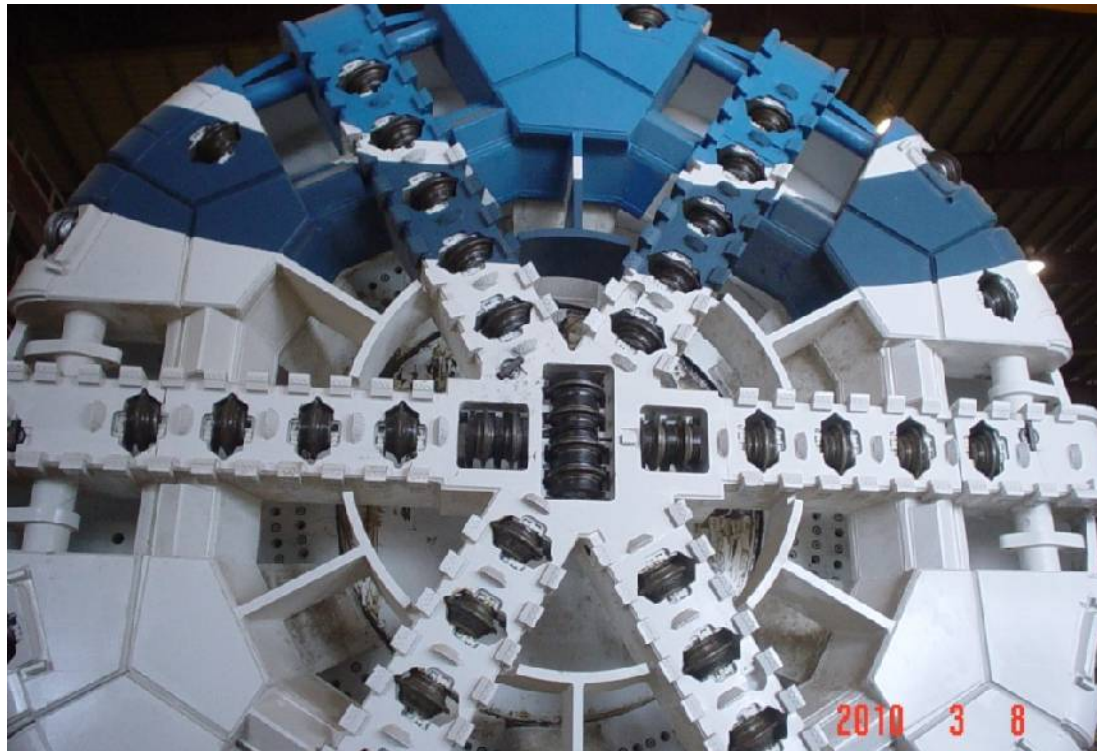
CUTTING DEVICES



**Single Disc Cutter
for Rock**



**Double or Triple Disc
Cutters for Rock**



Used for Rock and Boulders

SCREW CONVEYOR



Ribbon Screw: Rear Discharge Drive

SCREW CONVEYOR

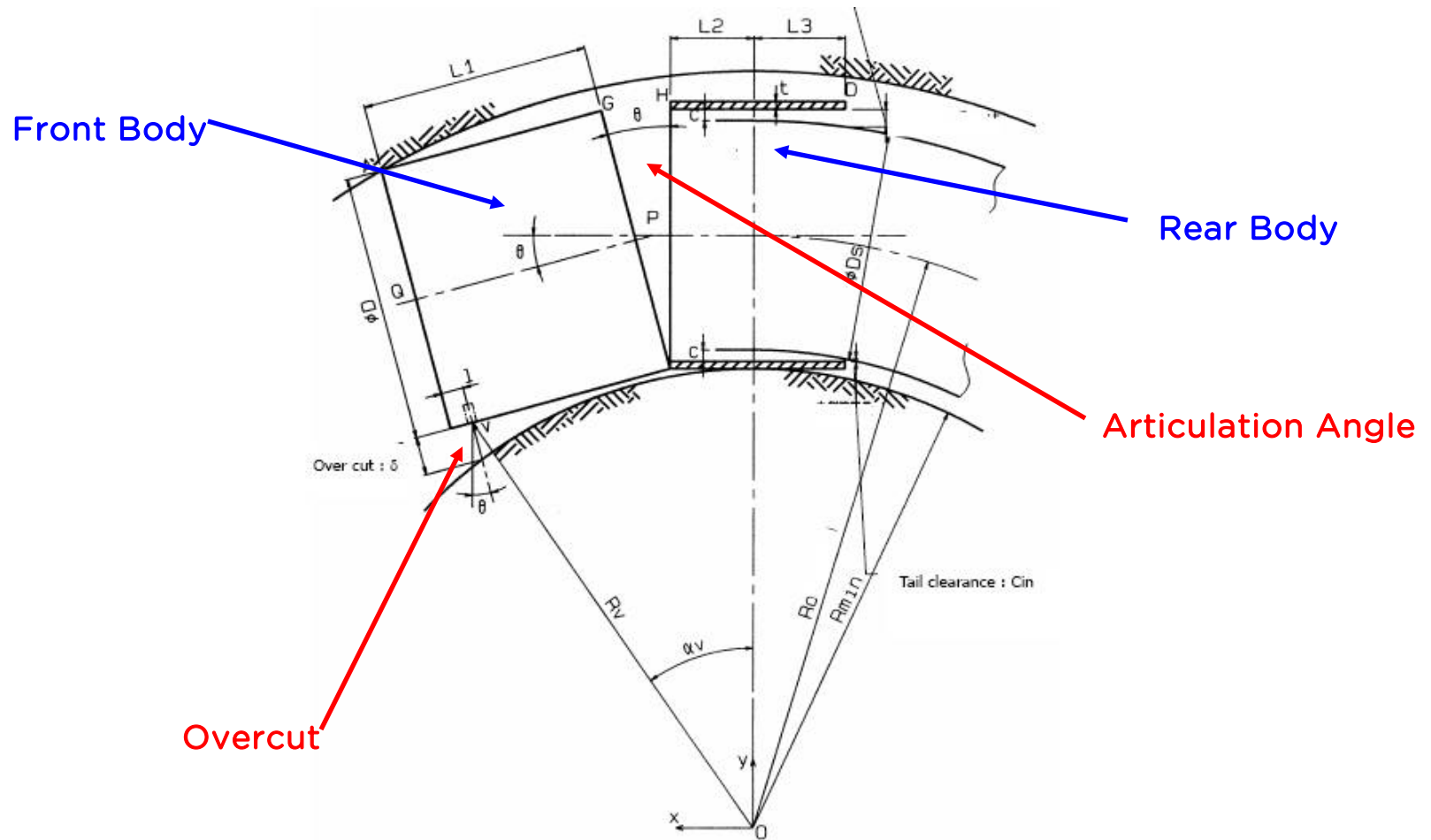


Ribbon Screw: Bulkhead Guillotine Gate

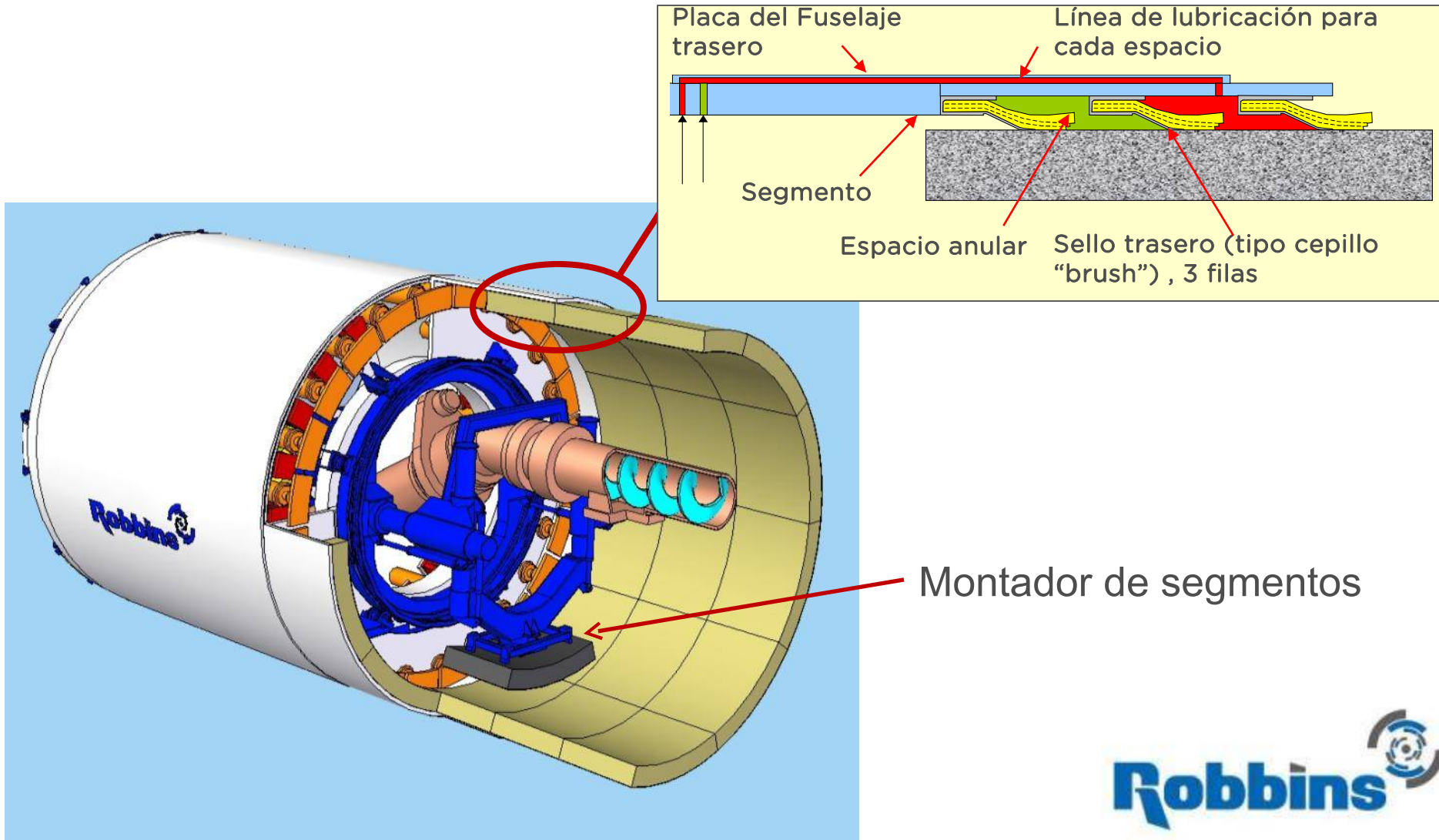


Ribbon Screw: Rear Guillotine Gate

CURVE NEGOTIATION



BALANCE DE PRESIÓN DE TIERRA (EPB)



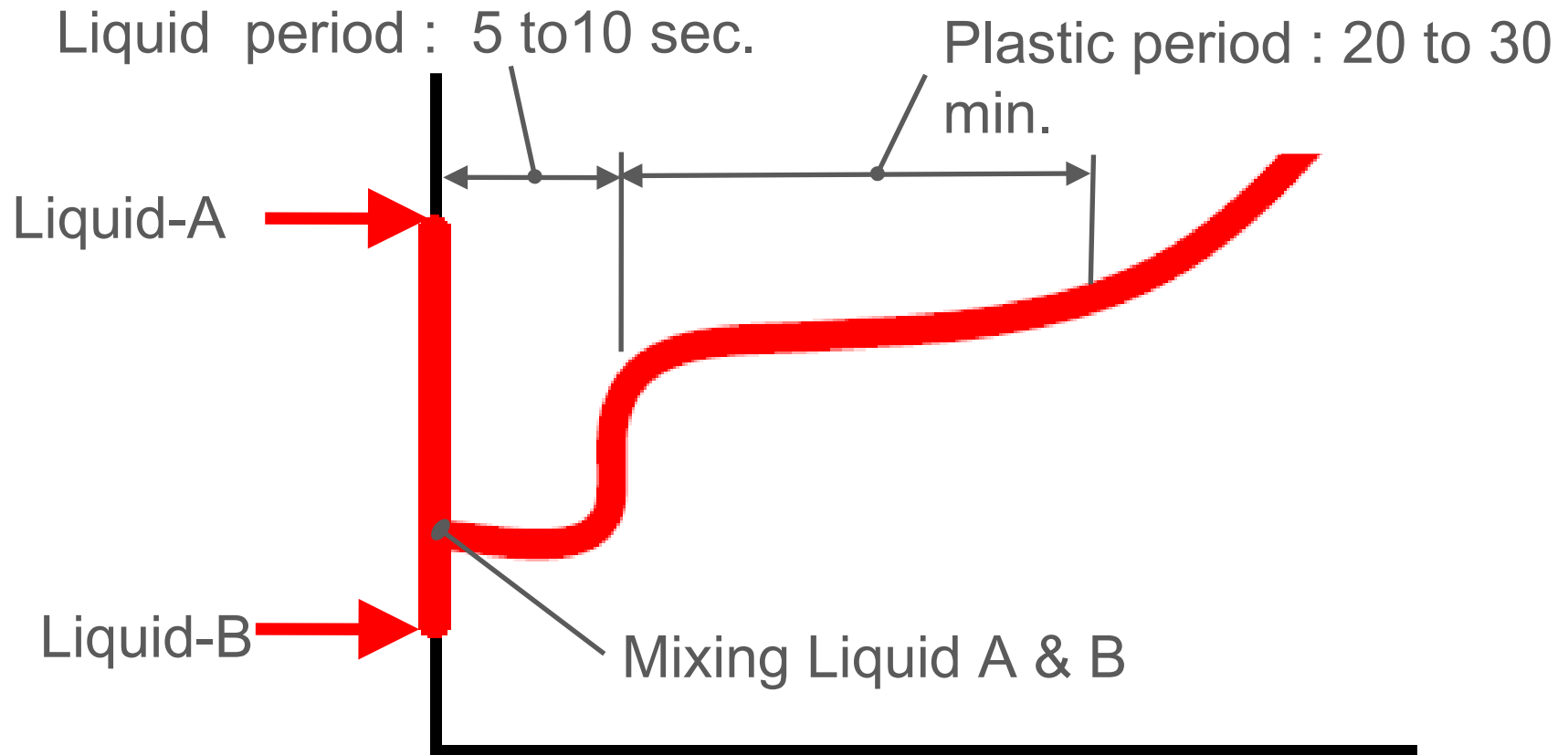
Factors to Consider:

- Settlement Risk
- Stability of the Ring
- Water tightness

Decisions to take:

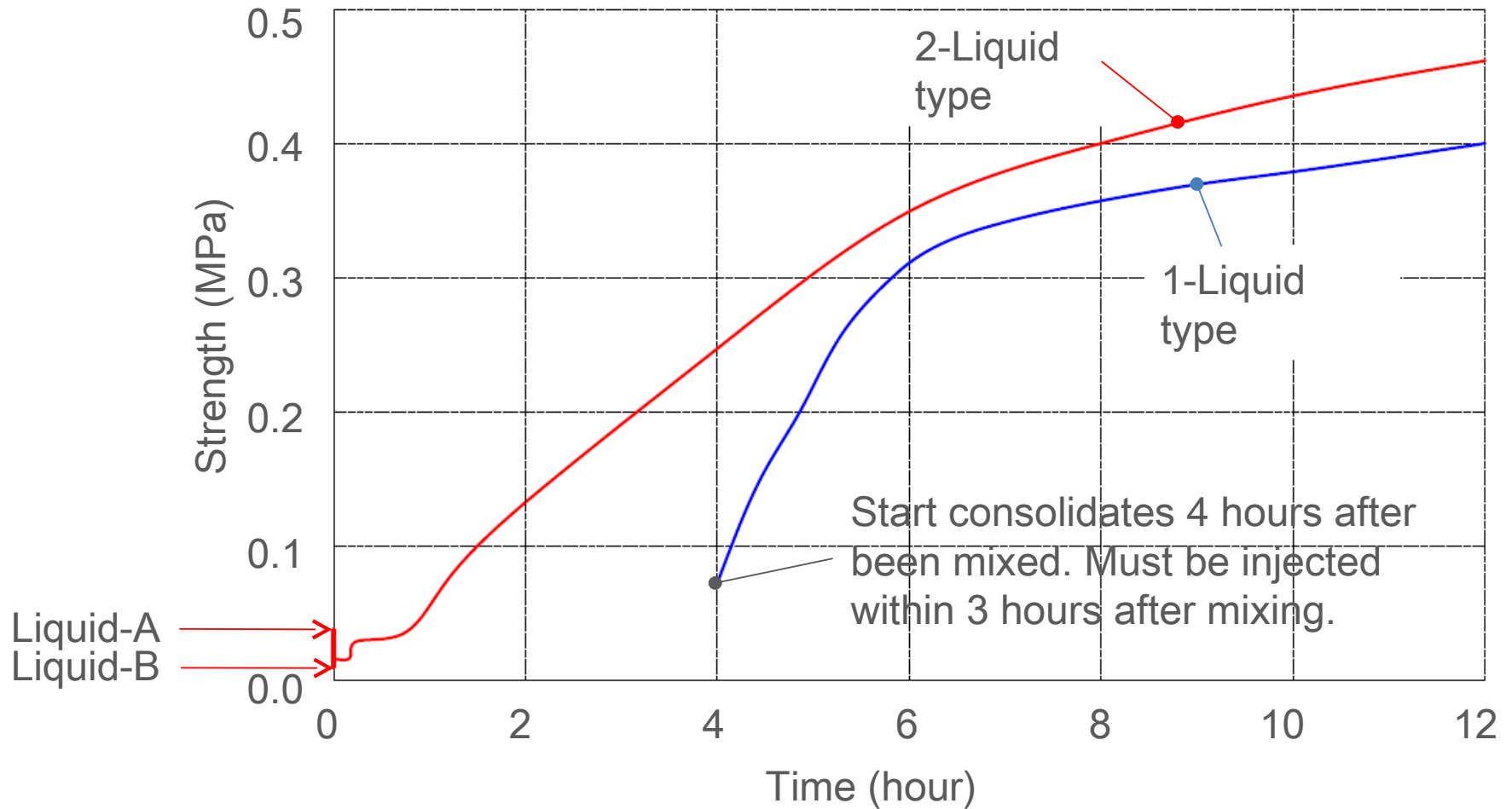
- Inject trough Segment or trough Tail Shield
- Use one or two liquid system

BACKFILLING SYSTEM



Consolidation Curve 2 Liquid

BACKFILLING SYSTEM

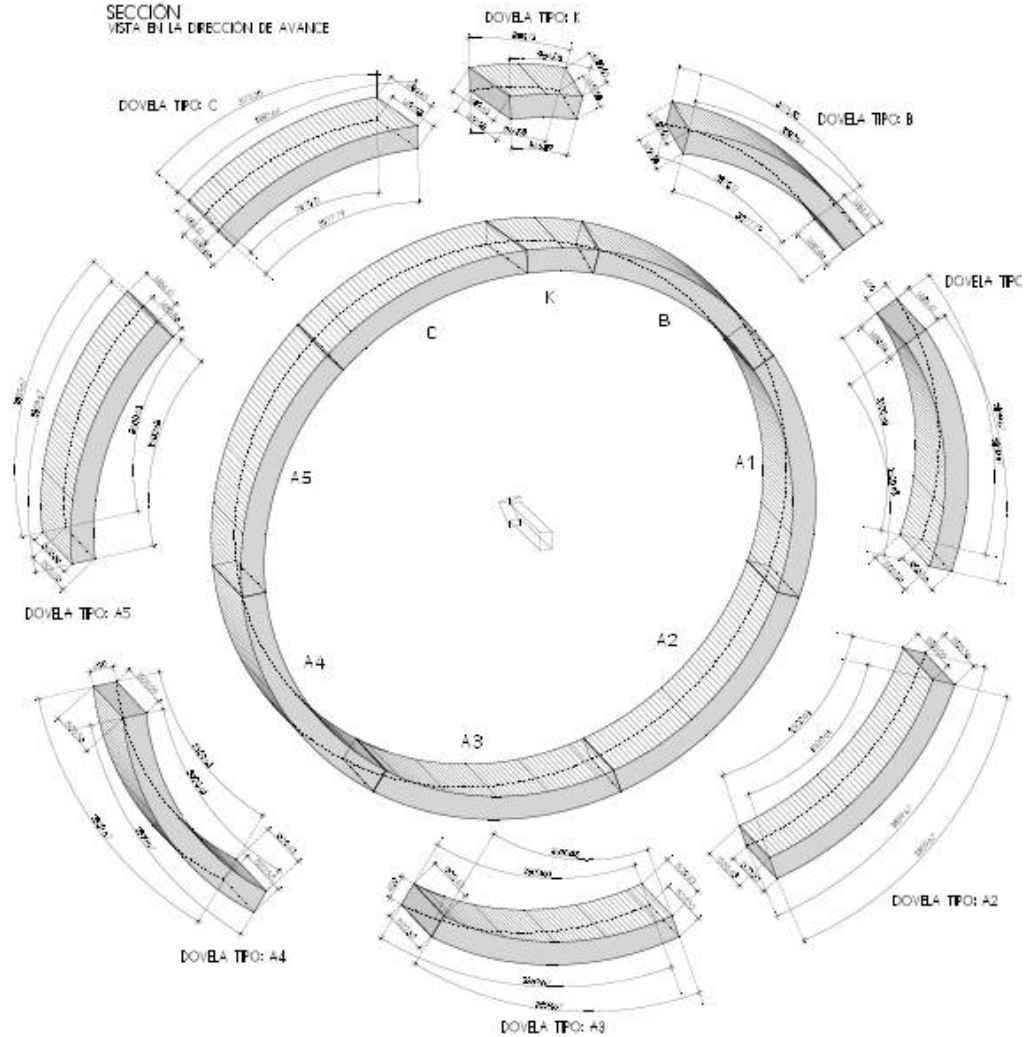


BACKFILLING SYSTEM

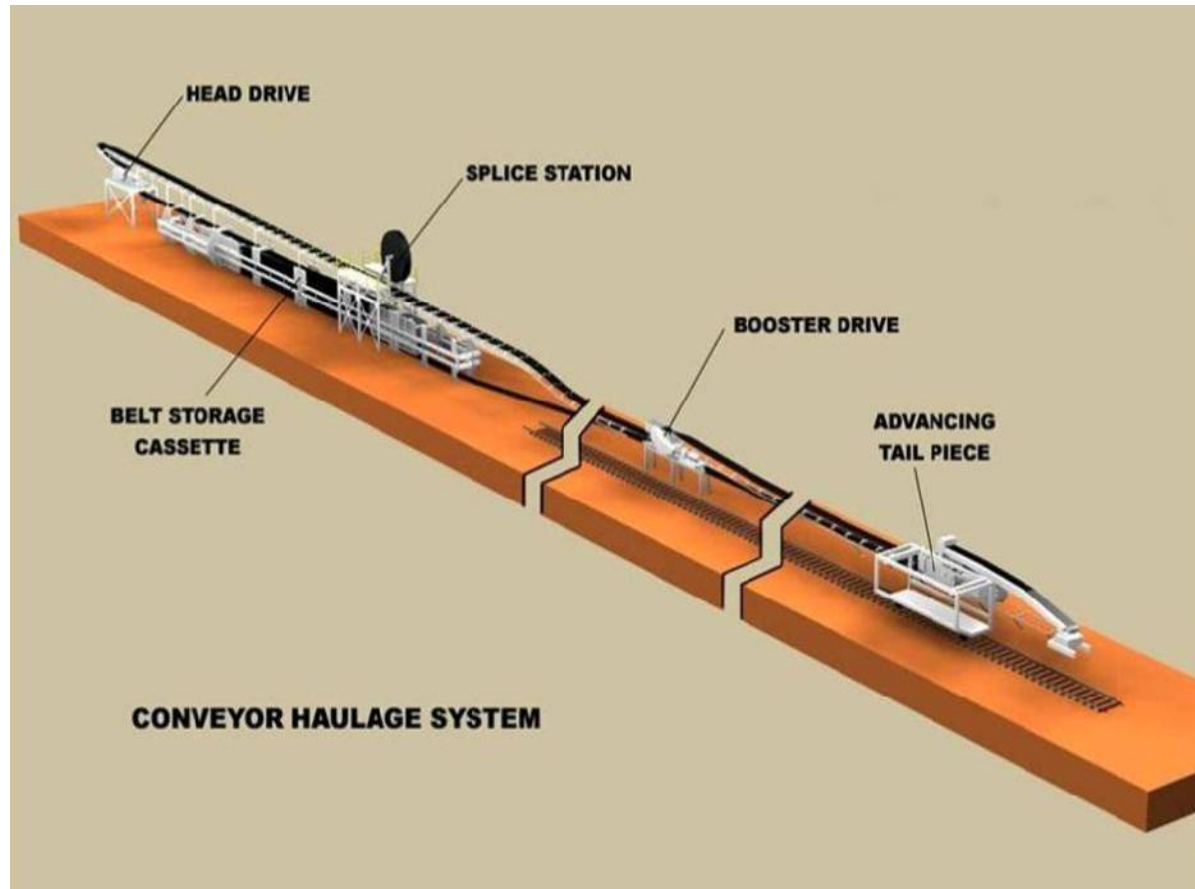
	1-Liquid type	2-Liquid type	
		A-liquid	B-Liquid
Cement	100 kg	250-300 kg	-
Bentonite	50-80 kg	25 – 40 kg	-
Fine sand	100 kg	-	-
Fly ash	300-350 kg	-	-
Decelerator	-	2-4 kg	-
Mixing	2-3 kg	-	-
Water	250- 300 L	800-850 L	-
Accelerator (SiO_2)	-	-	80-100 L

Typical Composition of

SECCIÓN
VISTA EN LA DIRECCIÓN DE AVANCE



CONVEYOR COMPONENTS



VERTICAL CONVEYOR



Horizontal Conveyor to Vertical Conveyor

VERTICAL CONVEYOR



Case Study Upper NW Interceptor Sewer, Sacramento





LOCATION
Sacramento, California, USA

EQUIPMENT TYPE
4.2 m (13.9 ft) EPB TBM

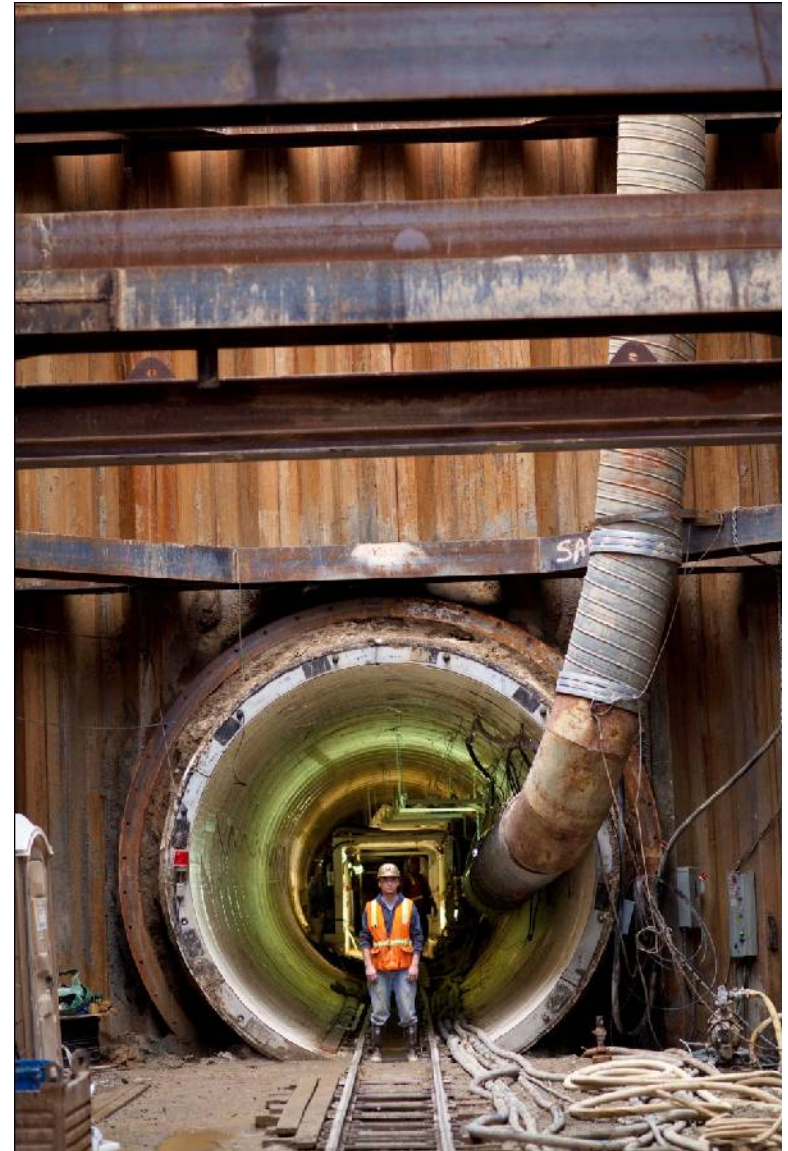
TUNNEL LENGTH
5.9 km (3.7 mi)

GROUND CONDITION
Clay and running sand

EPB Tunneling in Sacramento

Project description

- Owner: Sacramento Regional County Sanitation District
- Consultants: HMS & URS 293
- Contractors: Traylor Bros. & Shea J.V.
- TBM Manufacturer: The Robbins Company
- PVC liner: Ameron T-Lock



Project description

- Purpose: Part of more than 190 km (120 miles) of new pipelines that will relieve current sewer systems near Sacramento, California
- Length: 5.7 km (3.5 miles)
- Capacity: 560 million liters (148 million gallons) /day of waste water
- Geology: Clay and running sand with the possibility of rock
- Diameter: 4.25m (13.9 ft)



PVC-Lined Segments



PVC-Lined Segments



Welding Station Locations



Welding Station Locations

- Weld prior to blocked areas
- Near other activities
- Unobstructed access to lining and seams
- Workspaces compliment each other to provide 360° of unobstructed access to tunnel circumference.



Time Study

- Minimize construction time – Maximize rate of advance
- Two rings of segments per each train load
 - Delivery of segments once per hour
 - No need for passing track
 - Long handling trolley
- Solution: Segment lifters & segment feeder
 - Offload two rings of segments instantly
 - Storage directly behind erector

Segment Feeder

- Small diameter wheels + PVC + Curves
- Solution: Suspend Feeder from TBM/Backup
- TBM frame was reinforced to handle extra load
- Limited access into the shield
- Lifted off lining for the push, lowered prior to feeder extension

Segment Feeder



Startup Configuration

- 40m usable pit length
- 7.5m wide
- Half length rails



Deck 1 Structure

- Hydraulic cancellation of wheel load
- Open top for low angle conveyor
- Open bottom for installation of full length rail
- Clustered, steerable wheels
- Bridge support on rear of deck
- Integral bridge with conveyor and articulated hoist

Wheel Contact

- Anticipated conditions & parameters
 - 3.45 Mpa contact pressure
 - Side skidding
- Test results
 - 6.9 Mpa acceptable contact pressure
 - Resistant do skidding damage if clean
- Test setup



Continuous Conveyor



Other Robbins EPB Projects



BAKU METRO



LOCATION

Baku, Azerbaijan

EQUIPMENT TYPE

6.3 m (20.5 ft) EPB TBM

TUNNEL LENGTH

5.7 km (3.5 mi)

GROUND CONDITION

Clay, silty sand, mixed-face rock

Country's First TBM Will Modernize Capital City's Metro System

- A Robbins EPB will help to overhaul Baku's rail system
- EPB was launched in August 2011
- The country's first-ever TBM

SLEEMANABAD CARRIER CANAL



LOCATION

Madhya Pradesh, India

EQUIPMENT TYPE

10.0 m (32.8 ft) Hybrid EPB TBM

TUNNEL LENGTH

12 km (7.4 mi)

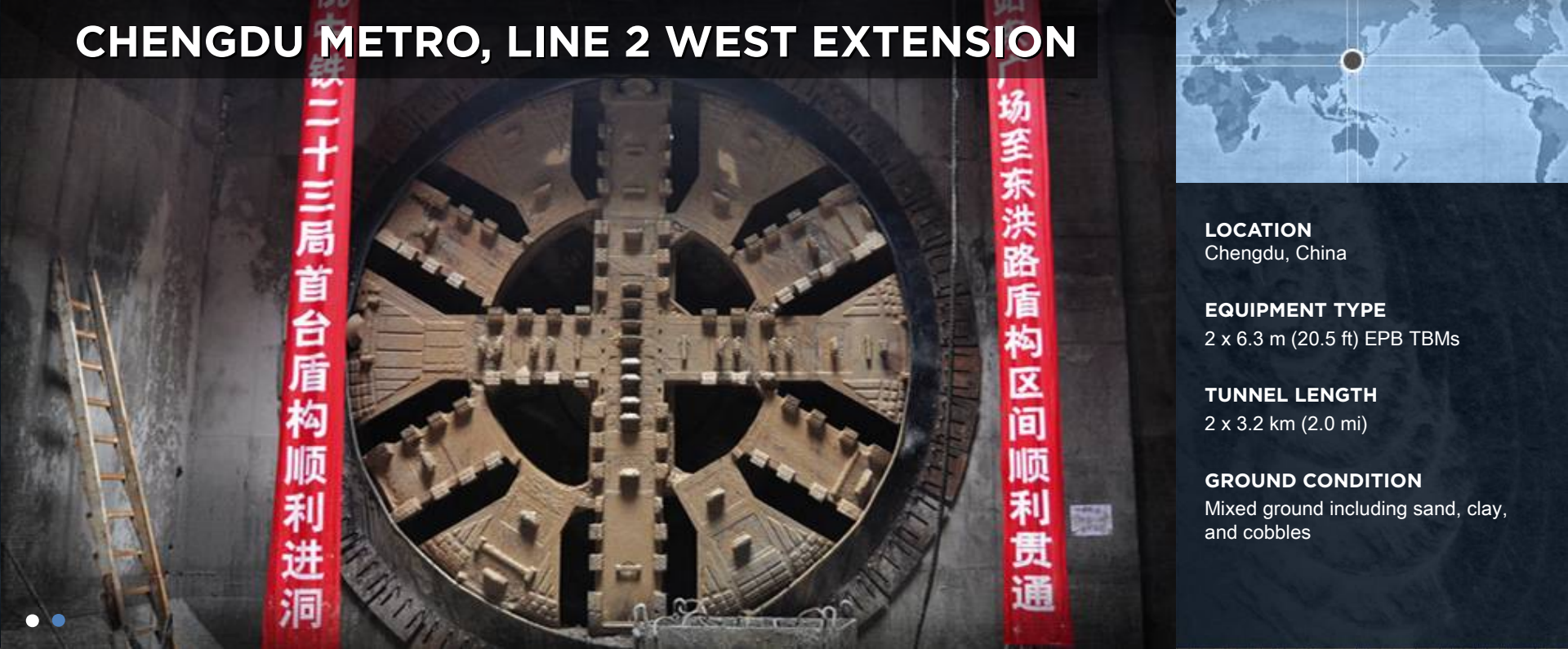
GROUND CONDITION

Mixed ground including clay, gravel, marble, and jointed rock

Hybrid TBM Assembled On-site for Indian Water Tunnel

- A Hybrid EPB TBM has been launched following Onsite First Time Assembly (OFTA)
- This is the first time the OFTA method has been used on a hybrid machine
- The TBM can operate as both an EPB and as a Single Shield TBM
- The Sleemanabad Carrier Canal will irrigate drought-prone Madhya Pradesh State

CHENGDU METRO, LINE 2 WEST EXTENSION



LOCATION

Chengdu, China

EQUIPMENT TYPE

2 x 6.3 m (20.5 ft) EPB TBMs

TUNNEL LENGTH

2 x 3.2 km (2.0 mi)

GROUND CONDITION

Mixed ground including sand, clay, and cobbles

The Next Evolution of Soft Ground Tunneling Debuts in Chengdu, China

- Two Robbins EPBs excavating parallel 3.2 km (2.0 mi) tunnels for metro line extension
- Machines equipped with newly designed features including modular VFD motors
- High-powered screw conveyors and safer man-locks optimize TBM performance

KUNMING METRO LINE 1



LOCATION

Kunming, China

EQUIPMENT TYPE

2 x 6.4 m (20.6 ft) EPB TBMs

TUNNEL LENGTH

2 x 1.5 km (0.9 mi)

GROUND CONDITION

Mixed ground including clay, silt, breccias, limestone, and pebbles

A Clear Solution for Mixed Ground Rail Tunnels in China

- Two Robbins EPBs with mixed face cutterheads broke ground in 2011
- Kunming, with a population of over three million people, has no rail transportation

XI'AN METRO LINE 1



LOCATION

Xi'an, China

EQUIPMENT TYPE

2 x 6.2 m (20.2 ft) EPB TBMs

TUNNEL LENGTH

2 x 2.9 km (1.8 mi)

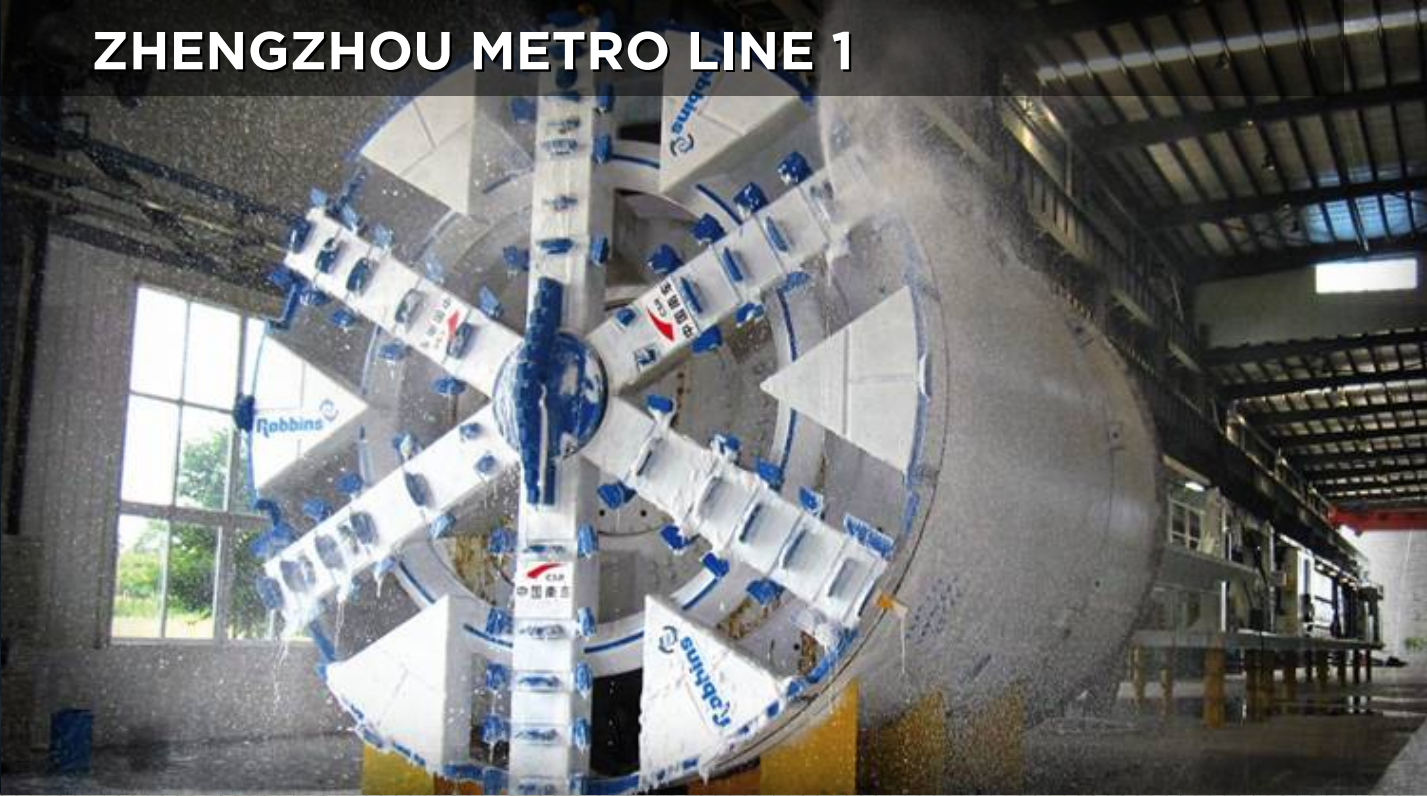
GROUND CONDITION

Sand, pebbles, and clay

Stemming Subsidence Using Soft Ground Tactics in Xi'an

- Crews have successfully negotiated permeable ground below one of China's most ancient cities
- A city ordinance was passed to limit settlement during tunneling to ± 15 mm (0.60 in)
- Little to no settlement has been detected below 12th century historic structures

ZHENGZHOU METRO LINE 1



LOCATION

Zhengzhou, China

EQUIPMENT TYPE

2 x 6.2 m (20.2 ft) EPB TBMs

TUNNEL LENGTH

2 x 3.6 km (2.2 mi)

GROUND CONDITION

Clay, fine sand, loess, pebbles

Record Rates in China's Soft Ground

- In September 2010, EPBs were launched to excavating 720 m (2,360 ft) in one month bore part of Zhengzhou's first metro line
- In 2011, a project record was achieved for

Small Boring Units



RESUMEN DE LOS MÉTODOS DE PERFORACIÓN DE TÚNELES DE SERVICIO.

- Perforación con Auger
 - Cabezas de corte convencionales
 - Unidad perforadora pequeña (SBU-A)
- Avance tubular
 - Escudo abierto con excavadora mecánica
 - SBU Motorizada (SBU-M)
 - Cabezal de roca de escudo sencillo (SBU-RHSS)
- Perforación de micro-túneles(MTBM)
- Perforación de túneles de escudo doble
 - Cabezal de roca de doble escudo Rockhead (SBU-RHDS)
 - Perforadora de túneles de doble escudo (SBU-DS)

PERFORACIÓN CON TORNILLO CON CABEZAS DE CORTE CONVENCIONALES



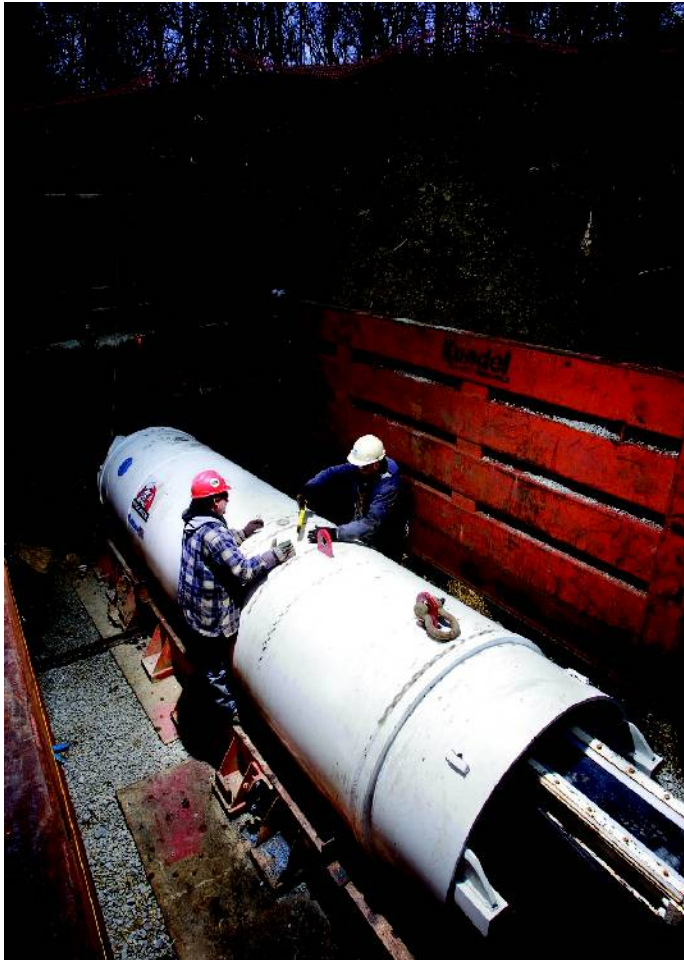
	Especificaciones SBU-A
Longitud	Perforaciones de 15 a 150 m
Diámetros	De 600 mm a 2.0 m
Carcasa	Acero
Tipos de cabezas de corte	Roca dura o suelo mixto
Geología	-Roca dura (De 28 a 175 MPa+) -Suelo mixto (aluvión con adoquines y bloques)
Condiciones del suelo	Seco (sobre nivel freático) y estable

AVANCE TUBULAR CON CABEZA DE CORTADORES DE DISCO (SBU-M)



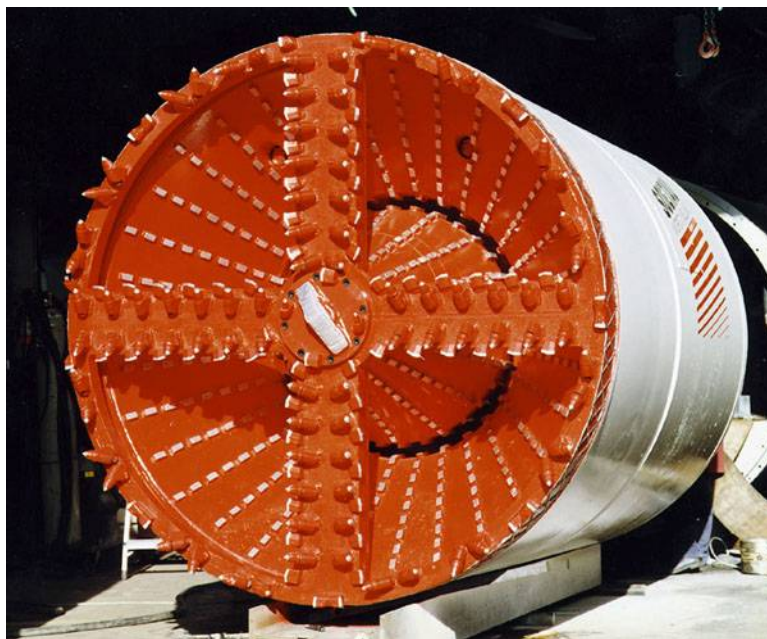
	Especificaciones de la SBU-M
Longitud	Perforaciones de 30 a 180 m
Diámetros	1.0 a 2.0 m
Carcasa	Acero
Tipos de cortadores	Roca dura o suelo mixto
Geología	-Roca dura (28 a 175 MPa+) -Suelo mixto
Condiciones del suelo	Seco (sobre el nivel freático) y estable

AVANCE TUBULAR CON LA ROCKHEAD



	Especificaciones de la Rockhead
Longitud	Horadaciones de hasta 600 m (RH-DS)
Diámetros	De 1.4 a 2.0 m
Carcasa	Acero o concreto reforzado
Tipos de modelos	Escudo sencillo (RH-SS) ó Escudo doble (RH-DS)
Tipos de cabezas de corte	Roca dura o suelo mixto
Geología	-Roca dura (de 28 a 250 MPa+) -Suelo mixto (Aluvión con Cantos y bloques)
Condiciones de suelo	En general arriba del nivel freático, en roca de estable a fracturada. Abajo del nivel freático en roca de baja permeabilidad

PERFORADORA DE MICRO TÚNELES (MTBM)



	Especificaciones de la MTBM
Longitud	Horadaciones largas (600+ m)
Diámetros	Ilimitado — 300 mm a 3 m
Carcasa	Cualquier tipo
Tipos de cabeza de corte	Suelo suave, Roca dura o Suelo mixto
Tipos de máquinas	Taladro, Lodo, o Tubo Piloto
Geología	-Suelo suave -Algunas condiciones de roca -Suelo mixto (Aluvión con adoquines pequeños y bloques)
Condiciones del suelo	Abajo o arriba del nivel freático, en suelo estable o inestable.

TBM (SBU-DS) DE PEQUEÑO DIÁMETRO Y DOBLE ESCUDO



	Especificaciones SBU-DS
Longitud	Perforaciones largas (hasta 6 km)
Diámetros	De 2.0 a 3.0 m
Carcasa	Cualquier tipo
Tipos de cabezas de corte	Roca dura o Suelo mixto
Geología	-Roca dura (De 28 a 300 MPa+) -Suelo mixto (Aluvión con adoquines y bloques)
Condiciones del suelo	Arriba o abajo del nivel freático y en roca estable o fracturada

