SLURRY, HYBRID AND LARGE TBMS

Levent Ozdemir
Tunneling Consultant
SLURRY SHIELD COMPONENTS

1. Tunnel face
2. Cutterhead
3. Slurry
4. Excavation chamber
5. Bulkhead
6. Feed line
7. Air bubble
8. Submerged wall
9. Working chamber
10. Slurry line
11. Grid
12. Segments
13. Tailskin
Face Pressure Control
Slurry Shield / Mixshield

Face pressure controlled by compressed air bubble
Face pressure controlled by slurry pumping rates.

Design Pressure
EPM and Slurry Shield Range

![Graph showing EPM and Slurry Shield Range for different sieve sizes and grain diameters]

- **Sieve Size**
  - Clay
  - Silt
  - Sand
  - Gravel

- **Grain diameter d (mm)**
- **Portion of grains < d in % of the total amount**
- **Sieve residue in weight %**

**Legend:***
- **EPB**
- **Slurry Shield**
SLURRY SHIELD TBM LAYOUT

- Slurry Circuit
- Slurry Treatment Plant
- Bentonite Mixing Plant
- Muck Discharge
- Compressed Air Plant
- Compressed Air Regulation
- Feed Line
- Discharge Line
CRUSHER TYPES

jaw crusher

roller crusher
Crusher Capacity (Grain Size)
Shield Dia. < 20ft: 20”
Shield Dia. 20ft – 33ft: 32”
Shield Dia. > 33ft: 47”
CUTTING TOOL CHANGES
CUTTING TOOL CHANGES UNDER ATMOSPHERIC PRESSURES

Access down into cutting arm spoke

Operator undertakes maintenance procedure's without the risk of having to work in the tunnel face

Back loading cutting tools
Non - Exposure Maintenance Solutions
“Atmospheric Cutterchange”

System for large diameter Mixshields with accessible cutter head structure
- First use in 1996 (Elbetunnel)
- Full face disc cutters 17” or 19”
- Full face for disc cutters and soft ground tools
- Individual tool condition and wear sensors
ATMOSPHERIC TOOL CHANGE at 12-bar PRESSURE
(Istanbul Strait Crossing Tunnel)
MANLOCKS FOR SLURY TBM INTERVENTIONS
Reasons for Chamber Interventions.

- Inspection of face conditions and mechanical equipment in the excavation chamber
- Maintenance / replacement of cutting tools and wear protection elements
- Maintenance or cleaning of other chamber installation
- Removal of natural or man made obstacles
- Repair of structural damage
Chamber Access, Types Of Interventions In Tunneling

- Compressed air 0-3.6 bar, up to 4.5 bar in exceptional cases, short duration
  - decompression in TBM airlock
  - state of the art,
  - coverage by rules and regulations

- Mixed gas for short duration up to 6.0 bar
  - decompression in TBM airlock

- Saturation for long term interventions above 4.5 bar
  - above ground hyperbaric habitat (crew transfer shuttle)
Types of Interventions

Compressed air intervention

Oxygen decompression
TYPES OF INTERVENTIONS

Mixed gas intervention

Submerged diving
FACE PRESSURES EXPERIENCED DURING EXCAVATION

- HERA HAMBURG, Mixshield, Ø 6.0m: 2.5 bar
- MÜLHEIM, Mixshield, Ø 6.9m: 3.5 bar
- GRAUHOLZ, Mixshield, Ø 11.6m: 7.5 bar
- SYDNEY, Mixshield, Ø 10.4m: 4.0 bar
- HAMBURG 4TH ELBTUNNEL, Mixshield, Ø 14.2m: 5.5 bar
- WESTERSCHELDE, Mixshield, Ø 11.4m: 7.5 bar
- HALLANDSAS, Mixshield, Ø 10.53m: 11.0 bar
- LAKE MEAD, Mixshield, Ø 7.18m: 14.0 bar
- ISTANBUL, Mixshield, Ø 13.71m: 11.0 bar

DIVERS ENGAGED
Face Pressure Lake Mead, Istanbul
CONVERTIBLE MACHINES

Open Mode

Conversion
• integrated
• modular

Closed Mode

Single Shield TBM

Slurry Shield

EPB Shield
Closed Mode – Slurry machine
- Submerged wall gate open
- Center belt and muck hopper retracted and sealed
- Slurry circuit and treatment plant in operation

Open Mode
- Submerged wall gate closed
- Center belt and muck hopper in forward position
- Closing / Mode change within 2 - 4 hours
LAKE MEAD HYBRID TBM
(ROCK/SLURRY MACHINE)

- Hybrid rock/slurry machine
- Open/Closed mode operation
- Designed for 17 bar pressure
- Excavation diameter 23.5ft
- Hyperbaric intervention at high pressure
CHANGE BETWEEN SLURRY SHIELD AND EPB
(Integrated concept)

- Slurry and EPB specific modules or subassemblies permanently installed
- Change of operation mode in the tunnel
- Chamber interventions for “activation” of mode specific equipment required
CHANGE BETWEEN SLURRY SHIELD AND EPB
(SOCATOP tunnel, France)

- Long tunnel (10km)
- Long single stretches within the alignment with clear preference for operation mode
- TBM size of 10m sufficient to install parallel systems
EPB Mode: Machine uses a screw conveyor to maintain face pressure and to remove muck

Slurry Mode: In slurry mode, muck empties into a enclosed slurry box where boulders are broken up using a crushing mechanism in the box and then fed into the slurry pipes.
Crossover XRE

- Mixed ground cutterhead: with disc cutters & soft ground tools or a combination of tools (interchangeable).
- Two-speed gearboxes: provide high torque at low RPM under soft ground conditions and high RPM under hard rock conditions.
- Cutterhead rotation: Single direction is more efficient in hard ground conditions and bi-directional is more efficient in soft ground to prevent roll.

Crossover XSE

- Equipped with both screw conveyor and slurry system for muck removal.
- Ground conditions: soft ground containing water under pressure (particularly for water pressures > 5 bar).
- The most universal of the Crossover machines, the XSE can bore in most types of ground.

Crossover XRS

- Highly adaptable to variable ground conditions; suitable for rock tunnels with water pressure > 5 bar.
- Hard rock machine with a rock cutterhead and slurry system in place.
- Capable of mining rock through high water pressure without grouting off water flows.
HERRENKNECHT “VARIABLE DENSITY” CONCEPT
(CHANGE BETWEEN SLURRY AND EPB MACHINE)

- Transformation between EPB face support and slurry face support in the tunnel without the need of modification or chamber intervention
- Full size and quality face support systems for EPB and slurry operation
- Safe and fully controlled conditions for face support during mode change
LARGE DIAMETER TUNNELS
LARGE DIAMETER TBMs over 14-m.
Tuen Mun-Chek Lap Kok Link  
Northern Connection Sub-sea Tunnel Section  
TBM Design and Operation

TBM S880
- 19” single disc cutter 117 Nos.
- 19” double disc cutter 6nos.
- Scrapers 200 nos.

TBM S882
- 19” single disc cutter 97 Nos.
- 19” double disc cutter 4 nos.
- Scrapers 114 nos.

- Slurry type TBM
- TBM fabrication was in both Germany and China by Herrenknecht AG.
- TBM S880 launched on 24 April 2015
- TBM S882 Launched on 12 June 2015
TELEMACH ROBOT
QUESTIONS ?