Lake Mead Intake No 3 Tunnel

Roberto Schuerch, ETH Zurich
Lake Mead Intake No 3 Tunnel

Hoover Dam (1934-1936)

Power, flood control, water storage, regulation, recreation
2015

highest water level

today's water level

Intake Nr. 1
Intake Nr. 2
Intake Nr. 3

2.7 m/Year

2015
Lake Mead Intake No 3 Tunnel

- **Shaft**
  - Length: 4.75 km
  - Diameter: 7.2 m

- **Tunnel**
  - Length: 4.75 km
  - Diameter: 7.2 m
  - Hydr. pressure ≤ 14 bar

- **Intake Structure**
  - Length: 1000 m

- **Metamorphic Rocks**

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Schuerch, R., 2015, *Lake Mead Intake No 3 Tunnel*
Lake Mead Intake No 3 Tunnel

Sedimentary rocks

Major hazard scenarios

Face instability

Contour lines of piezometric head

Seepage forces $f_s$
Major hazard scenarios

Face instability
Jamming of the shield
Unmanageable high water inflow

Lake Mead Intake No 3 Tunnel

hybrid TBM ø 7.22 m

Open mode:
Screw conveyor mounted

Closed mode:
Screw conveyor retracted
Mucking-out via hydraulic circuit
Face support by pressurized slurry
Aid to decision making – consulting tasks

Design phase (based upon excepted geological conditions):
- Tunneling operational plan (TOP)
- Tunneling condition assessment report (TCAR)

Excavation phase:
- Decision support during excavation
- Decision Tree (applies in case of deviations from the expected geological conditions)
- Analysis and interpretation of TBM data and of geological conditions
TOP – operational modes

Open mode (OM) excavation

Closed mode (CM) excavation at low (4.5 bar) high (4.5-10 bar) and very high support pressure (> 10 bar)

Auxiliary measures:
- Drainage boreholes
- Grouting

Experience of TBM tunneling
Tunnel advance

Station [ft]

Metamorphic rock: 53 m/month
Sedimentary rock: 192 m/month

Overall TBM utilization:
Netto advance / total time [-]

Overall 20%
Metamorphic rock 10%
Sedimentary rock 10%
TBM operation

Percentage of tunnel length [%]

- Open mode
- Closed mode

0% 25% 50% 75% 100%

Closed mode at low to high support pressure (< 10 bar)
Closed mode at very high support pressure (> 10 bar)

TBM operation

- Open mode
- Closed mode

0% 25% 50% 75% 100%

Closed mode at low to high support pressure (< 10 bar)
Closed mode at very high support pressure (> 10 bar)

Hallandsas
Shanghai
Nanjing
Weser
St Peterburg
Tokyo
Hamburg
Westerseide

Pressure [bar]
Encountered geological conditions

Percentage over the tunnel alignment [%]

0% 25% 50% 75% 100%

- Metamorphic rock
- Sedimentary rock
- Fault zones

Highly fractured rock mass

Metamorphic rock

Schuerch, R., 2015, Lake Mead Intake No 3 Tunnel
Highly fractured rock mass

Extremely high water inflow when lowering the support pressure

Metamorphic rock

Quantity of water inflow

Slurry pressure [bar]

372 m$^3$/hr

Maintenance works not possible (unmanageable amount of water)
Metamorphic rock

Highly fractured rock mass
Extremely high water inflow when lowering the support pressure
Maintenance works not possible (unmanageable amount of water)
Face inspection dangerous due to local instabilities (sudden rockfall)

Cutterhead repair in the metamorphic rock

Metal pieces of the cutterhead at the separation plant
Drop of the TBM penetration
Inspection/maintenance required
Cutterhead repair in the metamorphic rock

Metal pieces of the cutterhead at the separation plant
Drop of the TBM penetration
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→ 3 campaign of grouting

Cutterhead repair in the metamorphic rock

Metal pieces of the cutterhead at the separation plant
Drop of the TBM penetration
Inspection/maintenance required

→ 3 campaign of grouting

→ unsuccessful due to geometrical limitation of the drilling pattern (but enough to carry-out maintenance at the slurry lines)
Cutterhead repair in the metamorphic rock

CH repair in a isolated pegmatite block of sound rock
Cutterhead repair in the metamorphic rock

Niche excavation in front of the cutterhead (April 1, 2013 to April 12, 2013)
Cutterhead repair in the metamorphic rock

Station [ft]
Sedimentary rock

Clogging

Sedimentary rock

Clogging
Sedimentary rock

Clogging

Soil-like muck
Clogging

Soil-like muck

Mucking-out difficulties in open mode (for $Q > 25 \text{ m}^3/\text{h}$)

Repair of the cascade sealing system

Damage of the cascade sealing system (leakage between pressurized chambers) due to the unexpected length over which the TBM had to be operated at extremely high support pressure.
Repair of the cascade sealing system

Niche excavation in front of the CH

Forward push of the cutterhead for sealing substitution
Repair of the cascade sealing system

- 0 -100 m

Station [ft]

TBM-docking

17.12.2014
TBM-docking

Construction of the intake structure

Final TBM approach to the intake structure:
- Closed mode with full compensation of the hydrostatic pressure during breakthrough ("flooded shaft" principle)
- No advance exploration or grouting (risk of concrete cracking and/or blow-out)
TBM-docking

Excavation of the “soft-eye” (breakthrough)

TBM-parameters for breakthrough:
- Thrust force dependent on the advance in the soft-eye
- Small penetration (about 1.5 mm/rev)
- High rotational speed (3.5-4.5 rpm)
TBM-docking

Final position of the TBM
TBM-docking

Underwater inspection

Photo
TBM-docking

Lowering of the bulkhead and emptying of the intake chamber
TBM-docking

Thickness of the collapsed soft-eye 12 cm only!

Photo

The end
References


