TBM boring of the headrace tunnel at Nedre Røssåga HEP

TBM Application II

6. – 7. June 2016, Bergen

Dag Rindal Brox / Henrik Strøm
Content

- Røssåga HEP (HPP)
- Geology
- TBM boring
- Experience
Røssåga HEP

- Ownership: 100 % Statkraft Energi

- Øvre Røssåga
  - Annual production: 0,8 TWh (before rehabilitation and upgrading)

- Nedre Røssåga
  - Annual production: 1,7 TWh (before rehabilitation and upgrading)

- Annual total production 2,5 TWh
Røssåga HEP

- Øvre Røssåga uses the height of fall between Lake Røssvatnet and Lake Stormyrbassenget.

- Nedre Røssåga uses the height of fall between Lake Stormyrbassenget and the village of Korgen.

- Lake Røssvatnet has a reservoir capacity of 2.35 billion cubic metres and is Norway's second largest lake, based on surface area.
Røssåga HEP

- Before rehabilitation and upgrading:
  - Nedre Røssåga has six generating units with a total installed capacity of 250 MW

- After rehabilitation and upgrading:
  - In Nedre Røssåga, three of the generating units have been rehabilitated, and an additional unit of 225 MW will be built in a new cavern next to the existing power plants.
  - At the same time, three of the six existing units will be decommissioned, resulting in a net increase in capacity in Nedre Røssåga of 100 MW.
Røssåga HEP

- The total installed capacity of the two plants will be 510 MW after rehabilitation and upgrading.

- The rehabilitation of Øvre and Nedre Røssåga, which both have Francis turbines, will increase annual production by 300 GWh (100 + 200 GWh).

- Annual production from the new Røssåga (Øvre and Nedre) power plants of about 2.8 TWh.
Nedre Røssåga HEP

- Intake
- TBM area
- Power station area
- Adit to the hydro power station
TBM boring of the headrace tunnel at NR HEP

Nedre Røssåga HEP
Nedre Røssåga HEP
Overview station area
Geology

Tender Basis

Main rock types:
- mica schist / micaceous gneiss / greenschist
- limestone / marble
- granite / granodiorite
- quartzite
Geology

Tender Basis – rock quality

Tabell 1 og 2 angir antatt fordeling av typiske bergmasser og gjennomsnittlig sikring i de 4 klassene.

Tabell 1: Typiske bergmasser i de ulike bergkvaliteter og antatt fordeling i tilløpstunnel og avløpstunnel

<table>
<thead>
<tr>
<th>BERGKLASSE</th>
<th>ANTATT FORDELING</th>
<th>TYPISKE BERGMASSER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TILLØPS- OG</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AVLØPSTUNNEL</td>
<td></td>
</tr>
<tr>
<td>1. God til meget god</td>
<td>20 – 40 %</td>
<td>30 – 60 %</td>
</tr>
<tr>
<td>2. Middels til noe dårlig</td>
<td>30 – 70 %</td>
<td>10 – 40 %</td>
</tr>
<tr>
<td>3. Dårlig</td>
<td>10 – 30 %</td>
<td>5 – 15 %</td>
</tr>
</tbody>
</table>
| 4. Meget dårlig| 0 – 3 % | 0 – 1 % | Oppknuste bergmasser med eller uten leire, som i enkelte moderate leirsener og i store, komplekse knusningssoner.
Geology

The geological mapping after boring

- Large deviations from the tender basis in rock type
- Much less degree of fracturing
- Very high compressive strength (UCS) - up to 245 MPa
TBM boring

• The TBM
  • Open TBM (Robbins MB-263-308-2)
  • Diameter; 7.23 m
  • Machine thrust; 14,324 kN
  • Maximum Torque; 3,490 kNm at 8,3 RPM / 6,275 kNm at 4,62 RPM
  • Maximum stroke; 1,87 m
  • Cutterhead drive; Electric motors, hydraulic clutches, gear reducers
TBM boring

• Cutterhead power; 3.120 kW (8 * 315 kw + 2 * 300 kW)
• Cutters; 35 x 19-inch back-loading cutters + 8 x 17-inch Back-loading center cutters
• Cutterhead rotation speed 0 to 8.7 RPM
• Total TBM weight; 600 metric tons
• Total TBM length including back-Up System; 125 m
TBM boring
Prerequisites for the use of TBM

• Average production per hour; 3 m/h
• Boring time of total time; 40 %
• Production time per week; 144 h

It gives 170 m per week
TBM boring of the headrace tunnel at NR HEP

- **51 weeks total**
- **45 weeks boring**
- **6 weeks vacation**

**Replacement of main bearing:**
- **6 weeks and 1 shift**

**Comment:**
- **100 weeks total**

**Actual progress**

**Planned progress (170 m/week)**

**Total length (7.590 m)**
TBM boring
Really time-consuming overall time

• Boring; 30.5 %
• Regrip; 4.1 %
• Replacement of cutters; 14.0 %
• Various; 51.4 % *)

*) Repair, maintenance, installation (booster, convoys) etc
TBM boring

TBM utilization

- Planned boring time; 2,530 h
- Actual consumption boring time; 3,955 h
- Actual average production; 1,92 m/h
Experience

- The geological mapping must be on a different level than for drill and blast.
- The specification must be prepared for use of TBM - not adopted from drill and blast, which in this case.
- Will LNS use TBM again?
  - If the right premises are in place regarding contract
    - PERHAPS