Karavanke tunnels in permo-carboniferous rock

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Location
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Karavanke tunnels in perm-o-carboniferous rock
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Karavanke tunnels in permo-carboniferous rock
Geology

Upper carbon, shale, sandstone, quartz conglomerate, limestones

Top: Geologic prediction for railway base tunnel;
Bottom left: Geologic prediction for road base tunnel – first tube;
Bottom left: Geologic prediction for road base tunnel – second tube;

Mikoš (1991)
Geology

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Geology

Mikoš (1991)

Budkovič (1999)
Challenges to overcome

- High overburden → High primary stress
- Extremely weak permo-carboniferous rock
- Methane gas inflows

- 2nd tube of road base tunnel: Minimization of the effect on the first tunnel tube
Different methods facing the same challenges

Source: Geotechpedia

Railway base tunnel: Old Austrian Tunneling method
Railway base tunnel
Railway base tunnel

- Single tube – double track tunnel
- Excavation profile: cca. 120 m²
- Linning thickness: 1,5 m (invert) – 2,7 m (sidewalls)
- Excavation speed: 3-4,5 m/day
- Temporary support: up to 19 m³ of wood per m' (needed to be replaced up to 7 times)

52 ACCIDENTS WITH FATALITIES!
Different methods facing the same challenges

- **Railway base tunnel**: Old Austrian Tunneling method
- **Road base tunnel – 1st tube**: New Austrian Tunneling method

Source: UCMP, Berkley

Source: Geotechpedia
Road base tunnel – first tube

- Excavation profile: 90-110 m²
- Primary lining thickness: 15 cm – 25 cm
- Two or four longitudinal slots, with a width up to 50 cm
- Design over-excavation: 15-35 cm,
  - after the extreme squeezing in the Mlinca fault, overexcavation was changed up to 1,0 m.
- Excavation speed: 2-4,5 m/day
- Inner lining thickness: 25 – 45 cm

- The construction of the tunnel ended without fatalities.
Road base tunnel – first tube

<table>
<thead>
<tr>
<th>Depth (mm)</th>
<th>1200</th>
<th>900</th>
<th>600</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>120</td>
<td>90</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>H2</td>
<td>150</td>
<td>120</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

**Graph: Hoek (2001)**

- Strain greater than 10%: Extreme squeezing problems
- Strain between 5% and 10%: Very severe squeezing problems
- Strain between 2.5% and 5%: Severe squeezing problems
- Strain between 1% and 2.5%: Minor squeezing problems
- Strain less than 1%: Few support problems

**Equation:** $\sigma_{cm}/\rho_0 = \text{rock mass strength} / \text{in situ stress}$
Road base tunnel – first tube
Road base tunnel – first tube
Different methods facing the same challenges

Railway base tunnel: Old Austrian Tunneling method

Road base tunnel – 1st tube: New Austrian Tunneling method

Road base tunnel – 2nd tube: New Austrian Tunneling method + stress controllers

Sources:
- UCMP, Berkley
- Geotechpedia
- DSI
Road base tunnel – second tube

- Excavation profile: 120 m² – 180 m²
- Distance between 1st and 2nd tube: 70 m
- Installation of deformable lining:
  - 2 - 6 symmetrically installed stress controllers in top heading (fy = 8 MPa, umax=24 cm)
- Extensive bolting (also in invert): L = 6 – 12 m
- Round length in top heading: 0,85 - 1,3 m
Road base tunnel – second tube

- Distance between top heading face and invert closure: Max. 40 m
- Face stability:
  - Spiling: L = 5 – 6 m
  - Face dowels: 4 – 14, L = 15 m
- Pre-drilling and constant monitoring of methane concentration level
Road base tunnel – second tube

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Time schedule - comparison

Railway tunnel:
- 1425 days
- 3500 workers

Road tunnel (1st):
- 1021 days
- 210 workers

Road tunnel (2nd):
- 1195 days
- ? workers

Mikoš (1991)
Conclusion

- At this time preliminary design is „under the roof“
- Recently calls for tenders were released:
  - Geological investigation
  - Building permit design + execution design
- Additional mechanical and geomechanical investigations are required:
  - 3D stress state
  - Small strain stiffness
  - Stress state and strength of secondary lining – 1st tunnel tube
Thank you!