The Austrian Koralmb tunnel -
Investigation, Design and
Construction Process for a large
Base Tunnel Project

Gerhard Harer
ÖBB – Austrian Federal Railways
gerhard.harer@oebb.at
Project overview

Koralm railway as a part of the Baltic – Adriatic Corridor

- Double-track line, electrified
- 127 km overall length (at present 228 km overall length)
- Max. travel speed 250 km/h
- Travel time Graz – Klagenfurt 55’ (at present 2 – 3 h)
- At present rd. 63% in operation or under construction

- Expected fright volume 24 mill. tons per year
- Expected 15,000 passengers per day
Koralm tunnel – key data
Koralm tunnel - key data

- Koralmtunnel length 32,9 km
- Start of design and exploration 1998
- Start of excavation works 2010
- Expected completion of civil engineering works 2019
- Final operation 2023
- Target costs for Koralm railway 5.400 mill. EUR
  (for Koralm tunnel 2.100 mill. EUR)
Koralm tunnel - key data

- Tunnel system: twin-tube – single-track tunnel
- Tunnel Øi: 7.90 m
- Max. overburden 1.200 m
Compliance with regulations
Escape and rescue system
- Self rescue
- Simplicity in ventilation
Elimination of crossovers & switches
- Safer operation
- Simplicity in ventilation
- Less maintenance

Omittance of fire fighting water system & conventional signalling
- Only ETCS
- Less maintenance

Only one emergency halt
- Less maintenance
Koralm tunnel – investigation process

- Project phases
- Requirements
- Strategy
Koralm tunnel – investigation process

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Desk studies</th>
<th>Aerial &amp; satellite data interpret.</th>
<th>Mapping</th>
<th>Drilling</th>
<th>Geophysical survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project phase</td>
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<tr>
<td>Feasibility study</td>
<td></td>
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<td>1:25.000/1:10.000</td>
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<td>Route pre selection</td>
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<td>1:10.000</td>
<td></td>
<td></td>
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<tr>
<td>Route selection &amp; environmental impact assessment</td>
<td>1:5000</td>
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<tr>
<td>Detailed &amp; tender design</td>
<td>1:5.000/1:1.000</td>
<td>1:5.000/1:1.000</td>
<td></td>
<td></td>
<td>Σ 21.000 lfm</td>
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</tbody>
</table>

Σ 21.000 lfm

25.10.2012
Koralm tunnel – investigation strategy

- Stepwise investigation campaigns – „from coarse to fine“
- Investigations composed of:
  - Satellite- and aerial data interpretation
  - Approx. 300 km² of engineering geological mapping
  - 133 core drillings, overall length 21,000 m
  - Approx. 4,000 springs, wells, creeks under observation
  - Geophysical surveys from surface and in boreholes
  - Investigation tunnel system with 10 km length in total

- Special attention was paid to:
  - Structured processes
  - 3-dimensional compilation of the geological model
  - Advancement of methods
  - Diversity of methods
  - High quality of work
  - GIS-based data management
Koralmtunnel – integration of investigation data
Koralm tunnel – geological conditions

- Crystalline basement
- Tertiary sediments

Investigation tunnels

32.9 km
Koralm tunnel – geological conditions
Koralm tunnel – present status of works

<table>
<thead>
<tr>
<th>Baulos</th>
<th>Zeitraum</th>
<th>Vortriebsmeter gesamt</th>
<th>Fortschritt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigationstunnel Paierdorf</td>
<td>2004-2010</td>
<td>5.616 m</td>
<td>finished</td>
</tr>
<tr>
<td>Investigationstunnel Mitterpichling</td>
<td>2004-2007</td>
<td>2.516 m</td>
<td>finished</td>
</tr>
<tr>
<td>Investigationstunnel Leibenfeld</td>
<td>2005-2007</td>
<td>2.226 m</td>
<td>finished</td>
</tr>
<tr>
<td>KAT1</td>
<td>12/2008-4/2013</td>
<td>4.825 m</td>
<td>excavation works finished</td>
</tr>
<tr>
<td>KAT2</td>
<td>1/2011-3/2019</td>
<td>39.928 m</td>
<td>at present 4.375 m excavated</td>
</tr>
<tr>
<td>Ventilation shaft Paierdorf</td>
<td>1/2012-12/2012</td>
<td></td>
<td>under progress</td>
</tr>
<tr>
<td>KAT3</td>
<td>11/2013-6/2020</td>
<td>23.397 m</td>
<td>tender process</td>
</tr>
</tbody>
</table>
Suitable site organization is essential for flexible response, particularly in case of changing behavior!
Koralm tunnel – site organization

Owner / Client

Contractor

Tunneling expert

Site Management

Site Supervision

Designer/ Experts

- Geotechnics
- Geology
- Hydrology
- Structure
- Objects
- ...

- Geotechnical Engineer
- Engineering Geological Documentation
- Geotechnical Monitoring
Koralm tunnel – site organization – regular behavior

**Design check**

**Owner / Client**
- Decision making process (consensually ⇒ no dispute!)

**Designer/ Experts**
- Geotechnics
- Geology
- Hydrology
- Structure
- Objects
- ...

**Contractor**
- Site Management
- Site Supervision

**Information exchange**
- Daily evaluation of geological & geotechnical conditions of excavation
  - Daily geotech. report

**Daily evaluation**
- Information exchange
- Design check

**Geotechnical Monitoring**

**Tunneling expert**
Koralm tunnel – present status of works

Koralm tunnel – investigation tunnels

12.2003 beginning of construction

• 2003-2004 Investigation shaft Paierdorf
• 2004-2007 Investigation tunnel Mitterpichling
• 2005-2010 Investigation tunnel Paierdorf
• 2005-2007 Investigation tunnel Leibenfeld
Koralm tunnel – present status of works

Lot KAT1
Koralm tunnel – present status of works

Lot KAT2 – site installation

25.10.2012
Koralm tunnel – present status of works

Lot KAT2 – site installation

6 months after beginning
Koralm tunnel – present status of works

Lot KAT2 – site installation

15 months after beginning
Koralm tunnel – present status of works

Material management
KAT2

Total excavation
8,6 Mio. to

Concrete
1,5 Mio. to

Open sections
2,9 Mio. to

Dumping
3,0 Mio. to

Removal
1,2 Mio. to (by railway)
Koralm tunnel – present status of works

Segment production KAT2

- Ring
  - Width 1,90 m
  - Segmentation 6+0 (+ invert element)
  - Outer diameter 9,5 m
  - Thickness 35 cm

- Production
  - Number of segments 103,500 pcs.
  - Number of invert elements 17,250 pcs.
  - Unit weight per ring 47,5 t
  - Unit weight invert element 13,4 t
Koralm tunnel – present status of works

Some impressions KAT2
Koralm tunnel – present status of works

Some impressions KAT2
Koralm tunnel – present status of works

Tunnel boring machine
Koralm tunnel – present status of works

Tunnel boring machine
Koralm tunnel – present status of works

Tunnel boring machine - installation
The portion of investigation with respect of the budget of time and costs for large tunnel projects must not be neglected.

- Therefore from the very early stages of planning a strategy of a stepwise investigation has to be executed.

- All investigations have to be performed under high quality standards.
- The knowledge obtained by this stepwise investigation procedure has to be summarised in an expert system, e.g. by means of GIS.
Conclusion - design and investigation

The benefits of the performed stepwise investigation strategy and design process are clearly evident and enabled us at the Koralm tunnel to reduce risks and save significantly time and money.
Conclusion – site organization

Essential aspects for **site organization** are:

- Clear responsibilities of all project members
- Competent staff on site at all times (contractor and owner)
- Efficient decision making allowing for a flexible response
Muchas gracias por su atención!