Maintenance of railway tunnels in Finland

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25.9.2014
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In 2014:

one of the biggest infrastructure construction companies

- VR Track is Finland’s biggest track builder and among the biggest infrastructure builders and engineers
- The expertise covers the entire life span of infrastructure engineering – from design to project implementation and maintenance
Consulting

- Rail network, bridges
- Signalling, power equipment
- Geotechnics, tunnels, rock engineering
- Surveying services
- Risk management
- Private rails
1. VR Track Oy

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Finnish Rail Network

- Length of line  5 944 km
- **Single track**  5 371 km
- Electrified line  3 172 km
- Points  5 547
- Rail traffic operating points  349
- **Tunnels**  42

Tunnels categorized by length:
- **< 500 m**: 27, total 6 467 m
- **500 -2000 m**: 11, total 9 357 m
- **> 2000 m**: 4, total 23 072 m

- Total length of tunnels 38 896 m
- Shortest tunnel 26 m (Paksuniemi)
- Longest tunnel 13 575 m (Savio)
Railway tunnels in Finland

All tunnels are in hard rock

- "Drill and blast" as construction method
- Grouting as control for water ingress
- Bolting and shotcrete as main rock support
- In two tunnels there is a concrete culvert section due to the rock quality
- In 19 tunnels there are water and frost insulation structures made from PE-sheets
- In two tunnels the PE-sheet has shotcrete as structural protection
Tunnel structures and lining types
Technical systems and installations
Technical installations in new tunnels

- Handrail
- Cable shelf
- Smoke extraction fans
- Jet fans
- Electrical mains centers
- Transformers “rail”
- Transformers “civil”
- Smoke screens
- Fire hydrants (dry system)
- Emergency phone
- CCTV-system in selected locations
- Lighting in selected locations
- Pumping stations
- Fibre optic fire detection
- Earthing “separators” for rescue services
- Leaking cable for GSM-R

Tunnel maintenance has to deal with more and more complex systems.
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Tunnel inspections

- Challenges in the management of tunnels
  - “Tunnel register” for collecting the information
    - All inspections are not reported to the register
    - No numerical values for findings
    - No total condition evaluation tools based on findings
  
  - Yearly report on the development of tunnels
    - Always includes a list of worst tunnels
    - Always a recommendation for what should be done
    - But the budget to carry out works...

- Inspections are made with “different eyes”

- Liikennevirasto has published new guideline in 2014
  - ”A Study to Develop Methods for Structural Analysis of Tunnels and Rock Cuttings”
  - First training course specially for tunnel inspectors was held by the FTA in 2014
Tunnel inspections

- Normal walk-in inspections
  - Four times during the year, included in the maintenance contract
  - Visual inspection only

- Detailed yearly inspections
  - Once in a year, included in the maintenance contract
  - A tunnel expert responsible for the inspection
  - Visual inspection and also hammering as inspection tools

- Detailed main inspections
  - Every seven years, not included in the maintenance contract
  - All structures and installations are inspected by all necessary experts
  - Visual inspection, Hammering, Ultrasound, Ground penetration radar, Continuous measurements (displacement, convergence,...), Laser scanning
Laser Scanning in Tunnel Inspections

Can be used in all tunnels

- Rail
- Road
- Metro

Possibilities

- Inventory of tunnel structures
- Clearance analysis
- Analysis of the tunnel structures
- Commissioning of new structures
- Documentation of "as built" information
Laser Scanning in Tunnel Inspections

Findings are marked directly on the data
- In the office
- In a tunnel during a walk in inspection

All findings have information of
- Location
- Area
- Circumference/Length

In the future, also
- Criticality
- Damage class
Laser Scanning in Tunnel Inspections

- Example of results from comparison of cumulative damages in lining structure in different inspections along the tunnel length.
- A good tool for analyzing problematic areas.
“On-line” maintenance handbook

Structures
- Laser scanning (every 5-10 years)
- Yearly inspections
- Walk in inspections (four times/year)

Technical systems
- Maintenance handbooks of various systems
- Inspections based on these handbooks

Update of tunnel information in the database always after the inspection

Maintenance database
- Tunnel and track
- Technical installations
- Clearance points
- Safety points
  
  Tunnel condition value (numerical)

FTA’s database
“On-line” maintenance handbook
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Maintenance of Railway Tunnels in Finland

Basic maintenance
- Normal maintenance of tunnel structures and technical installations
- Make sure that everything is in operational and safe condition
- In the future this should be based on a maintenance guidelines of the tunnel

Basic repair
- Repair or change of broken structures

Upgrading
- Significant changes of tunnel structures or installations (i.e. widening of cross section, building of new exit routes, installation of new safety systems)
Common problems in railway tunnels
Common problems in railway tunnels
Maintenance of Railway Tunnels in Finland

- Majority of tunnels are on main track sections with heavy traffic
- 98% of the tunnels are on single track line sections
  - Always logistical challenges during works
- Tunnel maintenance is done in short time slots

20.00 00.00 06.00 09.00
Maintenance of Railway Tunnels in Finland

Basic maintenance works typically include
- Local hammering of lose shotcrete
- Local repair of lining structures
- Ice removal
- Installation of local water control systems
- Cleaning of drainage systems
Maintenance of Railway Tunnels in Finland

Repair works typically include
- Larger repair of lining structures
- Grouting
- Bolting
- Shotcreting
- Renewal of drainage systems
- New electrical systems
Case: Water and frost insulation lining in 500 m tunnel between Helsinki and Turku

- Structure breaks due to
  - pressure loads from traffic
  - Ice formation behind the lining
- Maintenance has used several different methods for local repairs
Case: Water and frost insulation lining in 500 m tunnel between Helsinki and Turku

- Laser scanning in autumn and in winter time
- Comparison of point clouds
- Location of deformations between scannings
Case: Water and frost insulation structures in 500 m tunnel between Helsinki and Turku

- During summer 2009 there was a one week total break in traffic
- It was not possible to repair the whole tunnel, so one location with most critical damages was repaired
- Chosen method was the installation of a new membrane structure on top of the old lining
Tunnel maintenance

Special problems relating tunnel maintenance in Savio tunnel
• A long (13 575 m) tunnel with permanent 100 % humidity for long stretch of the tunnel
• Affects on all tunnel installations
• After two years almost all smaller electrical centers are replaced
• Almost all technical systems have problems
• A high rate of rail corrosion is visible
• There are also damages in the catenary system

In future there will be challenges on the Ring Rail Line
• Problems with glycol infested ground water – bacteria growth in the tunnel
• Special structures designed on infected areas
• Will require more frequent inspection and maintenance
Conclusions

Challenges in the future for the tunnel maintenance are

• New technical equipment in tunnels
• Homogenity of the inspection data
• Effective use of the inspection data
• Short time frames for the maintenance works
Tack för intresse

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