

16<sup>TH</sup> INTERNATIONAL CONFERENCE

# UNDERGROUND CONSTRUCTION PRAGUE 2026

MAY 25–27, 2026 | CLARION CONGRESS HOTEL PRAGUE



## Aspects concerning the real operational availability of long railway tunnels

**Gerhard HARER**

ÖBB Infrastruktur AG, Vienna, Austria



# Why do we really build railway tunnels?



That's why, ..



that's why, ..



or that's why?

- The **main goal of railway tunnels** is to provide reliable and predictable **availability** to support train operations.
- **Operational performance** is the critical measure of tunnel **success**, not just construction metrics.
- Therefore, **design decisions** should be made based on their contribution to the long-term **quality** of rail transport.

# Specific characteristics of railway tunnels

- High positional stability and long-term durability are mandatory.
  - Railway systems are complex and subject to very high safety requirements.
  - Access in most cases is only possible via the track.
  - Health and safety regulations usually exclude parallel train operation and maintenance.
- Consequently, almost every **intervention directly restricts railway operations.**
- Maintenance therefore is inherently in conflict with traffic capacity and economic efficiency.
- **Long tunnels amplify all these effects.**



Ref.: orfat



## From construction focus to life-cycle optimized infrastructure

### Operational Availability Importance

- Operational availability is the key performance indicator for railway tunnels, impacting capacity and reliability.

### Lifecycle Cost and Risk Awareness

- Most costs and risks arise post-commissioning, emphasizing long-term maintenance and renewal.

### Operator Perspective on Infrastructure

- The view from operators highlights experience with tunnel performance (and related costs and risks) over time.

### Shift from Construction to Operation

- Focus shifts from construction milestones to ensuring reliable tunnel operation over decades.



# Why long tunnels change the rules

## Complexity of Long Tunnels

- Lengthy access, complex logistics and high safety requirements result in substantial non-productive time, making interventions in long tunnels more costly and highly disruptive to operations.

## Impact of Maintenance

- Maintenance works and windows reduce network capacity, and minor works can affect the entire railway system's operation.

## Design Principles

- Minimal necessary technical equipment and robust, tunnel-proven systems with remote monitoring ensure high availability.
- **As much as necessary – as little as possible!**



# Avoid – Shift – Improve (ASI)

## Example Koralm tunnel

For this reason, investigations were carried out on existing tunnels for the Koralm Tunnel Project as early as the early 2000s in order to find out which components are the "maintenance drivers".

- Non-essential equipment was eliminated. Systems were moved out of the driving tubes or changed into systems with less maintenance. Design features were adapted.

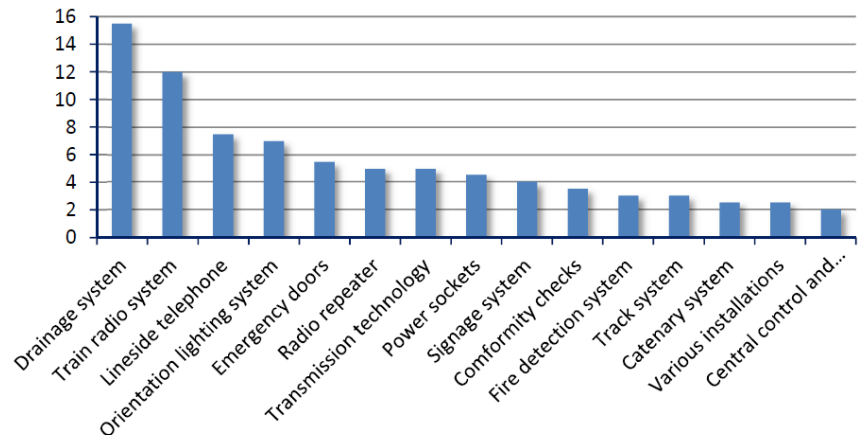


Fig.: Average percentage of inspection cleaning and maintenance works for various installations in Austrian railway tunnels (Ref.: Harer, 2008)



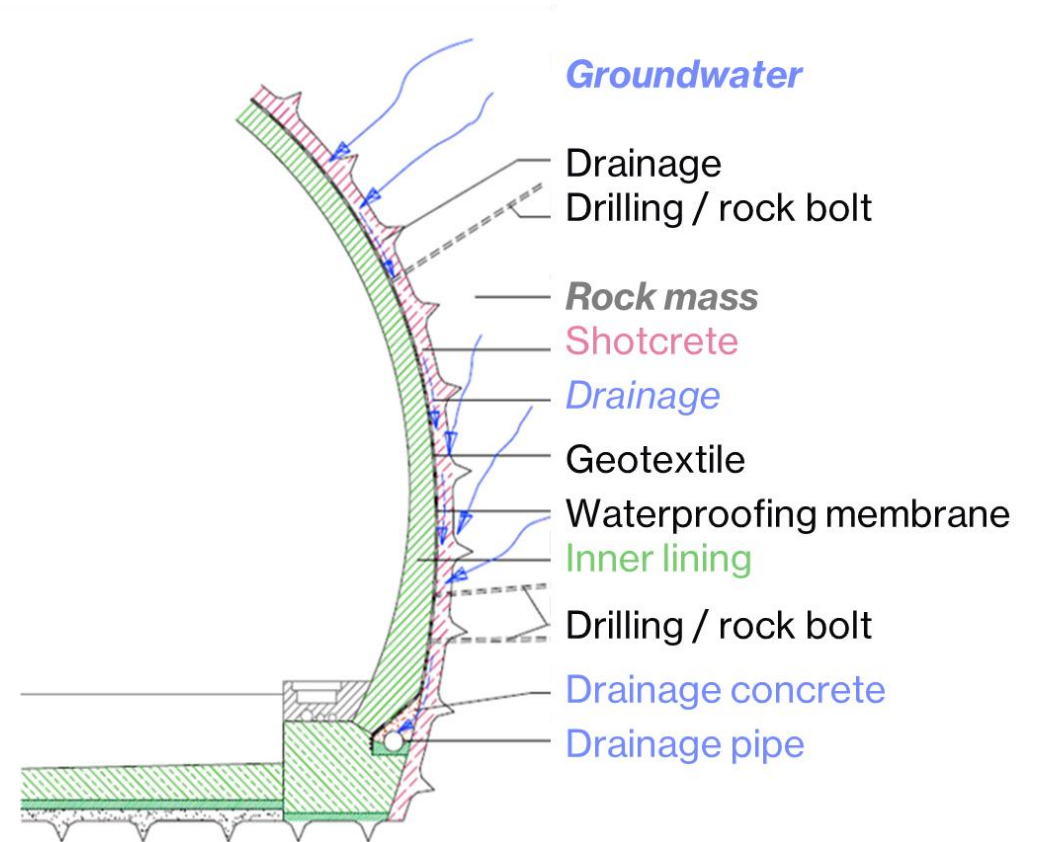
# Example: the effect of sintering



Sintering is a constant companion in the tunnel

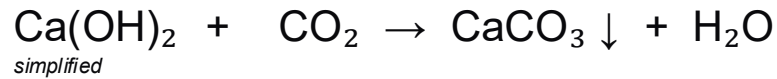


Fig.: Sinter formations in a drainage shaft inside the Gotthard Base Tunnel and heavily sintered pipe (Source: Harer)



# Example: the effect of sintering

## Sinter mechanism

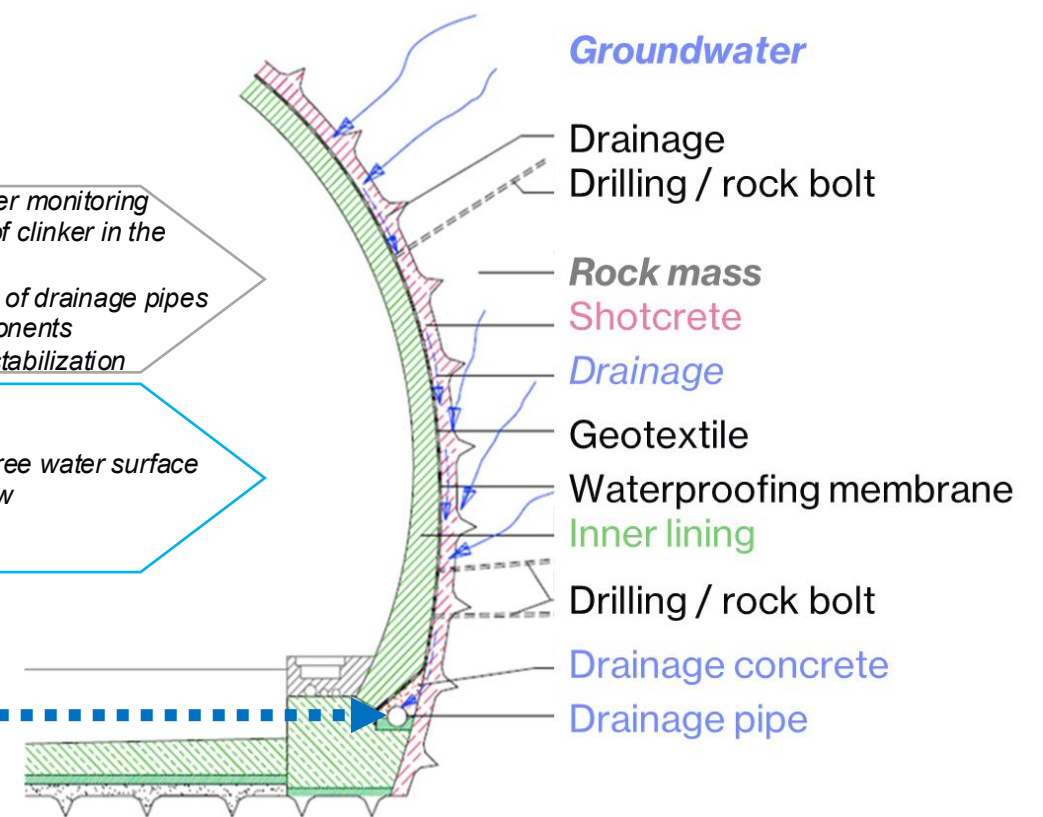
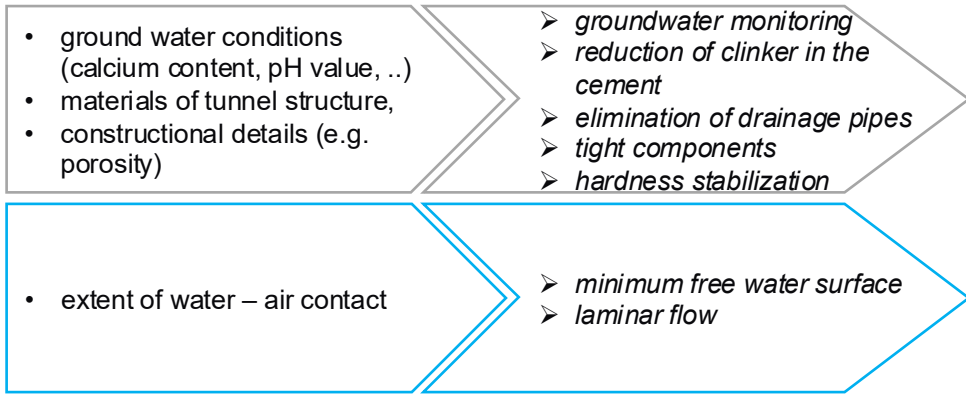


Rock,  
concrete,  
mortar, ..

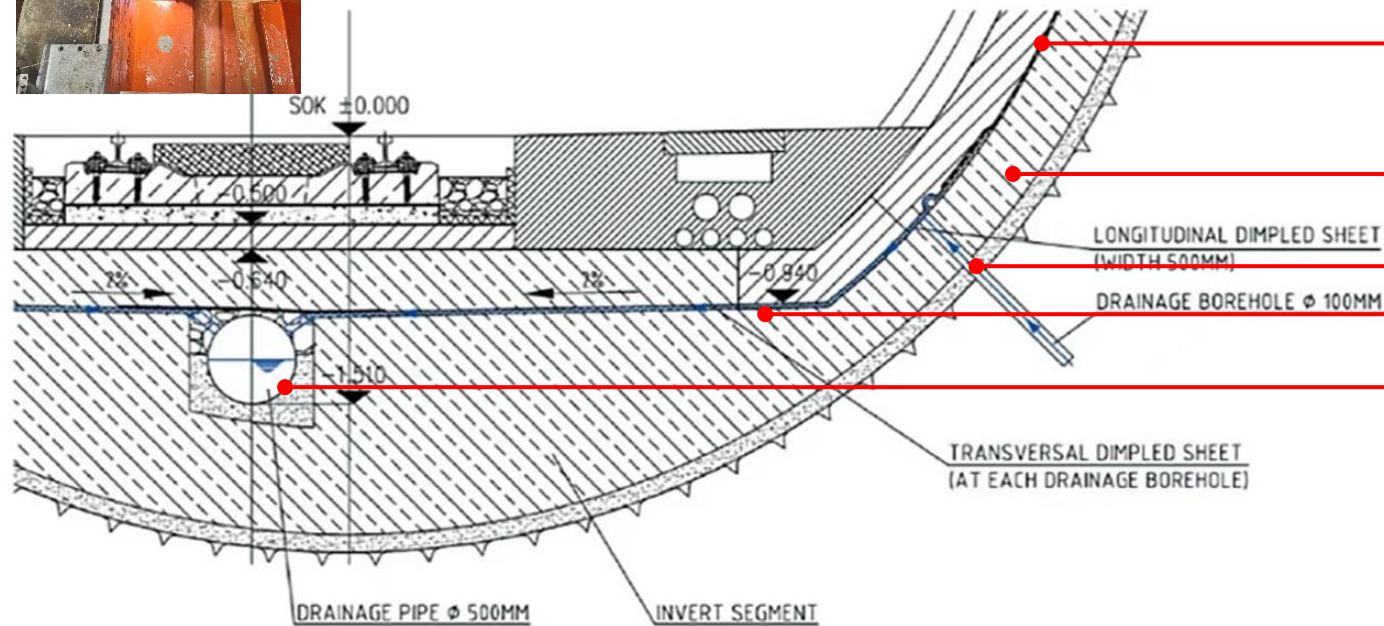
- Resolved Calcium

Air

Sintering



## Example: “Solution Koralm tunnel”



Automated monitoring and possibility of dosed addition of hardness stabilization

Segmental lining and/or modified shotcrete

Elimination of drainage

Water-filled dimpled sheet

Laminar Flow

Use of new, robotic-assisted drain jetting machines

Fig.: Optimized invert structure (Ref.: ÖBB)



# Example: Brenner Base Tunnel

## Conversion from exploratory adit to service tunnel

- Originally planned as an exploratory adit.
- Re-purposed as a service tunnel after extensive investigations.

## Functions today

- Access and logistics for construction and operation.
- Accommodation of utilities and railway technical systems.

## Benefits

- Significantly reduced need for rail-bound access.
- Substantial increase in railway operational availability.

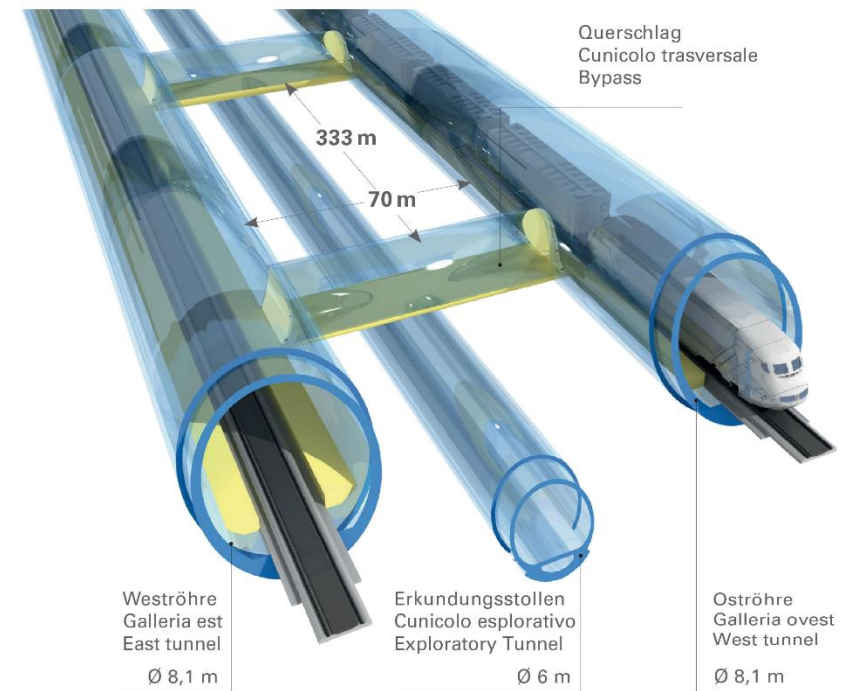


Fig.: BBT Tunnel system (Ref.: BBT SE)

# Example: Slab track

## Why slab track in tunnels?

- Comparable performance to ballasted track.
- Comparable inspection intervals to ballasted track.

## Key advantages

- No regular tamping or re-alignment required.
  - ~ 1/3 longer service life compared to ballasted track.
  - Significant aerodynamic benefits at high speeds.
  - Lower energy consumption.
- Fewer availability-impacting interventions in tunnels.
- Operational and life-cycle cost benefits exist, though their **systematic quantification remains challenging**.



Fig.: Slab track construction Semmering Base Tunnel

# Conclusion

## **Operational availability defines the real success of long railway tunnels.**

- In long railway tunnels, availability is driven less by construction performance than by system design, technical details and maintenance concepts.
- Railway-technical systems can significantly reduce availability, causing frequent possessions, high maintenance effort and substantial life-cycle costs – and thus, undermining the economic efficiency of the railway system.
- The key challenge for planners: availability-oriented design requires continuous optimization and close cooperation with operations and maintenance experts.
- Optimizations are continuously possible – and necessary, even in advanced project stages.

➤ **The tension is there: build cheaper vs. save money over the life cycle**



Betriebsfahrt

4746 137-0

OBB

SIEMENS

4746 137

Thank you very much!