



Challenges in the Remediation of the Glatschera-Railway-Tunnel, Bergün, Switzerland

Zilina, 11. November 2015



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1. Introduction

- client: Rhaetian Railway (RhB)
 - Switzerland's largest railway operator for routes throughout the Alps
 - 384 km of railway lines, 103 stops, 606 bridges
 - 115 tunnels with a total length of about 60 km
 - Since 2008 the Albula- and Berninalines belong to UNESCO World Heritage



2. Project overview and challenges

Glatscherastunnel

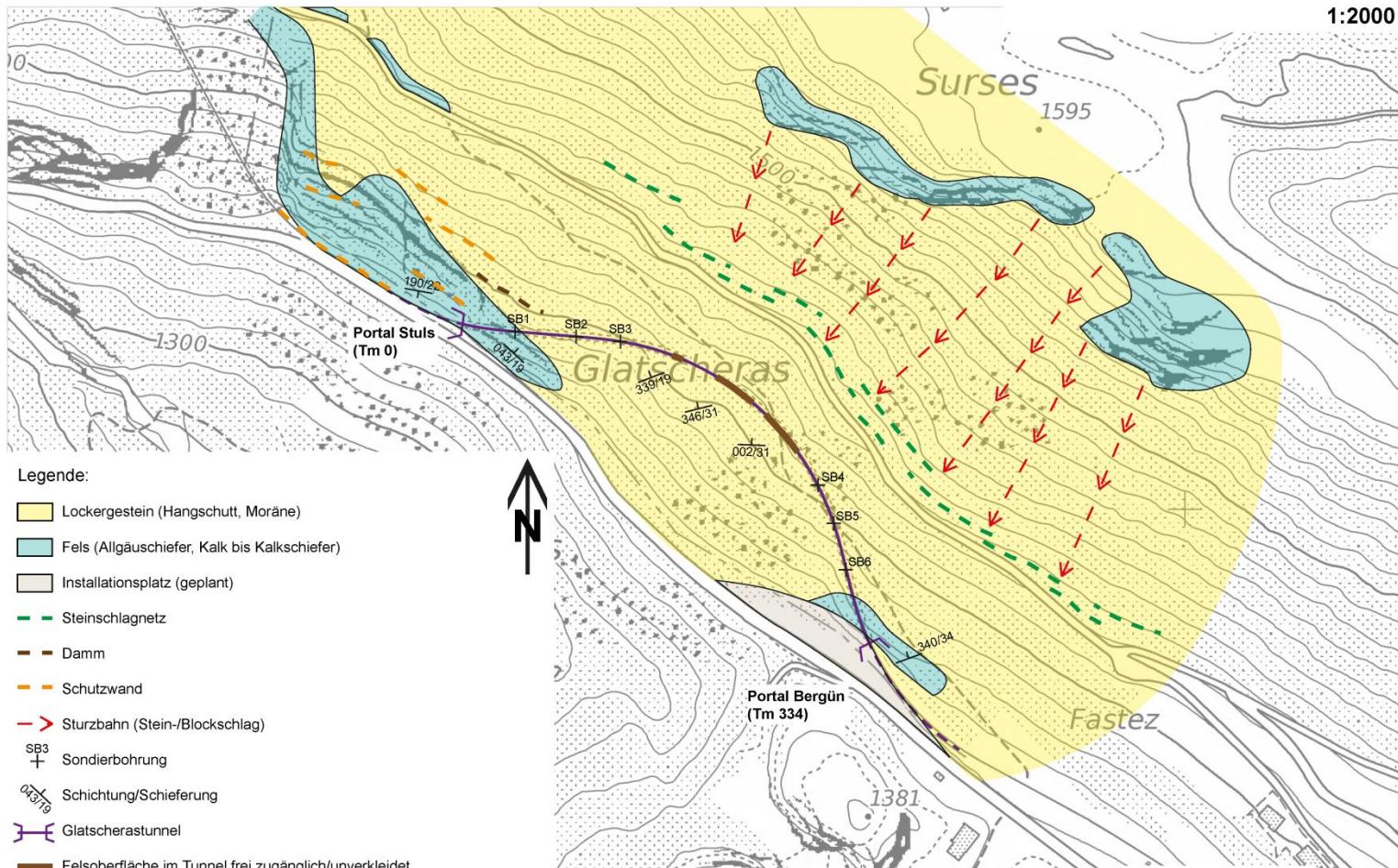
- Tunnel length: 334 m
- Single-lane metre gauge
- Part of the famous Albula Railway Line (UNESCO)
- 1,350 m above sea level
- Former Construction time: 1903 / 1904 → 144 days (drill & blast)
- Present Construction time: Sep. 2014 – Nov. 2016 (night shift; winter)
- 275 m natural stone masonry (incl. two portals), 59 m unsupported rock
- Strongly bended railway line ($R_{min} = 108 \text{ m}$)
- Track bed is made up of ballast
- **Remediation: First prototype of a new refurbishment-concept !!!**



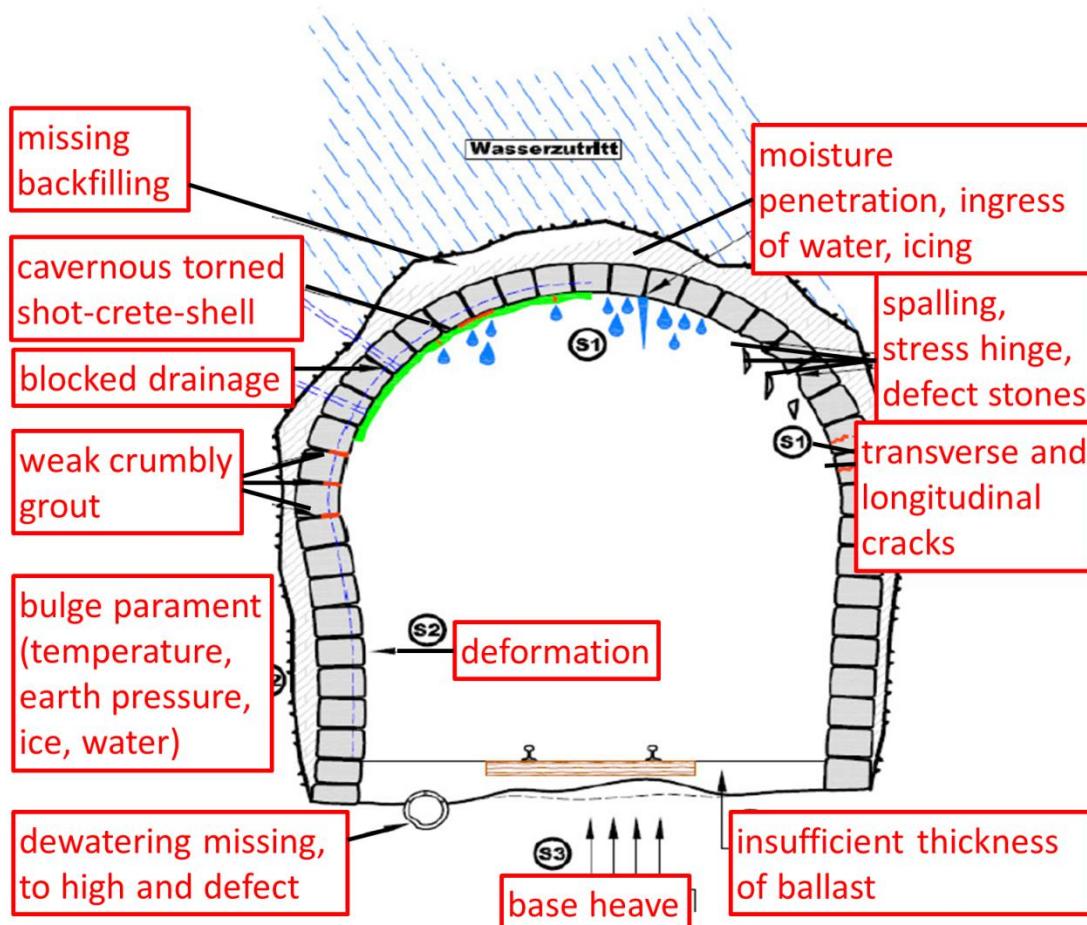
Bergün

2. Project overview and challenges

Glatscherastunnel

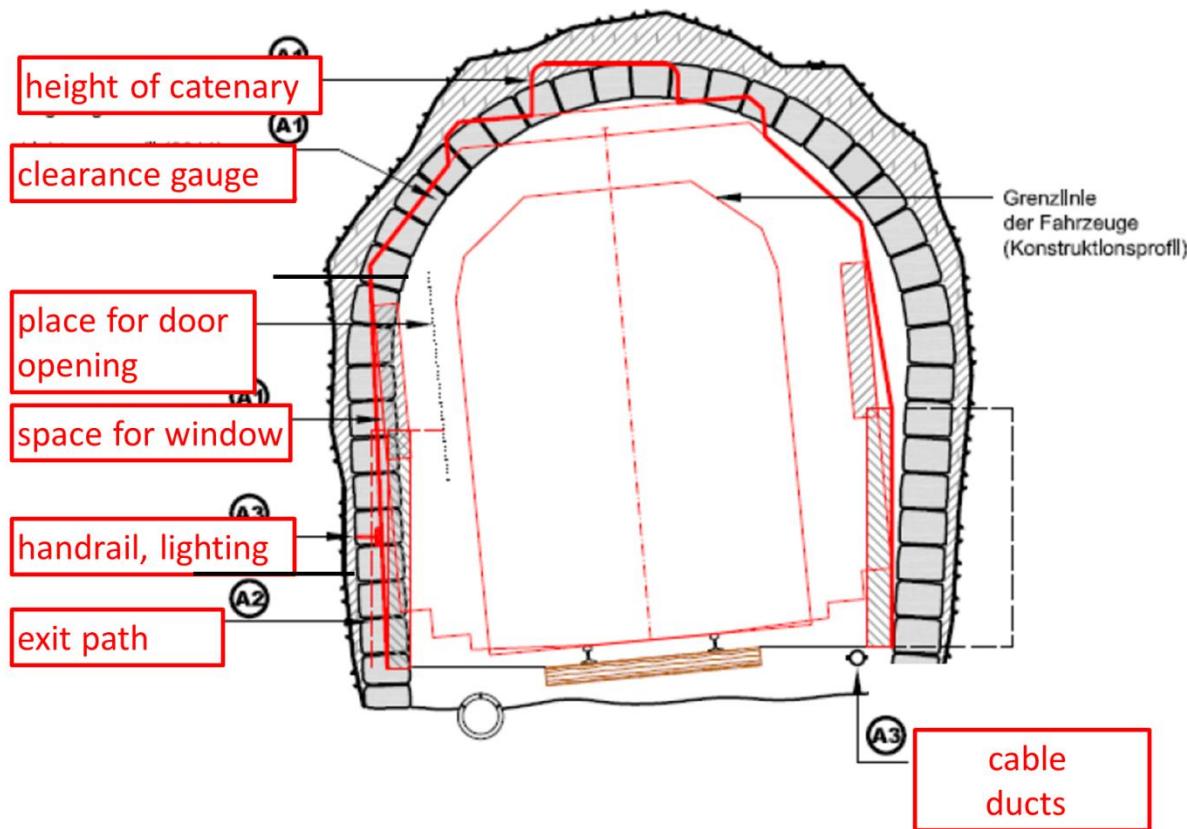


2. Project overview and challenges



- old cross-section: 27 m²
- horseshoe profile
- structural damages, but structural safety is usually not reduced
- usability is partly restricted

2. Project overview and challenges



- doesn't fulfil superior requirements
- necessity of widening the profile (tunnel and portals)
- remediation portals observing the conditions of UNESCO

2. Project overview and challenges



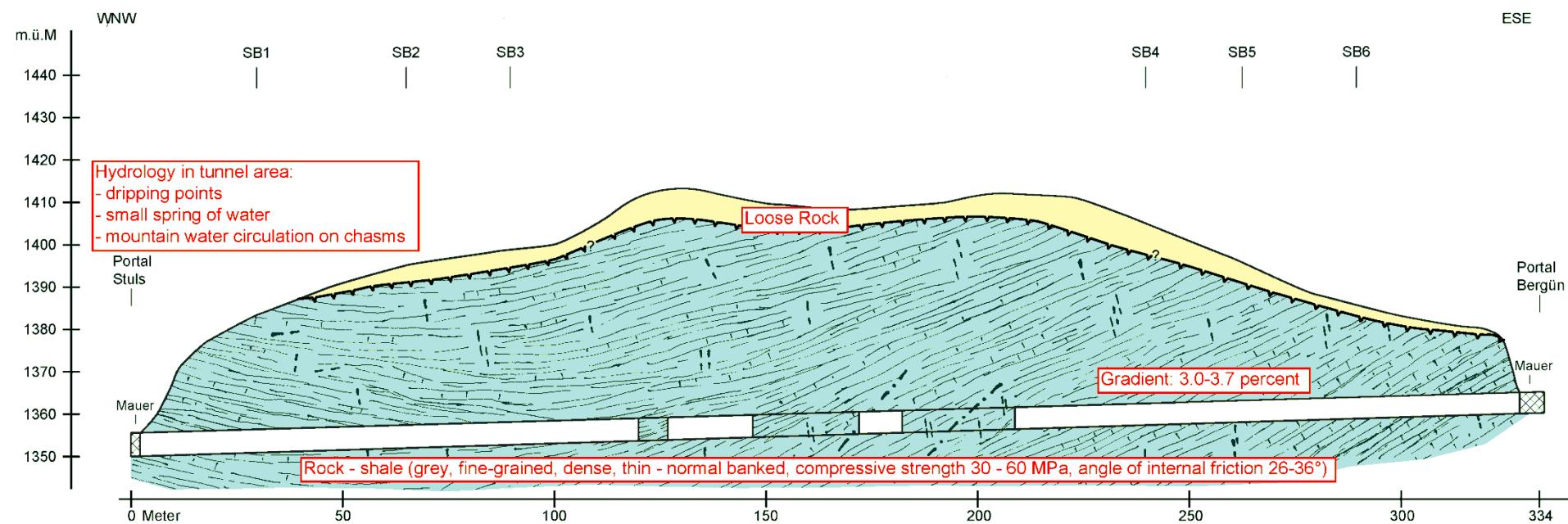
Portal Stuls (West)



Portal Bergün (East)

- longitudinal walls
- rock protection systems with spiral rope net, nails
- portal length: 6-8 m

3. Geological overview



Comparatively favourable rock conditions + short tunnel length + isolated location → reasons for testing the new method of tunnel remediation at the Glatschera-project

4. Objectives

- Remediate the existing structure in order to enable operation for the next 70-100 years
 - Refurbishment has to enable rail operations during the entire construction process (work: night shift)
 - Remediate the different damages of the structure
 - Fulfil the superior requirements incl. UNESCO-requirements for the portals
 - Practical, durable and inexpensive solution of high quality
- **Standardised planning and construction works will contribute to lower costs and a reduction in construction time**

5. Solutions

Milestones

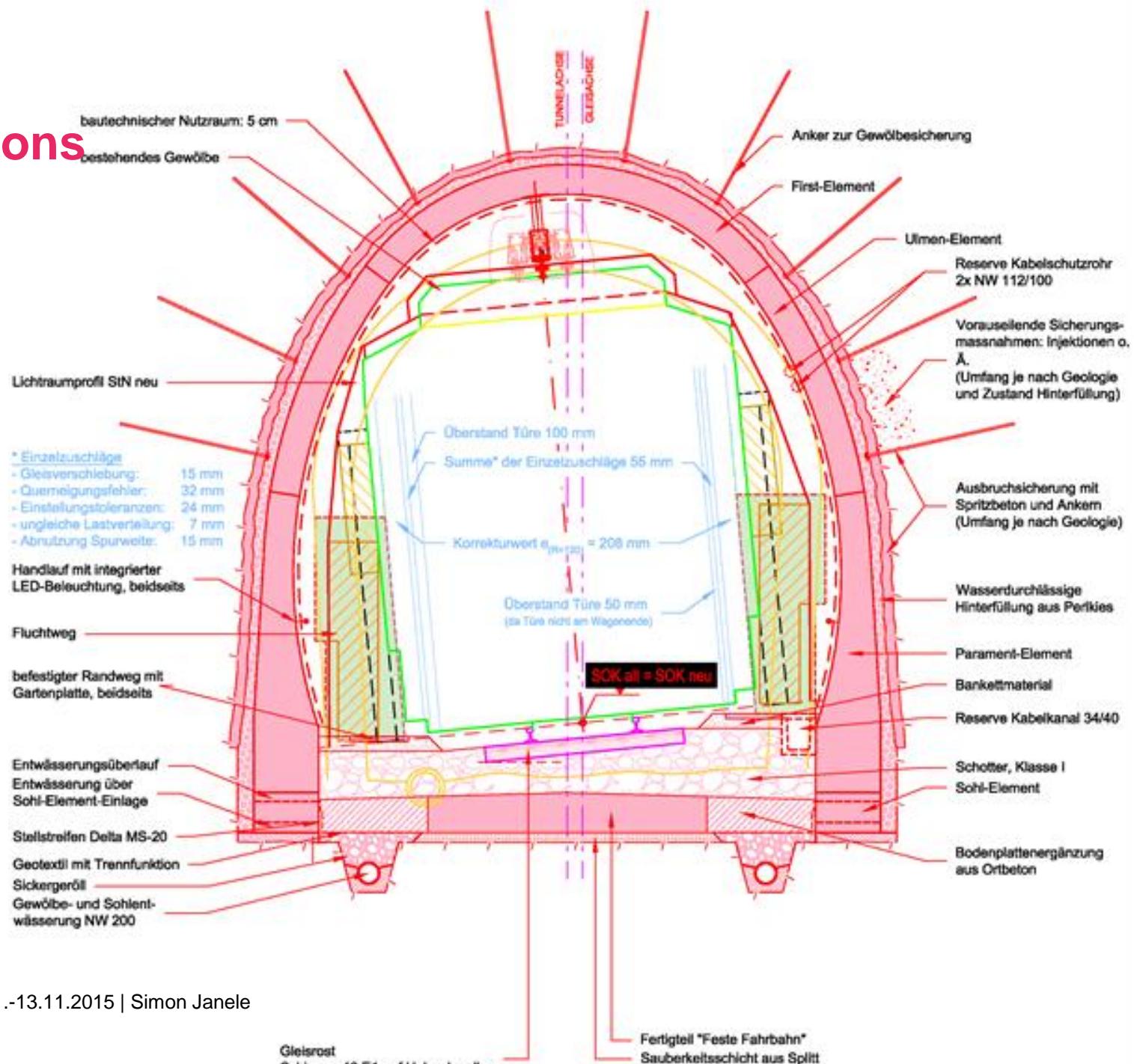
- 2011: First studies for a standardized remediation concept
- 2012: Intensified studies with prefabricated concrete elements
- 2013: Practice under real conditions in test mine
- 2014: Tender of the refurbishing works
- 2014-2016: From preliminary works - to finishing works

5. Solutions

- complete replacement of the tunnel lining
- new clearance gauge and safety requirements
- H x W x L: 6.70 x 6.28 x 1.50 m
- 7 screwed elements / cross-sec.
- seals ensure waterproofing
- primary support: reinforced shotcrete and anchor
- loose gravel to drain off



5. Solutions

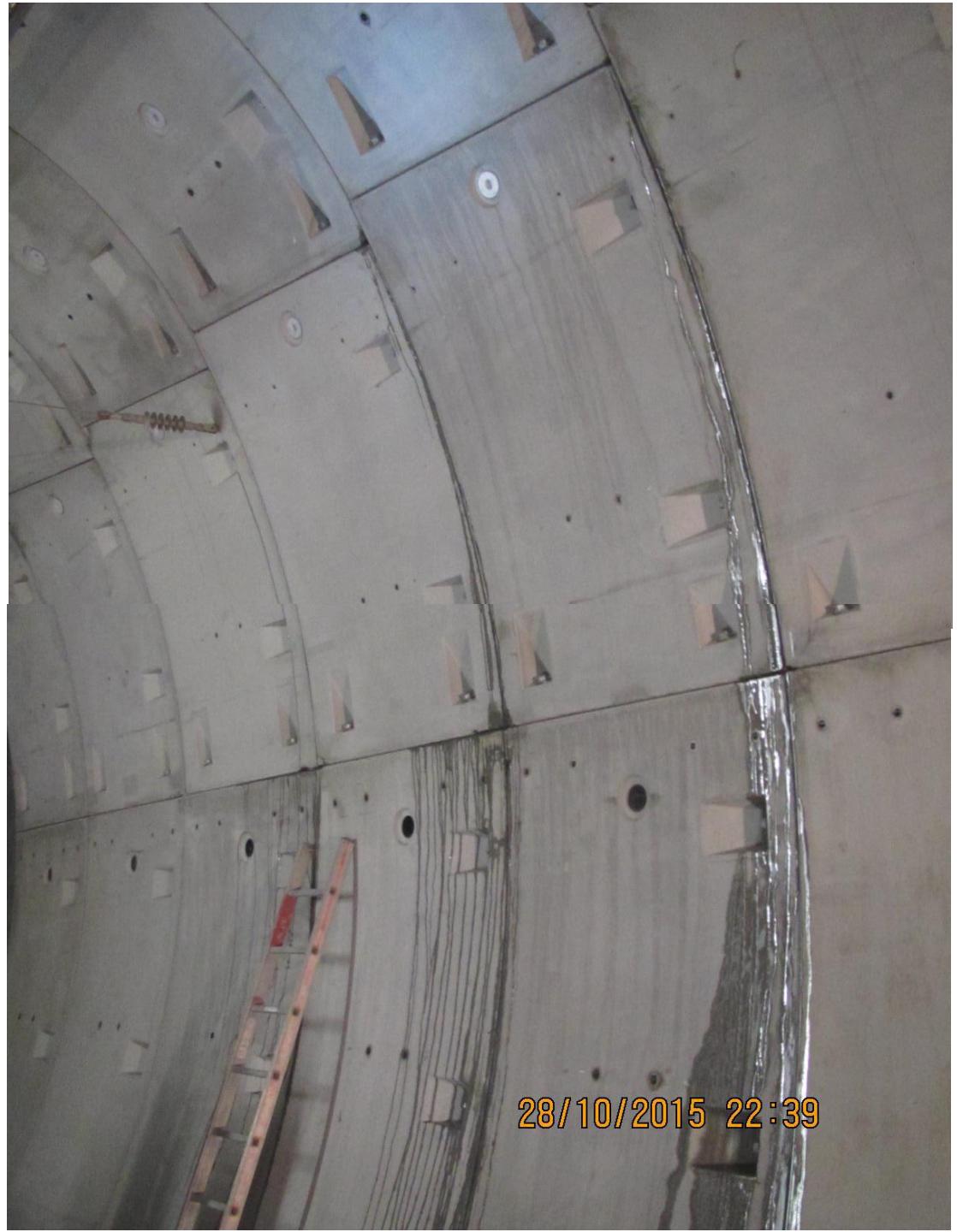


5. Solutions



Basler & Hofmann

5. Solutions

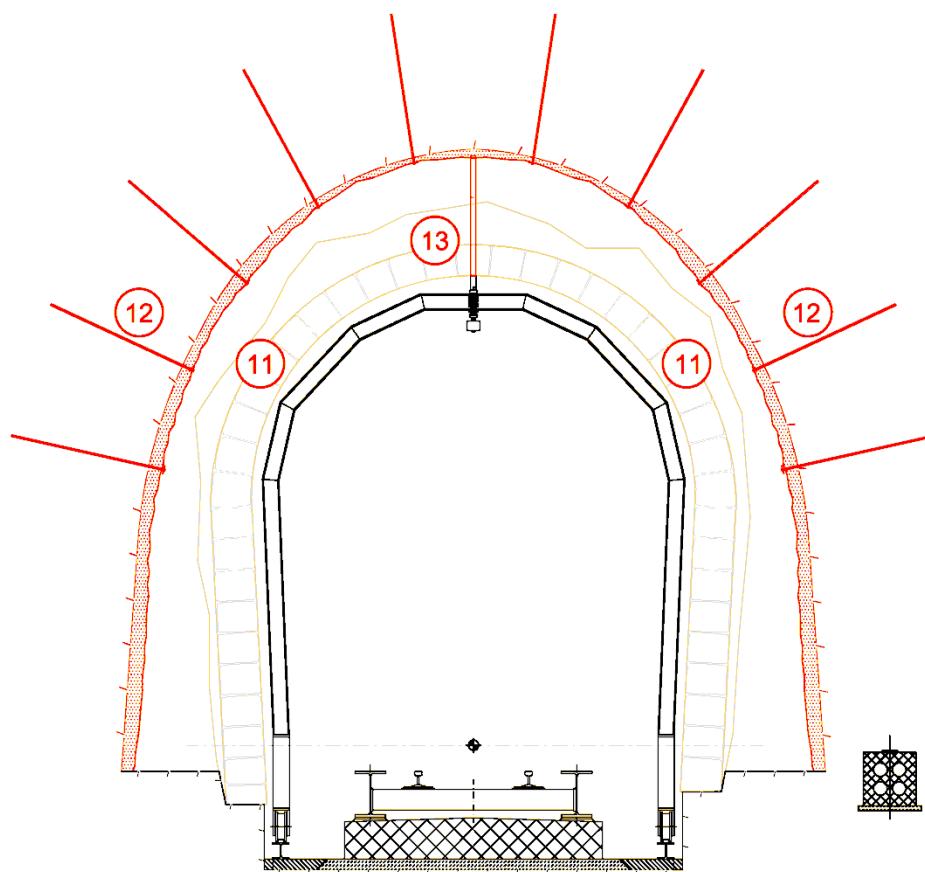


5. Solutions

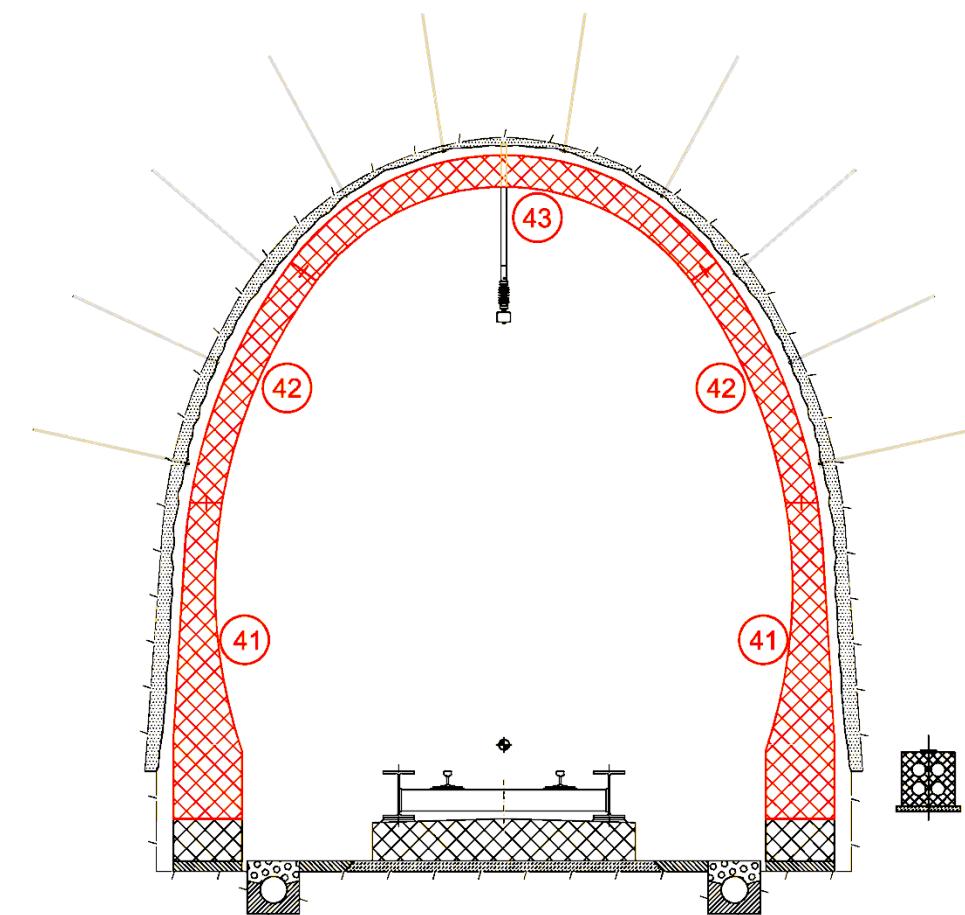
Remediation in eight construction steps:

- different preliminary works (rock stabilisation, substation construction etc.)
- excavation (the new excavated section is of 41 m²)
- primary tunnel support (rock bolts, reinforced shotcrete)
- installation of the dewatering system
- installation of the prefabricated elements and construction of the tunnel floor
- backfilling with pea gravel
- installation of the track superstructure
- various finishing works

5. Solutions



Interphase 1



Interphase 4

5. Solutions

Portals:

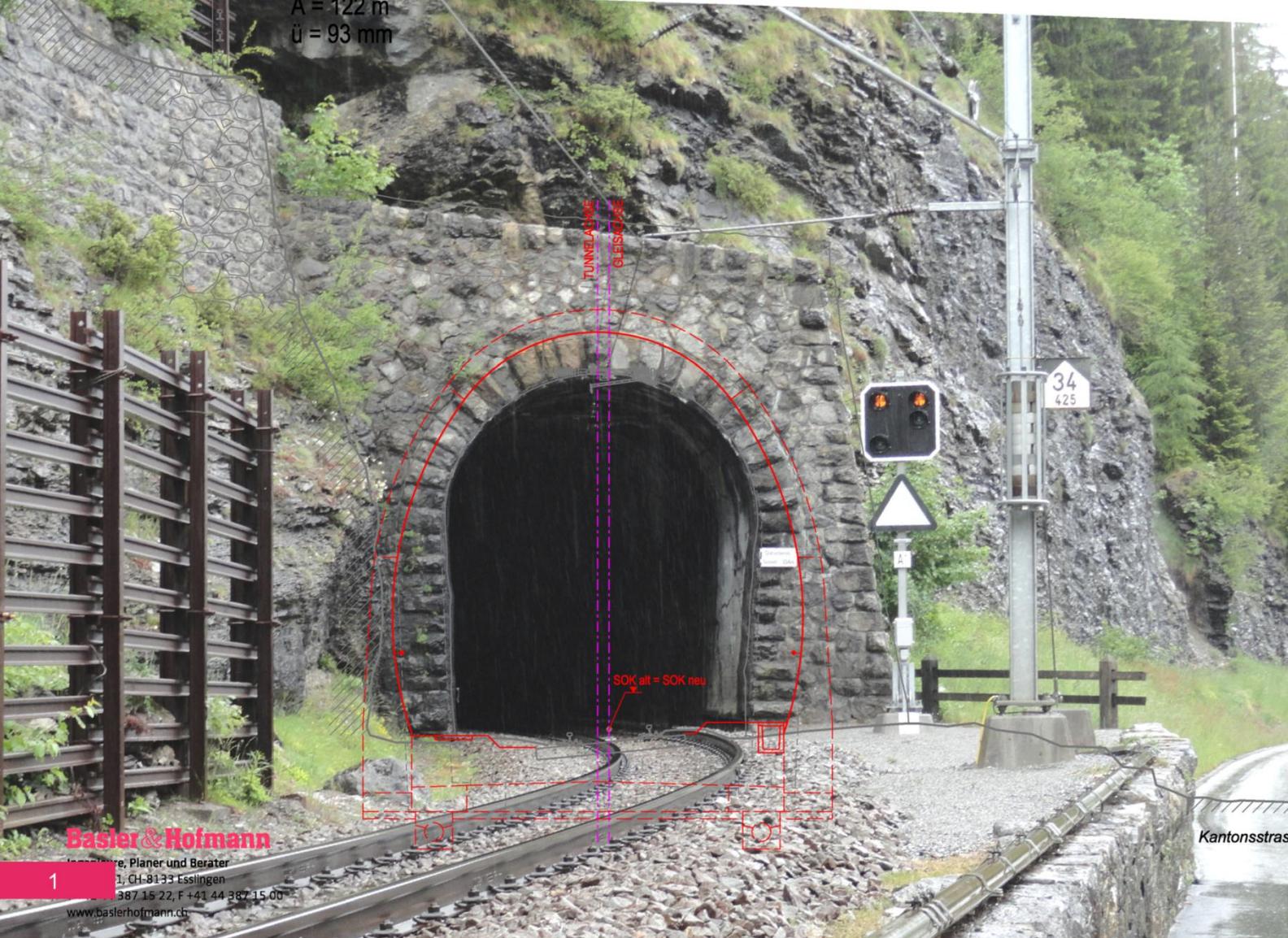
- The refurbished natural stone masonry has to appear similar to the existing portals
- UNESCO requirements:
 - maintenance of the scale relationship (height to width)
 - layout (stones, joints, arrangement etc.)
 - the first 5 m of inner lining has to appear in natural stone masonry

Glatscherastunnel, 1: 50

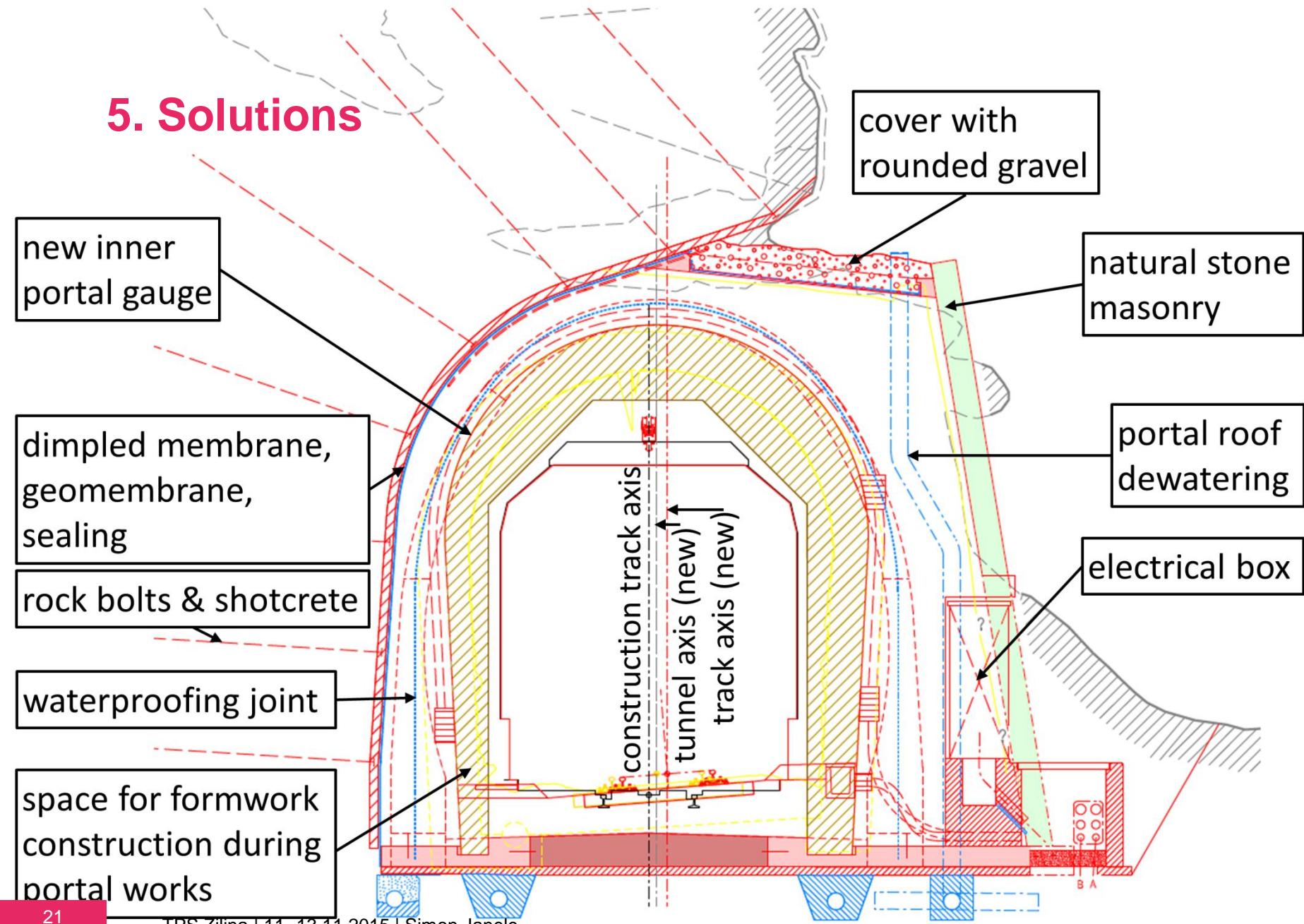
Stationierung km 72'275 (Portal Stuls)
LRP: StN neu, FT-Element 09.09.2013

A = 122 m

ü = 93 mm



5. Solutions



6. Closing remarks

- First application of the new refurbishment-concept called ‘Normalbauweise’.
- Main goals of the standardised remediation concept:
 - reduce construction / planning time
 - saving costs
- the on-going construction works will show if these goals can be achieved
- Meanwhile the excavation method changed from machine-aided driving in rock (MUF) to drill & blast (SPV)

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