ÚLOHY PRI REKONŠTRUKCII TUNELA GLATSCHERAS, BERGÜN, ŠVAJČIARSKO

CHALLENGES IN THE REMEDIATION OF THE GLATSCHERAS-RAILWAY-TUNNEL, BERGÜN, SWITZERLAND

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ABSTRAKT

334 m dlhý jednopruhový tunel Glatcheras patriaci železniciam Rhaetian (RhB) je časťou najznámejšej železničnej trate Albula vo Švajčiarsku, ktorá je svetovým dedičstvom UNESCO. Tunel sa nachádza vo výške okolo 1350 m n. m. a bol postavený v roku 1903 kvôli zosuvu pôdy, ktorá zakryla starú železničnú trať. Tunelové ostenie je vybudované z prírodného kamenného muriva, niektoré tunelové časti však toto ostenie nemajú.
Dva vstupné portály, ktoré ukončujú tunel sú taktiež z prírodného kamenného muriva. Tunel vykazuje značné porušenie konštrukcie a nespĺňa aktuálne požiadavky (napr. svetlé rozpätie, bezpečnosť). Hlavnou úlohou projektu je obnova existujúcej konštrukcie za účelom ďalšej prevádzky na nasledujúcich 70 – 100 rokov. Oprava musí prebehnúť pod dohľadom UNESCA (kvôli portálom) a musí byť umožnená prevádzka trate počas celej výstavby. Oprava tunela Glatscheras reprezentuje pilotný projekt s ohľadom k tzv. "Normalbauweise Tunnel" - štandartný rekonštrukčný koncept predstavený železnicami RhB, ktorý sa zakladá na inštalácii prefabrikovaných betónových elementov. Uvedením tohto štandartného konceptu, má klient v úmysle štandartizovať plánovanie a stavebné práce pre rekonštrukciu vlastných tunelov. Toto prispeje k nižším nákladom a skráteniu času výstavby.

ABSTRACT

The 334 m long single-lane Glatscheras-Tunnel of the Rhaetian Railway (RhB) is part of the famous Albula Railway Line in Switzerland, which is an UNESCO World Heritage Site. The tunnel is located about 1,350 m above sea level and was built in 1903 due to a landslide that covered the existing railway line. The tunnel lining consists of natural stone masonry; some tunnel sections are unsupported. Two portal structures of natural stone masonry complete the tunnel. The tunnel shows significant signs of structural damage and doesn't fulfil actual requirements (e.g. clearance gauge, safety). The main aim of the project is to remediate the existing structure in order to enable operation for the next 70 – 100 years. The remediation has to occur observing the conditions of UNESCO (for the portals) and enabling rail operations during the entire construction time. The remediation of the Glatscheras-Tunnel represents a pilot project with respect to the so called "Normalbauweise Tunnel" – a standard refurbishment concept introduced by the RhB basing upon the installation of prefabricated concrete elements. With the introduction of this standard concept the client intends to standardise planning and construction works for the remediation of their own tunnels. This will contribute to lower costs and a reduction in construction time.

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1 Introduction

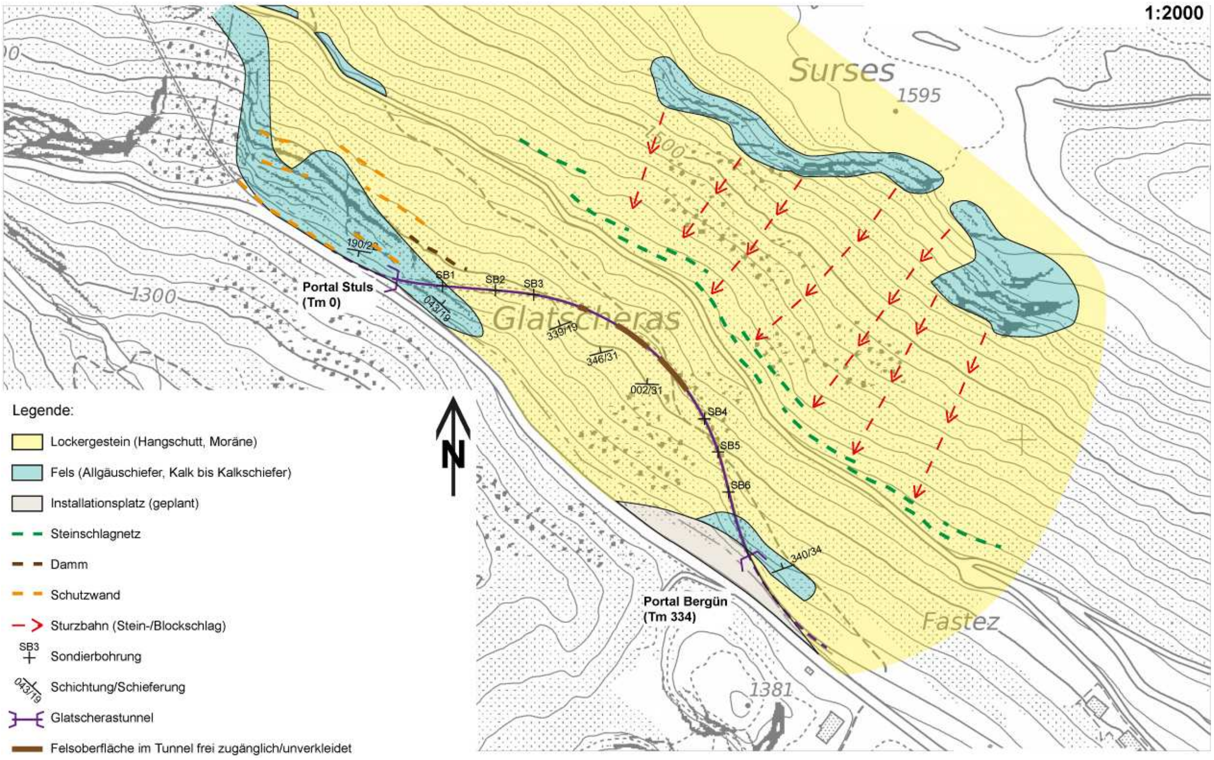
The Rhaetian Rainway (RhB) is Switzerland's largest railway operator for routes throughout the Alps. The 10 regular railway lines of the RhB consist of 384 km of railway lines, 103 stops, 115 tunnels and 606 bridges (impressions are shown in Fig. 1 and Fig. 2). These 115 tunnels have a total lenght of about 60 km.
The RhB started operating in 1889. Since 2008 the famous Albula- and Berninalines belong to UNESCO World Heritage Sites. About 1,500 employees carry around two million commuters, ten million tourists and roughly 600,000 tonnes of cargo per year [6].

Obr. 1 Regionálny vlak na okružnom viadukte Brusion [3]
Fig. 1 Regional train on circuit viaduct Brusio [3]

2 Project overview and challenges

The 334 m long single-lane metre gauge Glatscheras-Tunnel of the RhB is part of the famous Albula Railway Line (from Thusis to St. Moritz) in Switzerland (canton of Grisons), which is a UNESCO World Heritage Site. This railway line is used for both public transportation and rail cargo. The tunnel is located about 1,350 m above sea level and was built in 1903 due to a landslide that covered the existing railway line. At that time, the construction time was 144 days.
The plan view in Fig, 3 shows a strongly bended railway line (minimal radius R = 108 m). The tunnel lining consists of natural stone masonry (circa 275 m); some tunnel sections are unsupported (circa 59 m). The track bed is made up of ballast. Two portal structures of natural stone masonry complete the tunnel.

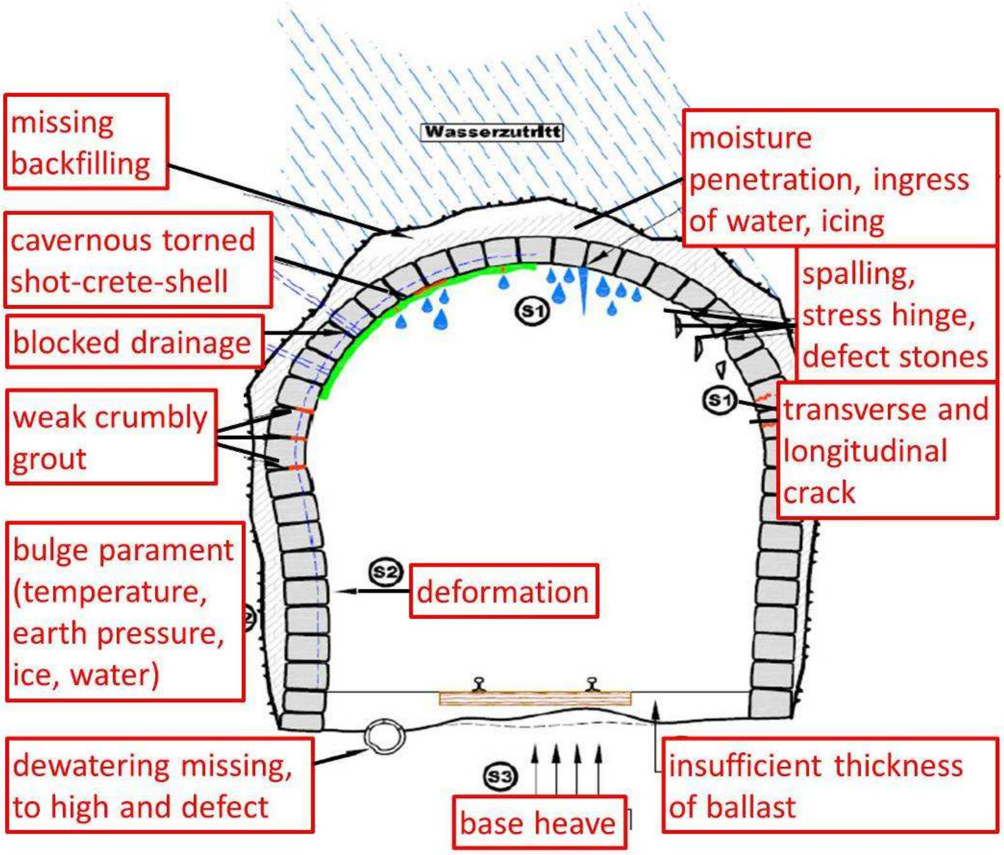
Obr. 2 Železničná trať Albula, Landwasserviadukt [8]
Fig. 2 Albula Railway Line, Landwasserviadukt [8]



Obr. 3 Geologické pomery tunela Glatscheras [1]
Fig, 3 Geological planview of the Glatscherastunnel [1]

This tunnel plays an important role for all future tunnel refurbishments of the RhB, as it is the first prototype of a new refurbishment-concept (see chapter 0).

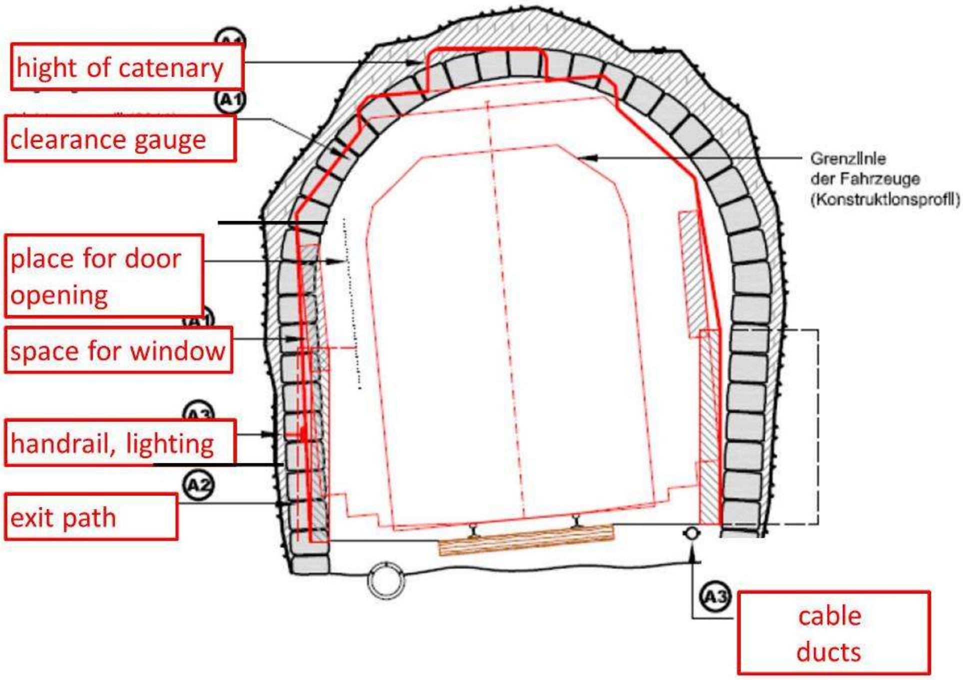
The current, old cross-section of 27 m^2 shows a horseshoe profile. The tunnel shows significant structural damage (e.g. damage of the masonry, spalling, insufficient ballast-thickness / dewatering; see Fig. 4) and doesn't fulfil superior requirements (e.g. clearance gauge, elevation reserve, height of catenary, safety standards / equipment; see Fig. 5). Due to this the usability is partly restricted, however the structural safety is usually not reduced.



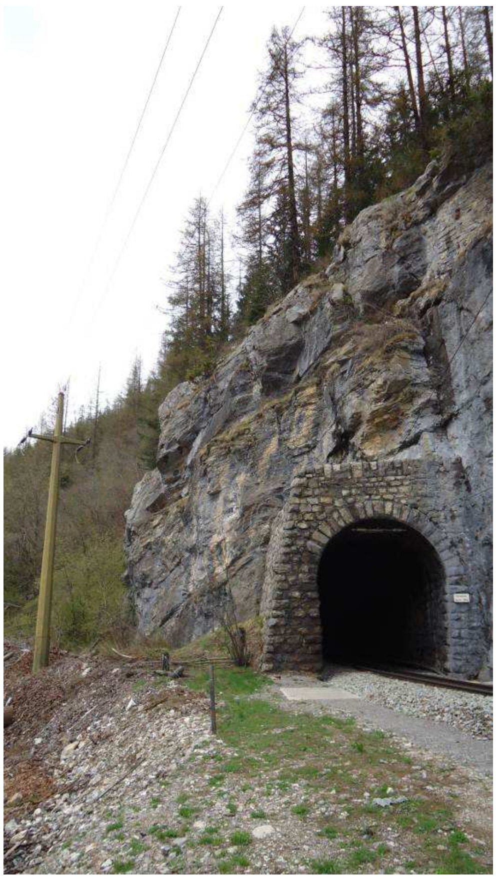
Obr. 4 Typický priečny rez s poškodeniami konštrukcie [4]
Fig. 4 Typical cross-section with damages of the structure [4]

Due to all the damage and the necessity of widening the profile, the tunnel and the two portals have to be refurbished. The remediation has to occur observing the conditions of UNESCO (for the portals, Fig. 6).

In the portal zones, many surrounding measures had to be implemented in the past as a consequence of landslides and rockfall. For example, longitudinal walls (see Fig. 6, left), rock protection systems with a spiral rope net, nails and anchors above and beside the portals.



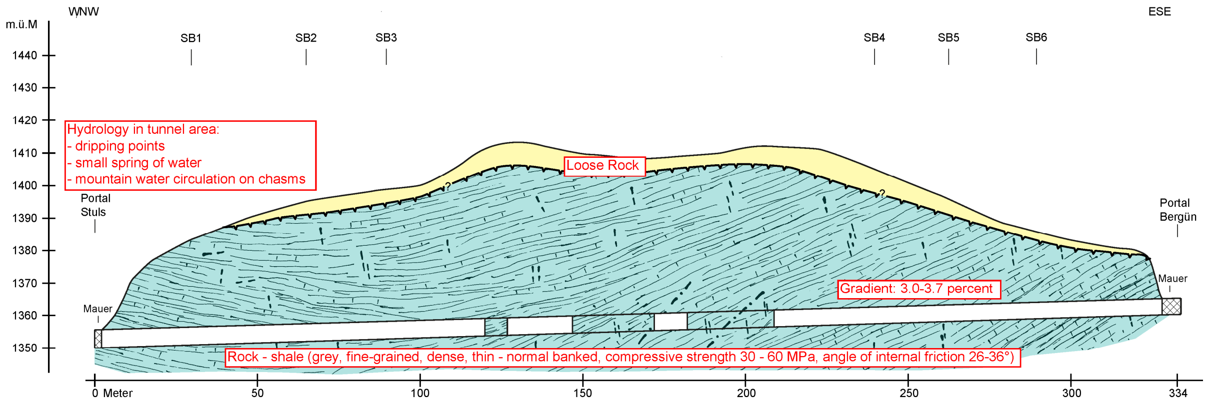
Obr. 5 Typický priečny rez s nesplnenými požiadavkami [4]
Fig. 5 Typical cross-section with unfulfilled requirements [4]



Obr. 6 Portál tunela Stuls (vľavo), portál tunela Bergün (vpravo)
Fig. 6 Portal side Stuls (left), Portal side Bergün (right)

3 Geological overview

The geological planview is shown in Fig, 3. The geological longitudinal section is shown in Fig. 7.



Obr. 7 Geologický pozdĺžny rez [1]
Fig. 7 Geological longitudinal section [1]

The comparatively favourable rock conditions, the short lenght of the tunnel and the location (good accessibility, place for installations) are the reasons for testing the new method of tunnel remediation at the Glatscheras-project.

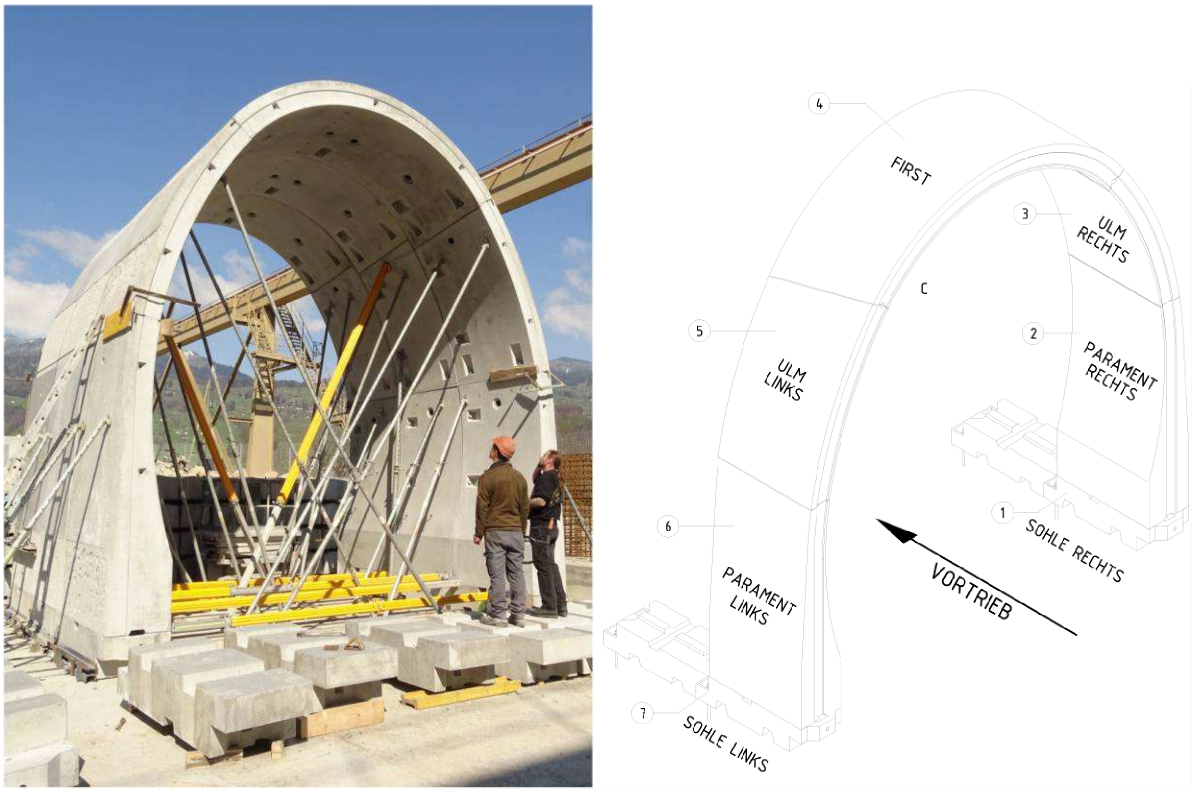
4 Objectives

The main aim of the project is to remediate the existing structure in order to enable operation for the next 70 – 100 years. The refurbishment has to enable rail operations during the entire construction process, this usually means work during the night shift and rail operation during the day. The construction works are scheduled from 2014 (preliminary works) to 2016.
The different damages of the structure (see Fig. 4) must be remediated and the superior requirements (see Fig. 5) must be fulfilled. This implicates the special requirements from UNESCO for the two portals.
Last but not least a practical, durable and inexpensive solution of high quality was sought. With the introduction of a standard concept, the client (RhB) intends to standardise planning and construction works for the remediation of their own tunnels. This will contribute to lower costs and a reduction in construction time.

5 Solutions

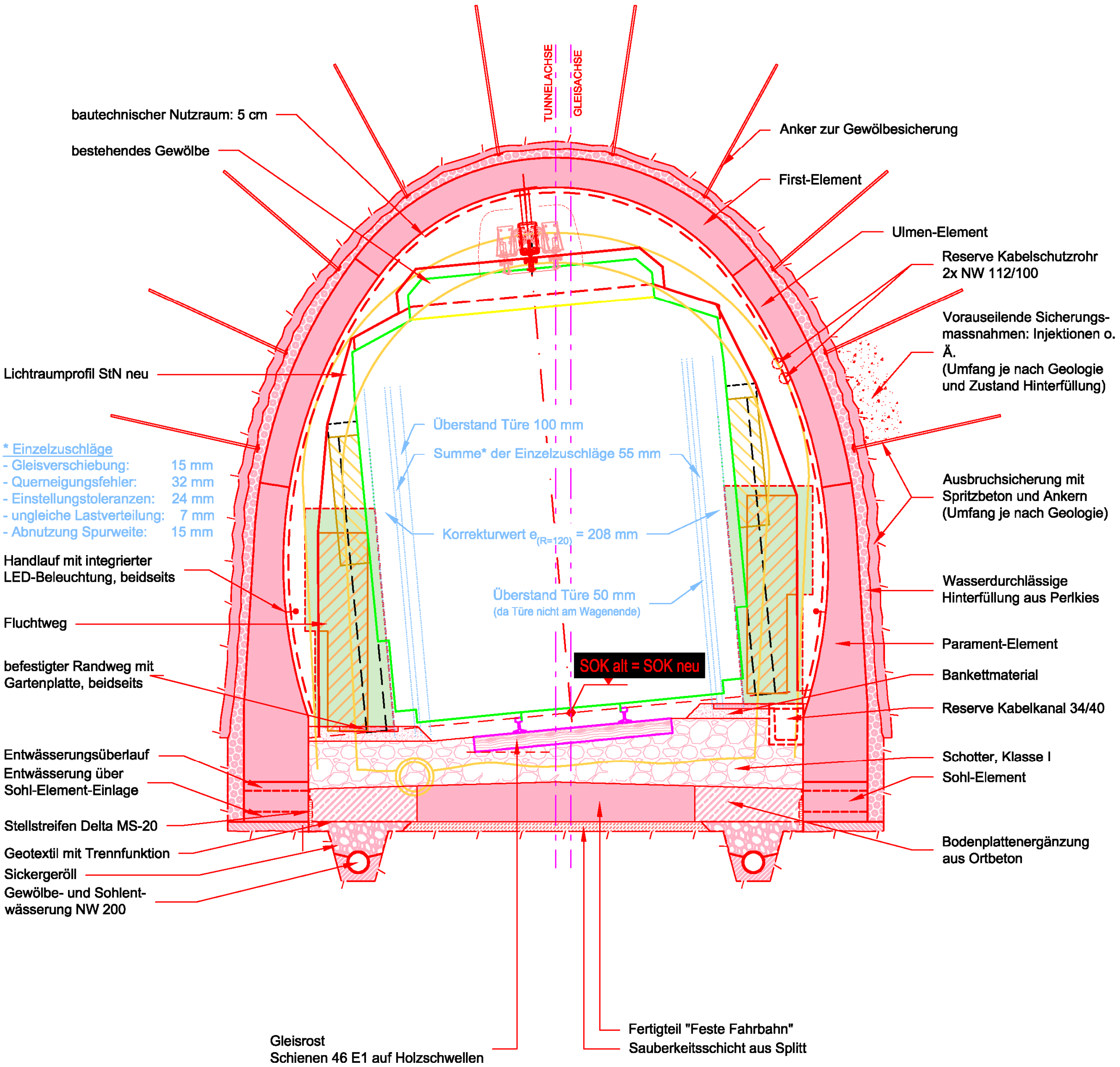
In order to solve the current problems (damage, superior requirements) for all RhB-tunnels, the first studies for a standardized remediation concept started in 2011. In 2012 these studies were intensified, especially with respect to the application of prefabricated concrete elements and the building process concerning the maintenance of railway operation. With the intention to optimise the remediation concept, the building process and the handling of the prefabricated concrete elements under real conditions, interested construction companies had the opportunity to practice in the Hagerbach test mine (Flums, Switzerland). Further important outputs of these tests were the information about necessary construction time and consequential costs. After those tests and based on a preliminary project, the preparation of

the tender began. Up to this point in time all the work was organised and carried out by an interdisciplinary team (client, planner, formworker, prefab) and further external reviewers.
The remediation of the Glatscheras-Tunnel represents a pilot project with respect to the so called "Normalbauweise Tunnel", a standard refurbishment concept introduced by the RhB based upon the installation of prefabricated concrete elements (see Fig. 8, left). This concept means a complete replacement of the tunnel lining under consideration of the new clearance gauge and safety requirements.



Obr. 8 Montované skúšobné prstence (vľavo); jednotlivé prvky (vpravo) [5]
Fig. 8 Prefabricated test rings (left); Single elements (right) [5]

The total height of the new cross-section is 6.70 m and the total width is 6.28 m. The prefabricated concrete elements are 1.5 m long. One cross-section consists of seven elements (see Fig. 8, right) which are screwed with the flanking elements and locally with the rock. Radial and longitudinal seals ensure waterproofing. Between the primary tunnel support (shotcrete) and the concrete elements, water is able to drain off into a layer of loose gravel to the inner dewatering system (see Fig. 9).



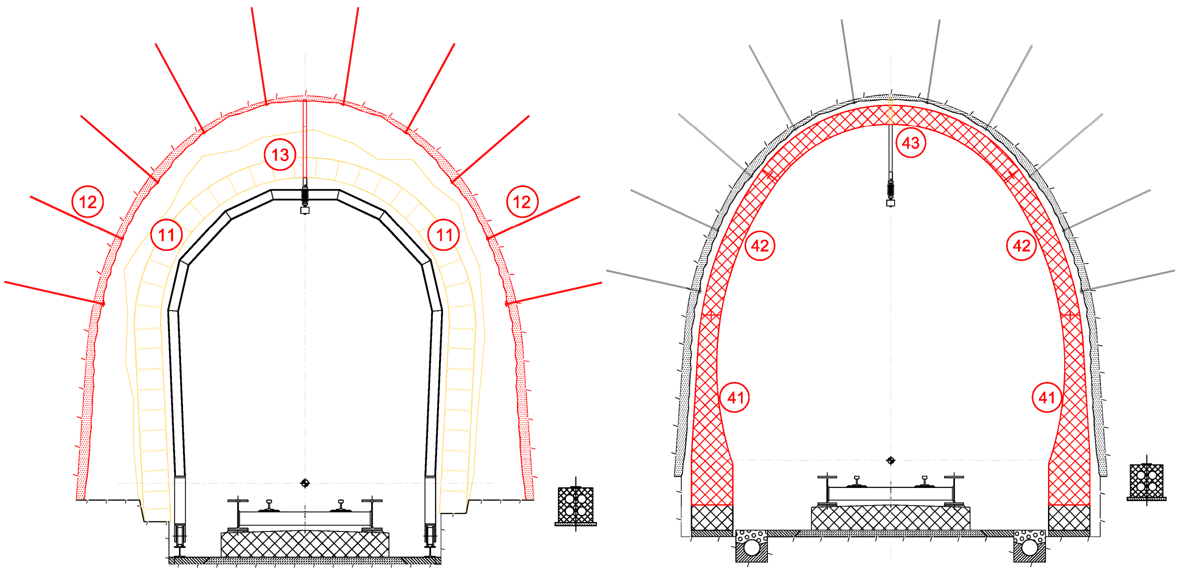
Obr. 9 Typický nový priečny rez tunela [5]
Fig. 9 Typical new cross-section in the tunnel [5]

According to the novel standard concept, the remediation is realised in eight construction steps (two interphases are shown in Fig. 10):

- a series of different preliminary works (rock stabilisation, substation construction etc.)
- excavation (the new excavated section is of 41 m^2)
- primary tunnel support (rock bolts, reinforced shotcrete; see Fig. 10, left)
- building-in of the dewatering system
- installation of the prefabricated elements (see Fig. 10, right) and construction of the tunnel floor
- backfilling with pea gravel
- installation of the track superstructure
- various finishing works.

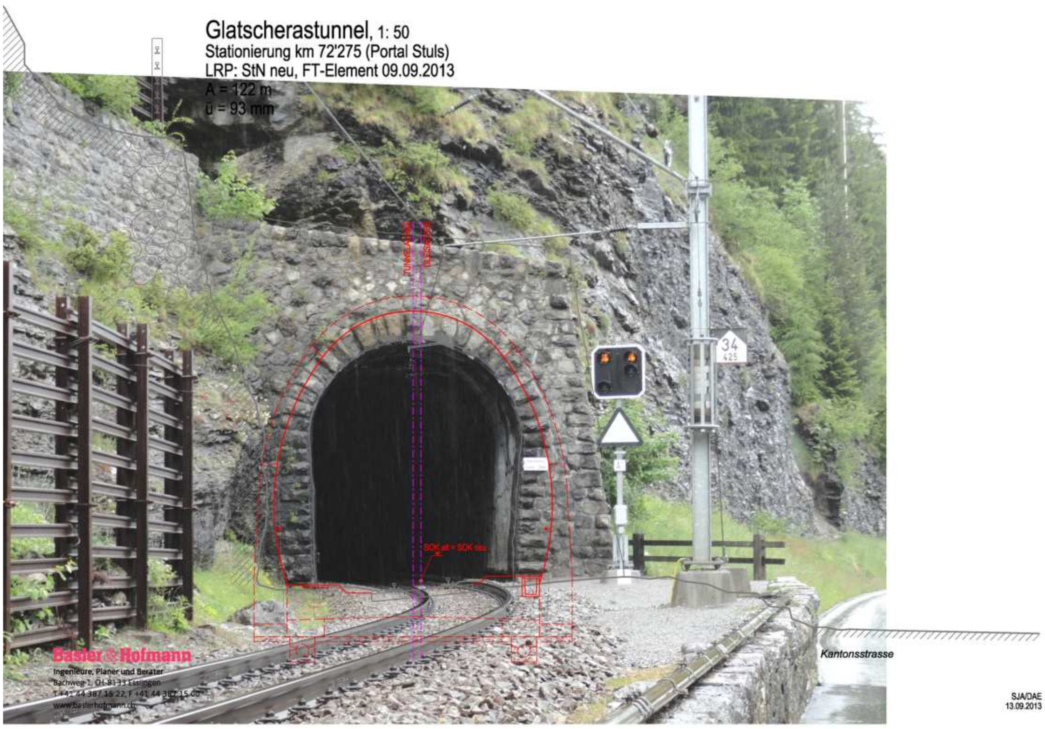
The final cross-section shows. In this way it is possible to replace and strengthen the tunnel lining, to fix the tunnel floor, to enlarge the tunnel in order to satisfy the requirements concerning the normative clearance gauge (including the required safety space), and to improve the safety equipment.

Before main construction starts, the railway track is put lowered by 52 cm, in order to create enough construction space for the works. At the end, the new rail will be on the same level as the old rail. The former existing catenary has changed for the benefit of a space-saving overhead conductor rail.



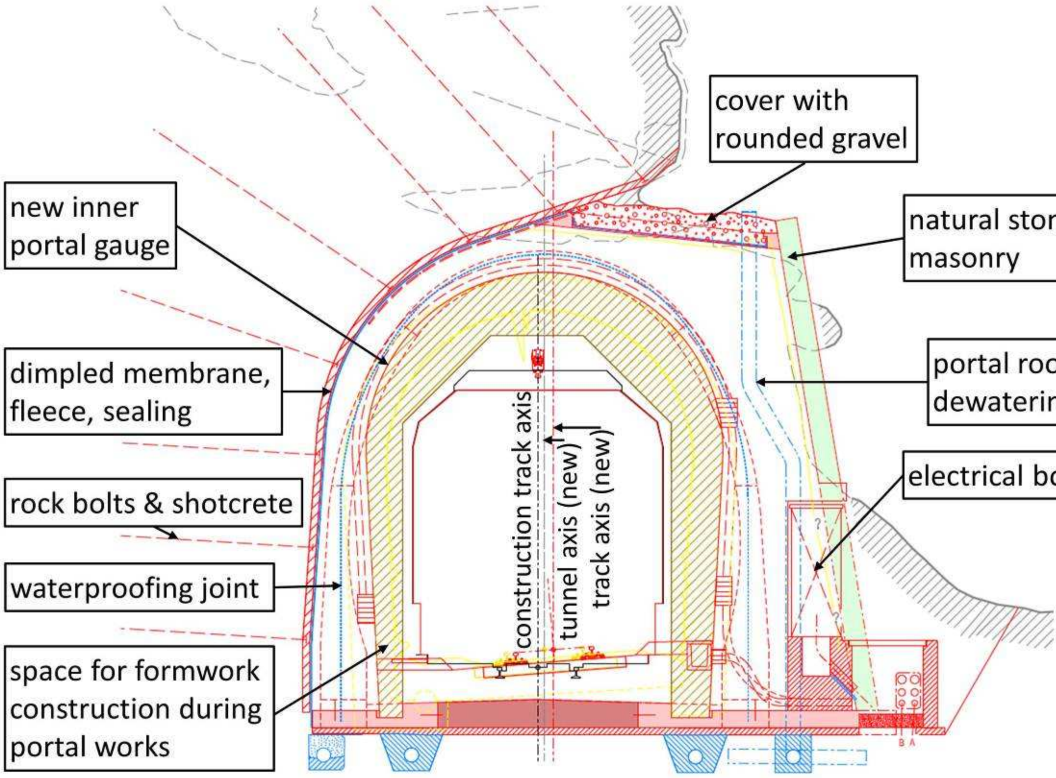
Obr. 10 Medziľahlé fázy 1 (vľavo) a 4 (vpravo), z celkového počtu 9 [5]
Fig. 10 Interphases 1 (left) and 4 (right) of total 9 [5]

Particular attention has to be paid to the portals (see Fig. 6). The refurbished the natural stone masonry has to appear similar to the existing portals in order to fulfil the requirements of UNESCO. The different cross sections are shown in Fig. 11. The requirements concerned especially the maintenance of the scale relationship (height to width), the layout (stones, joints, arrangement etc.) of the natural stone masonry of both the inner and outer lining.



Obr. 11 Čelný pohľad na portál so starým a novým (červený obrys) prierezom [5]
Fig. 11 Portal front view with old and new (red outline) cross section [5]

As an example of the complexity of the works, Fig. 12 shows a cross-section which is located in overhanging rock, near the transitional area of the first prefabricated tunnel elements.
Both tunnel and portals are built with the help of mobile protection constructions, which protect the railway operation during the day from down falling objects.



Obr. 12 Priečny rez tunela so skalným previsom [5]
Fig. 12 Cross-section portal with overhanging rock [5]

6 Closing remarks

For the RhB it is the first time the so called "Normalbauweise" is applied. The main goals of this standardised remediation concept are saving construction / planning time and costs. The on-going construction works (2014-2016; no works during winter due to frost) will show if these goals can be achieved.

Project experiences will be presented at the conference in Zilina.

7 References

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