SEMMLING BASE TUNNEL: CONSTRUCTION, DEEP INTERMEDIATE ACCESS SHAFTS, TBM- AND DRILL AND BLAST TUNNELING

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ABSTRACT

For the successful realization of major infrastructure project not only technical issues but also numerous legal problems have to be solved and intense processes of communication have to be conducted. The responsible project team of the ÖBB-Infrastruktur AG has been working intensely on the implementation of the Semmering Base Tunnel since 13 years. The project exhibits, based on its history and its complexity, very high requirements and challenges all parties concerned in new ways. [1]

The 27.3 km long Semmering Base Tunnel (SBT) consist of two single-track running tunnels for railway and is being driven from the portal at Gloggnitz and from three intermediate access points in Göstritz, Fröschnitzgraben and Grautschenhof. It passes geologically extremely challenging rock mass with an overburden up to 800 m.

For organizational, scheduling and topographical reasons, the tunnel is divided into three construction contracts. The eastern contract section SBT1.1 “Tunnel Gloggnitz” has been under construction since mid 2015. Construction started on the middle part, contract section SBT2.1 “Tunnel Fröschnitzgraben” at the start of 2014. The western contract section SBT3.1 “Tunnel Grautschenhof” has been under construction since May 2016. [2]

Keywords: Semmering Base Tunnel

1. THE SÜDBAHN ACROSS THE SEMMERING

The 41 km long mountain route across the Semmering, opened in 1854, is an important part of the European railway connections. Despite the brilliant engineering achievements of its builder Karl Ritter von Ghega, it increasingly proves to be a technical bottleneck for a future-oriented railway operation of the 21st century.

In the spring of 2005, a political consensus was reached between the Austrian Federal Government and the states of Lower Austria and Styria to provide a uniformly efficient railway infrastructure along the Südbahn as a nationally and internationally important transport axis for Austria as an economic location.

The two running tunnels of the Semmering Base Tunnel, designed with a low gradient according to the specifications is, in addition to the Koralm Railway and the Vienna Central Station, an essential component for the realization of this goal. In the future, it will ensure an economical and contemporary rail freight traffic and it will increase travel comfort by reducing travel time between Vienna and Graz by 50 minutes.

2. COMMUNICATION, COMPETENCE, COORDINATION - THE THREE PILLARS TO SUCCESS

After the project was commissioned in March 2005, an area for planning and evaluation of approx. 300 km² was specified between the starting point Gloggnitz and the intersection point with the existing route in Mürzzuschlag/Langenwang. Subsequently the development of the project was started.

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In addition to the actual evaluation and planning, an active involvement of the public for a
dialog between the project management, the responsible decision makers and the stakeholder
groups of the region was established.

In addition to the project-specific Steering Committee (ÖBB, BMVIT, SCHIG, Lower Austria,
Styria), project-accompanying local and regional committees (working forum) were set up to
publicize this important project in the region and to actively integrate suggestions and ideas
from the region into the planning process.

In 50 working sessions with an intensive exchange with the 170 members of the forum, the
development of a stable and locally accepted tunnel route was possible.

In addition to this process, the project was presented through an offensive information policy
in numerous regional, national and international lectures, conferences, papers and information
evenings. [1]

3. AUTHORITIES PROCESS

On May 31, 2010, the project was submitted to the Federal Ministry of Transport, Innovation
and Technology (BMVIT) to obtain the permits relating to the environment as well as the
approval of the railway authorities. This included more than 10,000 pages of report and 700 m²
of plans.

At the same time, the necessary submissions on the supplementary permit procedures for water
law, monument protection, aviation and waste management in the federal states of Lower
Austria and Styria were made, and the two nature conservation procedures at the administrative
authorities of the federal states were submitted. In the meantime, all procedures have been
completed in a positive manner, and all decisions for the construction of the Semmering Base
Tunnel have been obtained. [3]

4. THE PROJECT SEMMERING BASE TUNNEL

The 27.3 km long Semmering Base Tunnel will provide improved travel quality for passengers
and considerably increase the capacity for rail freight transport. The main components of the
entire tunnel system are two single-track running tunnels, cross passages at a maximum spacing
of 500 m and an emergency station in the middle section of the tunnel with two shafts about
400 m deep for ventilation an extraction in case of an incident.

Figure 1: Semmering Base Tunnel: Overview and construction sections (ÖBB, 3DSchmiede)

The rail tunnel is for reasons of scheduling, logistics and geology being driven from several
construction sites and access points, managed through three tunnel section contracts (Figure 1).
In addition to the logistical challenges, complex geological and hydrogeological situations
(Figure 2) have to be overcome.

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The contract section “Tunnel Gloggnitz” (SBT1.1) is being undertaken conventionally with excavator and blasting starting from two sites. The first driving starts from the tunnel portal in Gloggnitz in direction towards Mürzzuschlag. The intermediate access point in Göstritz consists of a 1,000 m long access tunnel and two 250 m deep shafts, from the bottom of which the running tunnels are being driven towards both directions.

The construction logistics are similarly complex on the contract “Tunnel Fröschnitzgraben” (SBT2.1): two tunnel boring machines are working from the intermediate access point at Fröschnitzgraben in the direction of Gloggnitz and blast and excavator heading is underway towards Mürzzuschlag. In Order that tunneling was able to start from the Fröschnitzgraben, two 400 m deep shafts were sunken since 2014. At the moment, large caverns are being constructed for the later emergency station and the conventional driving towards Mürzzuschlag has started. In 2018 the two tunnel boring machines will start operating towards Gloggnitz.

On the third contract “Tunnel Grautschelenhof” (SBT3.1), two 100 m deep shafts were sunken since September 2016. At the moment the caverns for logistics are being finished and the drivings of both running tunnels have started towards Mürzzuschlag as well as towards Gloggnitz.

5. CONTRACT SBT1.1 – GLOGGNITZ TUNNEL SECTION

Starting from the portal in Gloggnitz (Figure 3), the first 4.7 km of tunnel pass through a sequence of schists, phyllites and graphitic phyllites using conventional tunneling methods whereof about half has been driven so far.
The rocks tend to high convergence and are thus unsuitable for the use of tunnel boring machines. After crossing a valley with quartzite rocks and sericitic phyllites, the tunnel passes through the aquiferous carbonate stock of the Grasberg and into the Schlaml faultzone.

To control the hydrological conditions (up to 300 l/s and up to 26 bar) in the karstified carbonates, directed boreholes are drilled successively for advanced grouting. For this reason caverns will be built in a suitable distance to the grouted areas. From there 300 m long directed boreholes will be drilled around and in the tunnel section from which the rock will be grouted.

From the intermediate access point in Göstritz, which consists of an access tunnel about 1 km long and two blind shafts about 250 m deep, at the head and bottom of which complex caverns are needed for the logistics, two distinctive rock formations are encountered simultaneously:

- In the drive to the east, the approx. 1 km long Grasberg Schlagl fault complex with about 500 m overburden, with mica schist, slate and sericite phyllite, which are the product of a lateral displacement of about 10 km.
- In the drive about 1.5 km long to the west, the karstified dolomite/marble stock of the Mitterotter where the rock mass is to be pre-treated with advance grouting on the same principle as the drive from Gloggnitz.

The access tunnel and the caverns at the shaft head area have already been completed. At the moment the two shafts are being sunken, the bottom will be reached mid 2018 (Figure 4).

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**Figure 4:** Contract SBT1.1 – Tunnel Gloggnitz: junction at the shaft head area in Göstritz (ÖBB-Infrastruktur AG, Ebner)

6. **CONTRACT SBT2.1 – TUNNEL SECTION / INTERMEDIATE ACCESS POINT FRÖSCHNITZGRABEN**

For the intermediate access point Fröschnitzgraben, two shafts more than 400 m deep and with a diameter of about 10 m were sunken down to tunnel level. At the bottom of the shafts, a longitudinal cavern about 400 m long and cross caverns are currently being excavated to house the necessary equipment for tunneling such as workshop, concrete plant and areas for materials handling (Figure 5). In the complete state, this will be used as part of the emergency station.
In the approx. 8.6 km long east drive, predominantly gneisses and schists with minor localized faults and little water ingress are expected. This tunnel section is thus the only part of the entire project where tunnel boring machines can be used due to the competent rock mass conditions.

The requirements for the tunneling system derived from the geotechnical planning resulted in the specification and suitability of a tunnel boring machine (OD 10.1 m) with single shield (TBM-S) or one with double shield (TBM-DS). It also requires provision for the carrying out of appropriate additional and special measures in the cutter head and shield areas. The frequency and assignment of these are described as part of the geotechnical forecast in the contract documents, with the specific requirements being described in detail in the technical conditions of contract. The contractor has selected a TBM-S.

The need for a ring segment lining (30 cm) in combination with an in-situ concrete inner lining (25 cm) with pressure-relieved waterproofing between was derived from the forecasted ground conditions and the requirements concerning the future operation. A segmental lining system without waterproofing has therefore been chosen.

The 4.3 km long conventional drive to the west is essentially characterized by the boundary between the Wechsel unit (gneisses) and the Semmering unit (gneisses and greenstones). The thick fault zone of this boundary consist of quartzites, fractured phyllites and flaked aquiferous carbonates.

In this area, a zone with a length of about 200 to 300 m with heavy water ingress and high initial water pressures is expected and fractured rocks could tend to flowing conditions. As the critical zone is approached, it will be investigated and if necessary measures for waterproofing and improvement of the rock mass will be carried out trough up to 250 m long directed boreholes.

A significant part of this contract is the landfill site in Longsgraben, which is planned with an area of about 20 ha and a capacity of about 5 million m³ for the landfill compartments “excavated material” and “construction residues” (Figure 6). In this landfill material excavated from all three intermediate access points of the Semmering Base Tunnel will be deposited.
Material with more serious geogenic contamination such as gypsum, anhydrite and mineralized rock has to be disposed of separately.

Figure 6: Contract SBT2.1 – Tunnel Fröschnitzgraben: Landfill Longsgraben with the compartment “excavated material” in the foreground and “construction residues” in the background (ÖBB-Infrastruktur AG, Ebner)

Prior to landfill operation extensive preparatory measures were necessary (diversion stream to valley flanks, construction of site access road). After completion of construction, the landfill area will be recultivated and reforested.

The deposition of the material excavated from the tunnel at this landfill site near the tunnel will make a significant contribution to relieving the region from transport nuisance during the construction works. The material excavated from the drive in Gloggnitz will be carted away by rail.

7. CONTRACT SBT3.1 – TUNNEL SECTION / INTERMEDIATE ACCESS POINT GRAUTSCHENHOF

This tunnel section, almost 7 km long, is geologically dominated by the Semmering crystalline, consisting of mica schists, gneisses and carbonate units, with the Semmering main fault passing through as well. The intermediate access is down two shafts about 100 m (Figure 7).
Three transverse caverns will be constructed at the shaft bottoms for construction logistics.

At the end of the east drive (approx. 3.8 km), a fault system of anhydrite and dolomite will be reached, which has a high swelling potential. In the west drive, long sections will pass through the Semmering main fault where heavily fractured areas with mica schists, coarse gneiss and friable gneiss will be encountered. The aquiferous carbonates that have to be passed through may be encountered as relatively dry since the dewatering in the pilot tunnel of the previous tunnel project is still active. The west drive will continue until shortly before the station at Mürzzuschlag where it will meet the cut-and-cover slope cut.

In order to verify and determine the exact location and extend of the fault zones and the aquiferous carbonates from the tunnel, extensive advance investigation measures will be carried out (with backflow preventer up to 50 bar).

Grouting is planned in the karstified carbonate rocks at the eastern end of the contract section, where water inflows of up to 300 l/s with pressure of about 23 bar are forecast. For this purpose, grouting caverns will be constructed in the geotechnically most favorable section at an appropriate distance from the area to be grouted. From these, 250 m long directed boreholes will be drilled around the excavated section and the rock mass grouted. The objective is to produce an improved ring around the excavated section to protect the tunnel drive from high water ingress.

Most of the grouting will however be necessary in the area of the shaft bottom and the adjacent running tunnels, where the Fröschnitztal valley is crossed. According to the forecast heavily fractured and softened coarse gneisses will be encountered, sometimes with components that are susceptible to erosion, tending to flow out under the corresponding water pressure. In
contrast to the grouting work on carbonate rocks, the main objective of the grouting work here is not to reduce the permeability of the rock mass but to improve the bonding of the rock mass. First experiences were gained in the course of the sinking of the second construction shaft.

8. OUTLOOK

The construction period for the contracts described above will extend into the year 2024, with tunneling continuing until 2023. From 2023, the installation of the railway equipment will follow, partly simultaneously, until the tunnel opens at the end of 2026. In order to achieve this target, great challenges with the geological and geotechnical conditions will have to be overcome during the construction phase, in order that rail service can start after opening.

9. LITERATURE

