THE 33 KM LONG KORALM TUNNEL – FINAL CHALLENGES IN THE IMPLEMENTATION OF A MAJOR PROJECT

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ABSTRACT

The Koralm railway is a double-track, electrified new railway section between the Austrian provincial capitals of Graz in Styria and Klagenfurt in Carinthia. The maximum operational speed is 250 km/h. The length is about 130 km and its centerpiece, the twin-tube Koralm Tunnel, is around 32.9 km long.

The tunnel construction work began in 2008 and ended with the final tunnel breakthrough in 2020. The railway equipment work began in 2019 and should be completed by the end of 2024. Commissioning will take place in 2025, and regular passenger traffic will begin at the end of that year.

Keywords: Koralm Bahn, Koralm Tunnel, railway tunnel, Trans European Network, Baltic Adriatic rail corridor

1. INTRODUCTION

The so called 'southern corridor', which includes the Koralm railway (*Koralmbahn,* "KAB"), is part of the 1'800 km long Baltic–Adriatic rail corridor of the Trans European Network – Transport (TEN–T). It represents the eastern transalpine north-south link and connects the ports and regions in the north (Baltic Sea, Baltic region, Poland) with Central Europe and the ports and regions in the upper Adriatic area [7].

The KAB, with a length of about 130 km, connects the Austrian federal regions Styria and Carinthia, and their capital cities Graz and Klagenfurt. The key element of this new route is the Koralm Tunnel ("KAT") with a length of 32.9 km and a maximum rock overlying of about 1'200 m. The two single-track rail tunnels are connected via cross-passages every 500 m. These serve as escape routes and also contain the necessary equipment for tunnel operation. An emergency station, approximately 1 km in length, is located between the two tubes near the center of the tunnel.

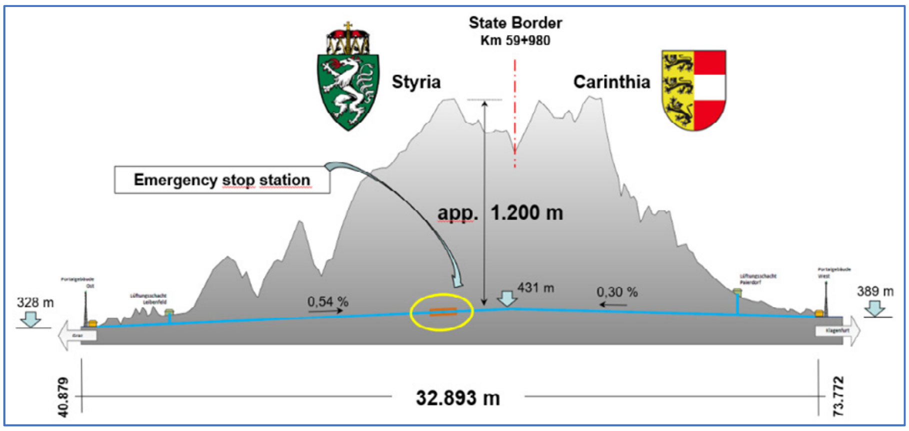

Figure 1: Koralm Tunnel overview – longitudinal cut

2. PROJECT HISTORY – PROJEKT STATUS

2.1. Introduction

Project planning for the KAB began in 1995. From 1997 onwards, the focus was on finding the route and conducting necessary investigations and preliminary studies. Dialogue with stakeholders in the regions was also carried out, and a consensus was reached. Based on this agreement, the necessary official procedures (environmental impact assessment, railway construction permit and numerous other relevant laws) were carried out in the following years. From 2000 to 2007, positive building permits were obtained step by step and in small increments. Construction work began immediately after each building permit was issued. The first new construction section, which serves as a connection to the KAT in Styria, could be put into operation for regional traffic as early as 2010 as a result of this procedure. The structural work will be completed in the following 14 years between 2008 and 2022. The first breakthrough between the east (KAT2) and west (KAT3) sections will take place in the south tube in 2018 and the final breakthrough on June 17, 2020.

Figure 2: Koralm Tunnel – final breakthrough June 17, 2020

This means that 18 years have passed between the first exploratory work in 2002, the start of construction of the three main construction lots KAT1 (2008), KAT2 (2011) and KAT3 (2013) and the final tunnel breakthrough in 2020. Until the planned commissioning in 2025, only 5 years, i.e. one fifth of the previous years, are available for the implementation of the railway equipment [11].

2.2. Railway Technical Equipment

Work on the railway equipment began in 2020, parallel to the ongoing construction. The first step was the construction of the slab track. Prior to or simultaneously with this, 13'000 elastically supported track slabs were produced for the KAT in Lower Austria (NÖ) and transported directly to the KAT in Styria by unit train, where they were laid, set and filled with self-compacting concrete (SCC).

Figure 3: Track support plates transshipment from road to rail / MABA in NÖ, October 2021

After completion of the roadway, the verges and sideways to the left and right of it, as well as all associated cable routes and shafts, were subsequently erected or concreted.

Figure 4: Koralm Tunnel – intermediate state of construction, December 2021

All subsequent activities, such as the transportation of further materials and equipment, as well as the transportation of people, could then only be carried out on rails. The cross passages are equipped with power supply systems, telecom systems, and telecontrol technology to transmit all data to the ÖBB control centers. In this setting, it is also necessary to install a large number of mechanical systems to protect the technical equipment from pressure peaks caused by fast moving trains in the track tubes and to remove the heat losses generated during operation.

Figure 5: Koralm Tunnel emergency station – intermediate state of construction, January 2024

As the KAT is ventilated by ventilation buildings and shafts located near the portal, both in the event of an incident and during maintenance operations, buildings had to be constructed on the surface in parallel with the work in the tunnel. Each building contains two axial fans for overpressure ventilation of the tunnel system.

Figure 6: Koralm Tunnel – West Paierdorf ventilation building, November 2023

Step by step, the entire tunnel is being brought to life and more and more usable and controllable content is being added to ensure reliable rail operations at the time of planned commissioning.

2.3. Logistics

Unlike tunnel construction, the equipment installation phase involves a large number of different trades and professions working simultaneously, either in a very confined space or widely distributed throughout the tunnel, to carry out the installations in the two tubes, the 70 cross-passages and the emergency station. The targeted and timely transportation of materials, starting with the receipt of materials on the construction site installation area, the onward transportation to the various installation points in the tunnel, in combination with the scheduling of useful work steps and processes with each specialist, requires forward-looking and detailed logistics planning across all trades. By continuously monitoring performance against targets, it is possible to quickly implement countermeasures and achieve the performance targets outlined in the construction contract.

The access options for the tunnel are only available through the KAT East and West portals. This presents a logistical challenge for transporting materials and staff. Other tunnel projects, such as the Lötschberg, Gotthard, Semmering, or Brenner base tunnels, have utilized intermediate accesses to create shorter and more accessible equipment sections.

2.4. Commissioning

A fully equipped and functional tunnel integrated into the ÖBB control systems should be available by the end of 2024 / beginning of 2025. The start of measurement runs, test runs and high-speed runs is planned for the beginning of April 2025, which should be successfully completed by summer 2025. In this context, it is important not to forget the "little things" such as the training (local and route knowledge) of more than 1,000 train drivers, dispatchers, emergency and safety personnel as well as future maintenance and repair personnel in this final and all-important phase.

After completing all sub-processes, the Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) should have all necessary documents, so that a positive operating permit for the KAT and the KAB can be issued in the fall of 2025.

2.5. Project Costs

Effective project management (including risk management and cost management) involves forming appropriate working groups at different decision-making levels to quickly and efficiently respond to changes. So far, KAB has been able to achieve a good balance between continuous change and cost-effective decisions, which is reflected in the fact that project costs have remained stable over the years. This level of stability has been achieved through consistent and continuous tracking of all cost components, ongoing consideration of all project risks, and prior value adjustment. The first cost estimates based on stable route planning were drawn up between 2004 and 2007. Up to one year ago, KAB's costs were kept at the internationally unique and unrivaled level of plus 1 %. Due to the pandemic and unforeseeable inflationary developments, the required project budget for KAB increased from € 5.4 billion to around € 5.6 billion (a 4 % increase). KAT's share of this is approximately 50 %, or € 2.8 billion.

3. SPECIAL PROJECT CHALLENGES AND INNOVATIONS

3.1. Introduction

Projects of this size present numerous challenges, particularly due to their long project duration of 20, 30, or more years. During these periods, laws, guidelines, standards, and the associated engineering and design approaches change. Moreover, the extended project environment can bring global changes in boundary conditions and project objectives, as well as fundamental changes in technology. In addition, it is important to consider the long-term foresight and future visions associated with these projects, spanning 50, 100, or even 150 years. From 1995 to 2024, the Koralm Railway has successfully maintained a balance between all these ongoing changes. This was achieved through the formation of working groups at various decision-making levels.

Some specific challenges will be discussed in more detail below.

3.2. Pressure Loads on Facilities in the Tunnel

The pressure loads in a railway tunnel caused by the continuous operation of the high-speed trains are a great challenge. Due to intensive fundamental research, useful design approaches have been found, which are now consistently applied to the dimensioning of various objects installed in the tunnel cross-section [3, 9, 10].

In this context, the tunnel doors should be mentioned in particular, as they play a crucial role in many ways. In case of an escape, the emergency exits should be easy to use and reliable. They also serve as a fire compartment between the tunnel and the cross-passage (safe area) and must remain fully functioning for a long period of time (30 to 50 years) with low maintenance and service requirements. In order to verify these requirements, load tests were performed using a servo-hydraulically controlled loading device with 1.5 million load cycles [8].

Figure 7: Emergency exit doors Koralmbahn – load tests in Vienna, March / July 2020

After considering all the advantages and disadvantages, it was decided to use sliding doors as emergency exit doors in all KAB tunnel sections [1, 13].

3.3. Fire Resistance

Tunnel doors often serve as fire barriers. To ensure technical feasibility, numerical CFD simulations were used to calculate potential temperatures and their time profile in the event of an incident.

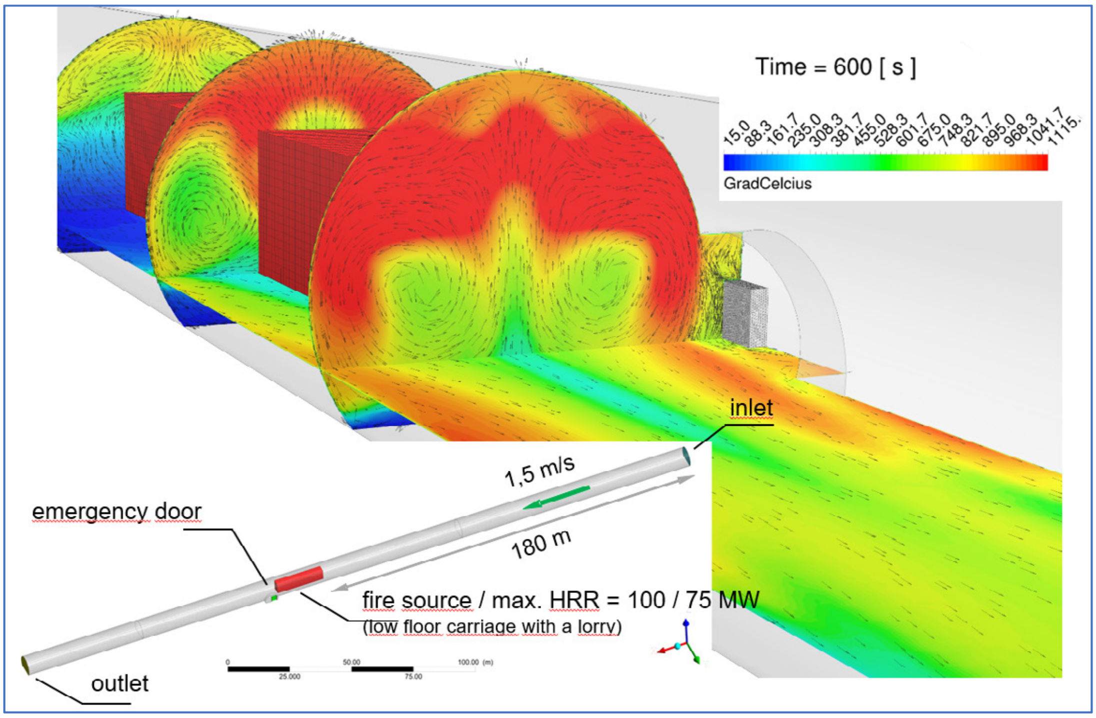

Figure 8: CFD simulation – results for 75 MW heat release rate after 600sec

In close consultation with consultants and experts, the decision was finally made to use the standard temperature/time curve ("ETK") as the design parameter for the doors of the KAB [5].

3.4. Ventilation and Cooling of Technical Equipment

In the KAT, most technical systems are located in cross-passages, which are then located in separate rooms. These rooms contain power supply switches that convert from medium voltage to low voltage, providing the necessary telecommunications and telecontrol systems for operational management. The heat losses must be removed reliably into the railway tunnels, where they are further distributed and discharged into the atmosphere by the rail traffic.

By considering various factors, including rock temperature and its changes over time, temperature distribution in the railway tubes, seasonal temperature curves at the portals, and global temperature trends, it was possible to develop an overall ventilation concept for the entire tunnel and its specific technical facilities. The decision-making process took into account the target temperature for the technical rooms, considering the system's service life (replacement cycles) that is dependent on temperature, energy consumption, the necessary maintenance and repair activities and the associated costs [2, 4, 6, 12, 14].

3.5. Building Information Modelling / BIM

The final phase of the structural implementation of the KAT utilized the BIM (building information modeling) method for the technical railway equipment. This served as a 3D planning tool to identify structural conflicts or collisions early on and as a data and information carrier during implementation, as well as support for maintenance and repair work required later [15].

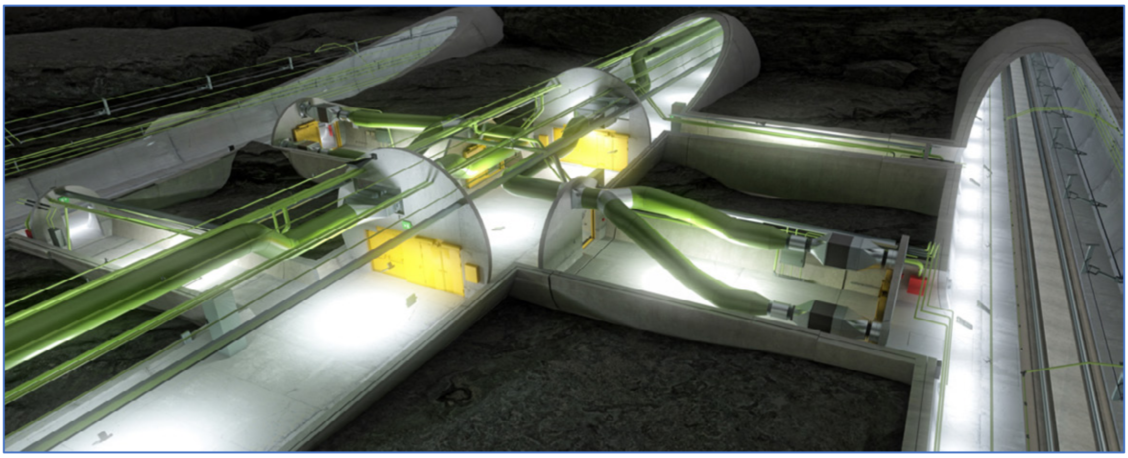

Figure 9: Koralmbahn – BIM method and a 3D view

4. SUMMARY AND CONCLUSION

Projects of this size can only be realized with a tight organizational structure and short, clear decision-making paths. The primary focus should be on identifying issues and making prompt decisions. In this context, decisions that are NOT made should definitely be viewed more critically than decisions that are made but may not be entirely correct.

The Koralm railway is scheduled to be fully operational for freight trains by mid-October 2025 and for passenger trains by mid-December 2025.

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