HIGHWAY AND TUNNEL CONTROL CENTRE S35 AT BRUCK/MUR AND SAFETY STANDARDS FOR TUNNELS ALONG THE S35 EXPRESSWAY

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ABSTRACT

ASFINAG is responsible for all planning, financing, construction, maintenance, operation and toll collection for the entire Austrian highway and expressway network - approximately 2,135km of roadway including 160km of tunnels and 2010km of bridges.

The construction programme for the current period, which runs through 2013 and has been confirmed by the overseer of ASFINAG, provides for about 7.8 billion Euro in investments into the expansion of the Austrian high-speed roadway network.

Simultaneously there is a need for expanding the existing roadway network as well as construction of new highway and expressway sections due to ever increasing traffic volume. ASFINAG Bau Management GmbH is planning and constructing both new high-speed roadway sections and second tunnel tubes for existing tunnels such as the section between Mixnitz and Bruck/Mur on the expressway S35 which is currently being completed.

The Austrian high-speed road network is operated by means of control centres, such as the control centre at Bruck, which are staffed round the clock. The construction of such control centres is overseen by the ASFINAG Bau Management GmbH.

1. INTRODUCTION: KIRCHDORF TUNNEL AND KALTENBACH TUNNEL

In May 2010 ASFINAG will open the second construction section of the expressway S35 Brucker Schnellstraße between Stausee Zlatten and Mautstatt (see Figure 1). The aims of this project are increased safety for roadway users and improved traffic flow. In addition, disturbances related to transit traffic for people living in the surrounding area will be significantly reduced. This expressway section (Stausee Zlatten – Mautstatt) is about 7km long and includes centrally two twin-tube tunnels, namely Kaltenbach Tunnel and Kirchdorf Tunnel, the construction of which is being carried out according to national and international standards and regulations.

Figure 1: S35 construction section Nord Stausee Zlatten - Mautstatt
2. OPERATION AND TUNNEL SAFETY EQUIPMENT OF THE KIRCHDORF TUNNEL AND THE KALTENBACH TUNNEL

The operation and safety equipment for both the Kirchdorf Tunnel and the Kaltenbach Tunnel are to be planned observing parts of the following national guidelines for road construction (RVS¹) in addition to international regulations (EU Directive).

Austrian Road Tunnel Safety Law
Operation and Safety Tunnel Equipment: RVS 09.02.22
Ventilation Tunnel Equipment - Fundamentals: RVS 09.02.21
Ventilation Tunnel Equipment - Calculation of Air Requirement: RVS 09.02.32
Tunnel Equipment - Lighting: RVS 09.02.41
Tunnel Equipment – Radio Communication: RVS 09.02.61

The current AADT for the local federal road is approximately 18,000 vehicles per 24 hour period, 20% of which are heavy transport vehicles. The traffic volume for 2017 is expected to be about 22,700 vehicles per 24 hour period. Due to these traffic estimates the Kaltenbach Tunnel and the Kirchdorf Tunnel are assigned as danger class II and danger class III respectively according to the Austrian RVS guidelines.

As the two tunnels are located very close to each other – only about 300m separates them – all facilities of both tunnels are designed in compliance with RVS 09.02.22 for danger class III.

The Kirchdorf Tunnel is a unidirectional tunnel; the first tunnel tube in the direction of Bruck is 2,647m long and the second tube in the direction of Graz is 2,787m long. Each tube has been equipped with two breakdown bays. The tunnel tubes are connected with a total of ten cross connections, eight of which provide the possibility for people to use and two may be used by emergency vehicles. The distance between the cross connections is on average about 250m. Both tubes are provided with 45 emergency phone areas (niches) which are spaced 120m apart. The IP emergency call system can be operated from both the local operation centre and the control centre at Bruck. In addition to the possibility for an emergency call from an enterable call box, people in need of assistance can trigger a SOS or fire alarm by pressing a button.

In both tubes, 49 fire extinguisher niches are arranged at regular distances of about 125m; they are equipped with hydrants and hoses of approximately 100m length with spray nozzles and there is also a power supply. In the breakdown bays, so-called wall hydrants containing foam admixes are installed. This facility essentially consists of a 60m long hose on a spool, a fire extinguishing foam dispenser and a spray unit.

When the door of the emergency call cabin or the fire extinguisher cabin is opened, a camera in the control centre at Bruck is automatically switched on. Making an emergency call, taking down a fire extinguisher or pressing an emergency button (fire and/or SOS) initiates the respective control programmes which start measures of various levels ranging from the imposition of speed limits to the complete closure of both tunnel tubes. In addition, various events such as traffic congestion, a driver driving in the wrong direction, smoke in the tunnel, vehicles in breakdown bays, etc. can be automatically detected by means of cameras which are installed at maximum distances of 125m.

The road pavement within the tunnel is made of concrete and the driving lane is bordered by two elevated hard shoulders which are demarcated using LED reflectors. If specific events occur these reflectors start blinking, either only in a certain section of the tunnel or over the entire tunnel length. Up to a height of four metres the tunnel side walls are coated with a clear

¹ Prepared and issued by the Austrian Association for Research on Road, Railway and Transport, Karlsgasse 5, 1040 Wien

5th International Conference ‘Tunnel Safety and Ventilation’ 2010, Graz
light-reflecting coating which can be easily cleaned. In addition emergency exit lights and highly reflecting emergency exit signs indicating the distance from the two nearest cross connections are installed in the walls at distances of respectively 50m and 25m in both the tunnel entrance and the exit area. In the tunnel interior zone the emergency exit signs are also spaced 25m apart.

Both tunnel tubes are equipped with tunnel radio facilities which can be used by the emergency services, the ASFINAG operating staff and traffic broadcast services.

The Kirchdorf Tunnel is equipped with a longitudinal ventilation system providing ten jet fans per tube, each of them having a power rating of 22kW and producing a shear force of 875N. The functioning of these ventilators at temperatures exceeding 400°C must be guaranteed for a time period of at least two hours. The appropriate functioning of the ventilation system is regulated by carbon monoxide and visibility measurements as well as by measurements of the longitudinal airflow. On the one hand, the ventilation system provides for overpressure in the tunnel tube which is not affected by the fire in order to prevent smoke from entering the tunnel tube and the cross connections. On the other hand it guarantees optimal stratification of hot smoke gases in the tube affected by the fire allowing people to escape exiting via the nearest cross connection.

The Kirchdorf Tunnel is the first tunnel in the world to be equipped with an acoustic monitoring system. In recent years the Austrian Research Association “Joanneum Research” in Graz in collaboration with ASFINAG has been testing a pilot acoustic monitoring system in the Plabutschunnel. This pilot system is intended to collect specific sounds and then save them in a database. In addition, in different tunnels various tests have been carried out and recordings made (e. g. a vehicle crashing against the tunnel wall) and the resulting sound data was entered into the database. This allows for real-time classification and evaluation of different events on the basis of characteristic sounds. After a specific sound has been detected several cameras automatically activate within the detection area. The sounds are detected by means of 54 microphones installed at an average distance of 100m. The evaluation is performed in the operation centre by comparing the relevant data with the archived data in the database; the results are then sent to the tunnel control system. On the basis of a decision matrix, the associated cameras are switched on automatically by the tunnel control system. Taking the relevant video information into consideration the tunnel operator chooses the appropriate control mode, in the worst case initiating a total closure of the tunnel.

The tube of the unidirectional Kaltenbach Tunnel in the direction of Bruck and that heading towards Graz have a length of respectively 1,014m and 1,109m and are equipped with breakdown bays; they are connected with each other by a total of four (4) cross connections at distances of about 230m. One (1) cross connection is intended for emergency vehicle use.

The equipment is principally the same as that of the Kirchdorf Tunnel but with differing numbers of emergency call niches (19), fire extinguishing niches (21), cameras (48), cross connections (1 EQ) and jet fans (14) used for tunnel ventilation.

ASFINAG has prepared special planning manuals which are intended to complete the national guidelines specifying in detail the facility designs defined in the applicable guidelines. In issuing these planning manuals, ASFINAG pursues the aim of setting an Austria-wide standard with regard to the design and the application of safety equipment for roadways and tunnels, streamlining operation, maintenance and operator training as well as inventory control for replacement materials. For example, the planning manual “Ventilation PLapPB 800.542.10” defines the requirement for only six standardised ventilators for longitudinal ventilation systems. All ventilation systems have to be designed and set up observing the regulations contained in the national guidelines RVS 09.02.31 and RVS 09.02.32, in addition the utilisation of the types of ventilators prescribed in the planning manual.
3. **INTRODUCTION: CONTROL CENTRE AT BRUCK/MUR**

The control centre at Bruck has been in operation since 1984. Until today all tunnel structures on the expressway S6 Semmering Schnellstraße between St. Marein and Leoben East and the open sections (i.e. the emergency call system) of the expressways S35 Brucker Schnellstraße and S36 Muralt Schnellstraße has been controlled from this centre. There are six (6) twin-tube tunnels (i.e. Tanzenberg, Bruck, St. Ruprecht, Oberaich, Niklasdorf and Massenberg) on the section of the S6 specified above. The section between St. Marein and Gloggnitz of the S6, including the tunnel structures Semmering, Spital, Steinhaus and Ganzstein, are currently controlled by the control centre at Mürzzuschlag.

The section of the A9 highway between Kalwang and the junction Deutschfeistritz/Peggau, including the tunnels Wald, Pretall, Gleinalm and Schartnerkogel, are currently monitored and controlled by the control centre at Gleinalm (Figure 2).

![Figure 2: Monitoring and oversight areas](image)

In 2005/2006 a study defining the pros and cons of consolidating the above mentioned control centres was carried out. On the basis of this research, ASFINAG prepared a new operation model envisioning the creation of a central control centre in Bruck for all monitored areas. Hence the new control centre at Bruck is to oversee both the existing and the planned new roadway sections as shown below (Figure 3).

![Figure 3: Area monitored by the control centre at Bruck after completion of the roadway network](image)
Thus the new control centre at Bruck will monitor open roadway sections with a total length of approximately 218km and tunnel sections having a total length of about 71.01km including 30 tunnel tubes.

This means that, after the completion of the planned roadway, the control centre at Bruck will be the second only to the control centre St. Jakob in Tyrol as to the length of the Austrian roadway network monitored.

In planning the control centre at Bruck, extensive research has been carried out focusing on ergonomic design, lines of sight and operating cycles (Figure 4 and Figure 5). The operating staff defined the most frequent operating cycles and weighed them by percentages. Then the lines of sight were analyzed along with the types of monitors needed to carry out operations with optimal arrangement of the monitors.

The findings of the research together with the expansion of the areas to be monitored suggest the need for eight process control monitors per operator (instead of four, as was used previously) as part of their immediate workspaces.

Due to the expansion of the area to be monitored (tunnels and open roadways) the control centre is now staffed by two operators and also has an additional workplace.

The new facility arrangement of the control centre has three workplaces, two of which are staffed round the clock and one for the supervisor.

In front there is a video wall including 16 (2 rows of 8) 70” monitors for the display of both video images and data visualisation (Figure 7).

All three of the operating desks are ergonomically designed and adjustable for height in order to guarantee optimal desk fit and monitor height for the operating staff and supervisor. Operators are free to choose whether to do their work standing or seated and can adjust the angles and height of the monitors.

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2 After completion, taking into account the section of the S36 between Judenburg and Scheifling and the second tube for the Gleinalm Tunnel.
In order to comply with all requirements and regulations contained in the applicable standards, a model desk was assembled for assessing both correct lines of sight and sitting positions. An expert in ergonomic design was involved as a consultant throughout the planning of the control centre. This was particularly important for the overall design and the graphic set-up of the entire screen layout focusing on colour design for images and distance-based type sizes in compliance with the regulations.

The construction of the entire addition to the existing control centre has been carried out without causing any traffic restrictions in the monitored areas.

The existing control centre equipment was temporarily put into storage while the modifications to the control centre were carried out as described below:

As the Tanzenberg, Bruck, St. Ruprecht, Oberaich, Niklasdorf and Massenberg tunnels had previously been provided with redundant connections to the control centre at Bruck, a parallel operating facility could be set up before establishing the temporary control centre. This was done by installing a gateway in one of the redundant connections through which the existing data were transformed into the IEC standard protocol 60580-4-104 in order to transmit them to the control centre at Bruck via the fibre optic cables of the ASFINAG telecontrol system.

At the same time the processor designed for the new control centre which already contained the future visual data representations was installed in the temporary control centre.
After putting the processor into operation in the temporary control centre, the data connection to the existing control centre was cut and the facilities were completely disassembled in order to install the new facilities in the room.

As the new connections to the control centre are likewise redundant and there are three fully equipped operating desks, the new control centre could at the same time be put into operation after installing additional processors.

The new control centre at Bruck was completed and put into operation in August 2008 (Figure 8); it then started monitoring the section between St. Marein and the junction at St. Michael of the S6 expressway.

The new control centre includes a crisis intervention room which is located directly adjacent to the monitoring and control room; it is acoustically separated by a glass wall in order to provide a good view of the video wall for the emergency services personnel who may ask the operator for specific TV images of the tunnel concerned. (Figure 9).

All radio services can be operated from the crisis intervention room.

In 2008/2009 the monitoring system of the renovated Tanzenberg Tunnel was completely integrated into the control centre; this required no more effort than carrying out adaptations in terms of data and visualisation systems. Likewise the remaining tunnels (i.e. Bruck, St. Ruprecht, Oberaich, Massenberg and Niklasdorf), which will be completely refurbished within the current period which runs through 2014, will also be integrated.

As provided for in the ASFINAG protocol, all tunnel structures are connected to the control centre via an interface (the so called “tunnel head”) installed in the respective operation centre which transmits the relevant data in the form of an IEC protocol to the control centre.

The integration of the Kirchdorf Tunnel and the Kaltenbach Tunnel on the expressway S35 Brucker Schnellstraße has been carried out in the same way, i.e. the connection to the control centre functions via an interface installed in the operation centre.

In summer 2010 the Semmering Tunnel Chain (currently monitored by the control centre at Mürzzuschlag) as well as the both the Gleinalm Tunnel and the Schartnerkogel Tunnel (currently monitored by the control centre at Gleinalm) will be integrated into the control centre at Bruck.

Lastly the section between Judenburg and Scheifling and the second tube of the Gleinalm Tunnel will be completed and integrated into the control centre at Bruck which will then be in full operation; a summary of the information is listed below:
With this I would like to close my presentation. Thank you for your attention.