Appendix 2.1 - AUSTRIA – Vienna – Kaisermühlentunnel

1. SUMMARY – A NEW MULTIMODAL TUNNEL

The "Kaisermühlen" tunnel is located in the city of Vienna (Austria). The Kaisermühlen tunnel is a motorway tunnel in Vienna and part of the Danube highway A22. It is the longest road tunnel in Vienna carrying the highest traffic load in a tunnel in Austria (~155.000 vehicles/day – 2014). It is designed as a cut and cover tunnel crossing the Donau City, Reichsbrücke and residential complexes in the Kaisermühlen district (**Figure 1**). The tunnel runs parallel to the Danube river.

Figure 1 - Kaisermühlen tunnel location

The Kaisermühlen tunnel is owned and operated by "ASFiNAG" - a state-owned company.

The tunnel was put into operation in 1988 from the east portal to Reichsbrücke (1 km) and in 1994 from Reichsbrücke to Kagran (1,2 km) with 2 tubes and four lanes in each tube (**Figures 2 and 3**). Multiple ramps, collector and access roads make this tunnel a complex underground road system.

Currently the tunnel no longer complies with the Austrian regulations. ASFiNAG decided in 2010 to launch a refurbishment programme in order to improve the safety level and to comply with the European Directive 2004/54/EG and the national regulations (RVS). This includes an upgrade of the operation and safety facilities as well as the ventilation system.

2. MAIN CHARACTERISTICS

2.1 GEOMETRY

- Tunnel length: ~ 2.150 m
- Horizontal alignment: ±0,50 %
- Vertical alignment: 2,50 %
- Ramps: 10 ramps
- Breakdown lanes: 1 break down lane in each main tube
- Height of the traffic room: ≥ 5,10 m

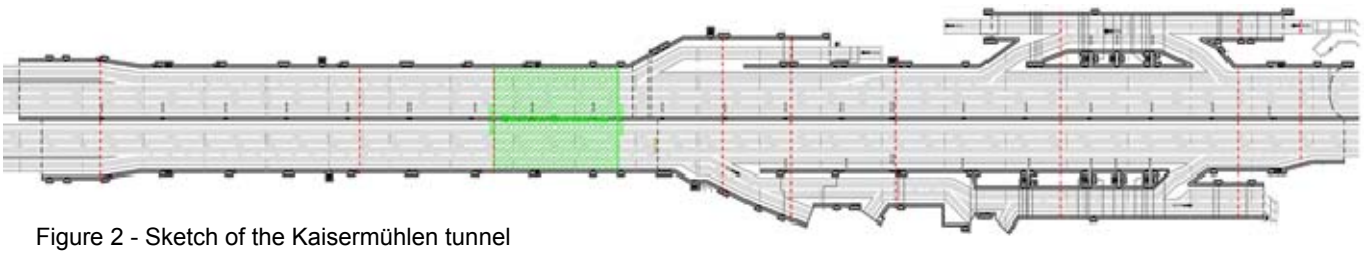

Figure 2 - Sketch of the Kaisermühlen tunnel

Figure 3 - Longitudinal profile of the Kaisermühlen tunnel

2.2 CROSS SECTION

2.2.1 Road tunnel

The cross section of the road tunnel is shown **Figure 4** below. The main characteristics are:

- Lane width main tunnel: min. 3,25 m in both tubes
- Lane width exit and entrance ramps: min. 3,70 m
- Vertical clearance: ≥ 5,10 m

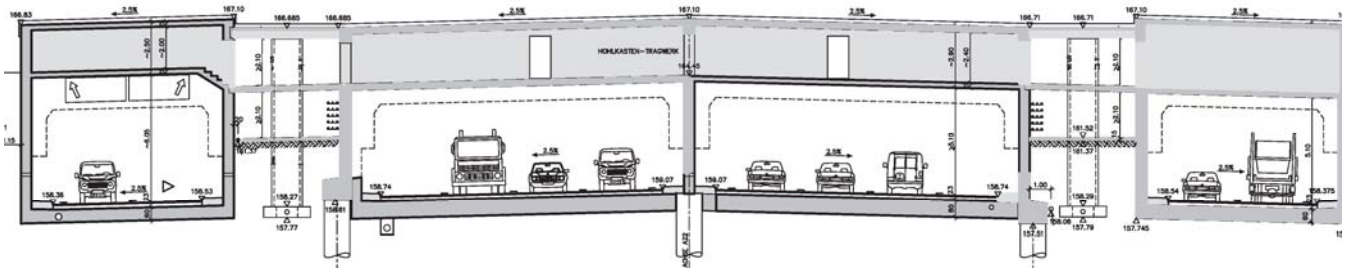

Figure 4 - Cross section of the road tunnel

2.2.2 Escape route

- Staircases: 4, closed by doors and ventilated (**Figure 5**)
- Cross passages between the tubes: 27 with at a spacing of 100 m

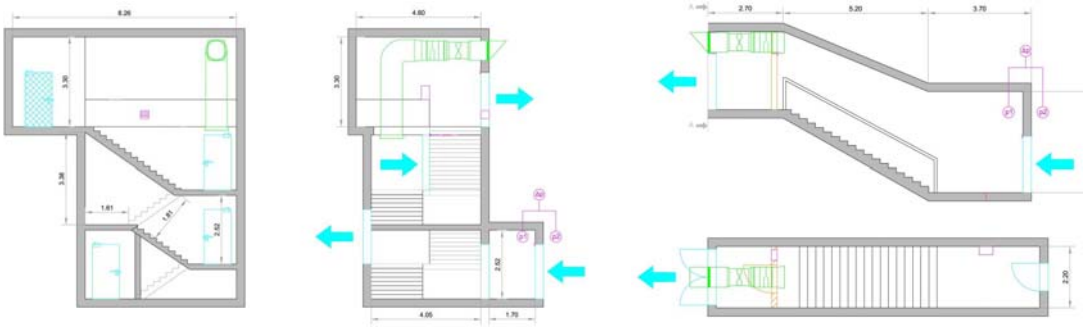

Figure 5 - Staircases

2.3 TRAFFIC CONDITIONS – BREAKDOWNS AND ACCIDENTS

- HGV traffic: allowed
- Hazardous goods vehicles: allowed
- Buses: allowed
- Bicycles and pedestrians: prohibited
- AADT (annual average daily traffic): 155.933 veh. / day (2014) with a growth of about 0,5 % per year
- Speed limit PCU: 80 km/h (enforced)
- Speed limit HGV: 60 km/h
- Particular speed during peak hours: between 25-35 km/h
- Detection of traffic jam: Loops inside the tunnel with alarm to the operator

2.3.1 Present Traffic conditions

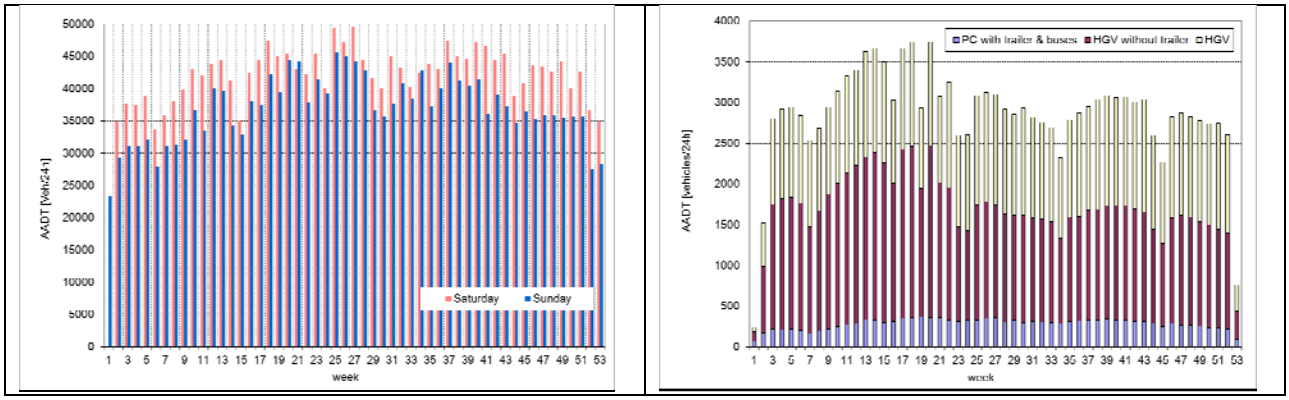

Figure 6 - Yearly traffic on Sunday and Saturday (left), yearly traffic amount HGV (right)

2.3.2 Breakdowns and accidents before refurbishment

The number of accidents during the period from 01.01.2006 until 01.01.2013 is as follows:

- Inside the tunnel: 70 accidents
- Outside the tunnel: 22 accidents

2.4 VENTILATION

2.4.1 Ventilation of the main tunnel

The main tunnel is equipped with a longitudinal ventilation system. Reversible jet fans are situated near the portals **(Figure 7).**

Normal operation with regular longitudinal ventilation depending on measured values of

- Visibility, carbon monoxide and air velocity (≤ 10 m/s)

Incident ventilation has the following objectives:

- designed in order to reach air-velocities in the traffic space of about 2,0 m/s
- control of the longitudinal air flow in case of fire
- in case of fire air-velocities of about 1,5 m/s – 2,0 m/s must be reached

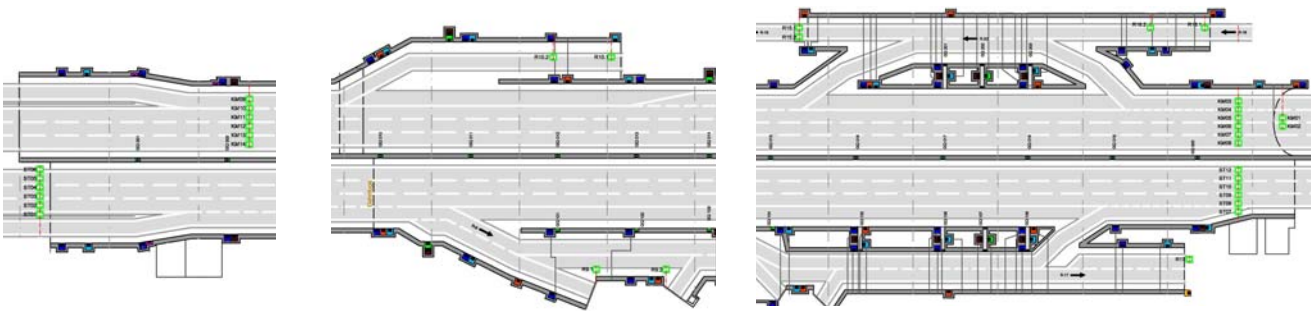

Figure 7 - Sketch of the ventilation system in the main tunnel

The ventilation system is managed automatically by the SCADA system for normal operation and incident ventilation. In the case of fire the ventilation system operates in specific emergency modes to provide the appropriate response to assure the safety of the tunnels.

2.4.2 Ventilation of the ramps

The ventilation system in the ramp sections is managed by jet fans in the main tunnel and additional jet fans in the ramp sections to achieve the required velocity in the ramp sections **(Figure 8)**. Depending on the location of the fire, the ramp sections may be used as a path for smoke removal in order to limit the smoke-affected area inside the tunnel.

Under normal operation conditions:

- no specific ventilation provided in the ramps.

In the case of an incident

- control of the longitudinal air flow in the ramps in case of fire in order to support the incident ventilation in the main tunnel.

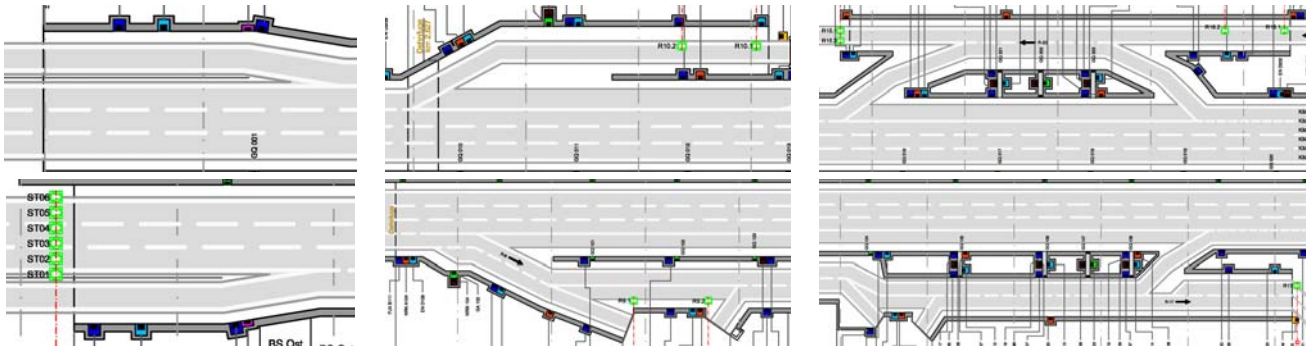

Figure 8 - Sketch of the ventilation system in the ramps

2.5 ENVIRONMENTAL ISSUES

2.5.1 Air quality

There is no consideration of the environmental impact of pollution dispersion outside the tunnel.

2.5.2 Noise

The jet fans are equipped with silencers.

2.5.3 Water quality

Water is collected inside the tunnels with continuous slotted gullies, which lead to tanks located at the tunnel portals. Tanks are equipped with decant and oil separator systems.

2.6 FACILITIES AND OPERATION EQUIPMENT

The two tubes are equipped with all the standard operation and safety equipment. Particular attention has been given to the systems for communication with users, traffic management and safety systems: impact absorbers, CCTV, AID (automatic incident detection), heat detection cables etc.

2.6.1 Audio tunnel monitoring (AKUT)

Microphones transmit data to a dedicated database. Specialist software is used to differentiate between the normal sound of the traffic and unusual noises such as collisions or screeching brakes. Any alarm automatically activates the camera nearest to the abnormal sound source; so that staffs in the control centre are alerted and can respond immediately.

2.6.2 Impact absorbers

Impact absorbers at the portals, and at locations where the ramps branch off from the main tunnel, are provided to reduce accident severity or direct errant vehicles back onto the traffic lane.

2.6.3 Power supply

In case of emergency, the tunnel has an autonomous power supply system (transformers, emergency generators).

2.6.4 Fire extinguisher points

Fire extinguisher points containing a stand pipe are installed every 125 to 150 m. The fire extinguisher points are placed in accordance with the requirements of the local fire brigade.

2.6.5 High-tech tunnel monitoring

A range of high-tech systems such as video image evaluation and fire detectors (linear heat detectors) enable quick responses to any incident. The opening of doors is monitored with door contact switches. Emergency signals – SOS or fire – can be activated by manual and automatic alarms.

2.6.6 Information systems

To ensure that drivers are kept fully informed about traffic conditions, a range of information systems such as loudspeakers, information boards, radio announcements and variable messages signs are available.

2.6.7 Intelligent light systems

Illumination sensors ensure optimum lighting for human vision at all times. The brighter it is outside the tunnel, the brighter it will be in the entrance portal zone. This allows appropriate adaptation of the eyes to the illumination level.

2.6.8 Emergency phone systems

Emergency phones with illuminated compartments are located approximately every 125 m in the tunnels.

2.6.9 Traffic

The tunnel is fitted with CCTV which transmits images to the tunnel control centre. Sensors in the tunnels provide additional information about traffic levels, visibility and air conditions. In the case of disruptions, traffic can be quickly managed by the tunnel operators.

2.6.10 Section control

Section Control ensures a uniform vehicle speed within the monitored road (**Figure 9**). On sections with high risk of accidents, this improves road safety. Since this system was installed in 2003, the average speed of cars has fallen by 10 km/h and that of HGVs by 15 km/h. The number of accidents involving injuries has dropped by a third.

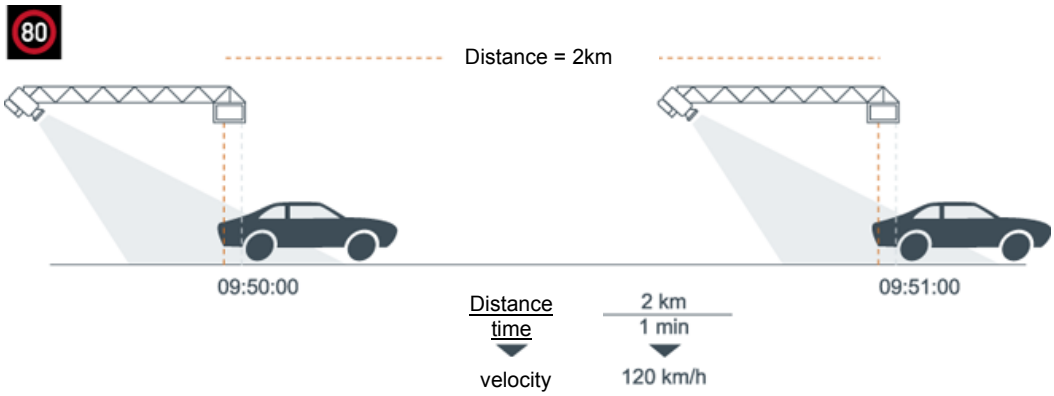

Figure 9 - The average speed of the vehicle is calculated over a defined section of road

3. OPERATION

The Kaisermühlen tunnel is operated by a central supervision centre (manned 24h / day).