Appendix 2.6 – FINLAND Helsinki – Service tunnel KEHU

1. SUMMARY – THE "HELSINKI CITY SERVICE TUNNEL" (KEHU)

The tunnel network is located in the city area of Helsinki, Finland (**Figure 1**). There are 610,000 inhabitants in the city and 1.2 million in the metropolitan area.

A long-term strategy for the future development of Helsinki's "Underground City" includes a new service tunnel network, which has been constructed to remove commercial supply traffic from the surface of the historic city centre. The 2.2 km service tunnel is also used to service shops, restaurants, offices and hotels in the area as well as three large underground parking facilities.

There is also access to a large electricity station and some service areas dealing with the district heating systems. It is forbidden to drive with private cars through the tunnel itself – these may only travel to the underground parking areas. Some parts of the tunnel are also equipped as civil shelters.

KEHU tunnel is a hard rock tunnel and consists of two different portals, one from the west for all cars and one from the east for service transport only. The tunnel was built in two parts – the old part in the 1980s (grey colour on the right site **Figure 1**) and the new one from 2006 - 2010. It is intended that the current tunnel network could be enlarged quite easily in the future if needed.

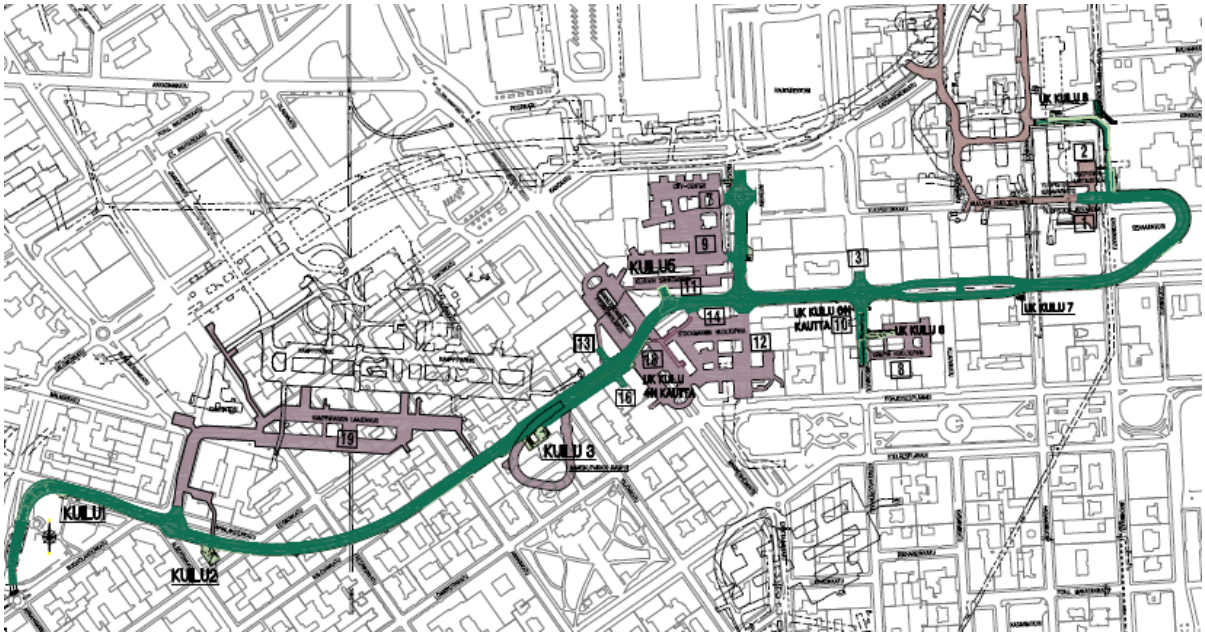


Figure 1 – Helsinki Service Tunnel

2. MAIN CHARACTERISTICS

2.1 GEOMETRY

The main geometrical characteristics are as follows:

- Tunnel length: 2,200 m. It is the length of the main tunnel and the branches in green colour shown **Figure 1**,
- Horizontal alignment: curve. The minimum radius is on the roundabouts,
- Vertical alignment: max 7% (**Figure 2**)

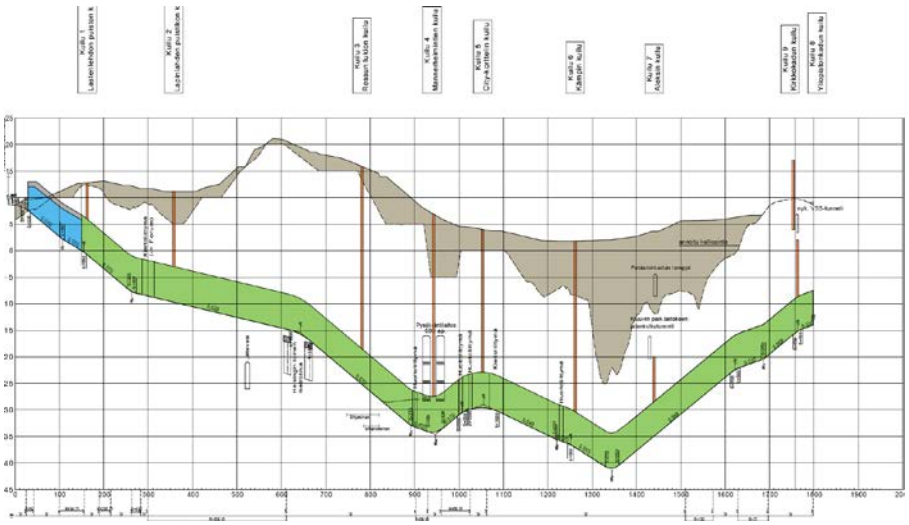


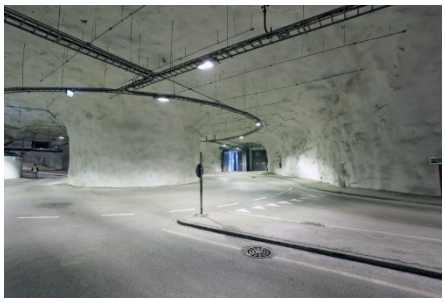
Figure 2: vertical alignment max 7%

2.2 CROSS SECTION

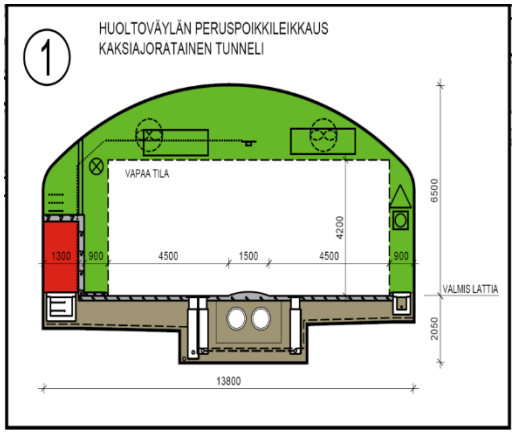
The main characteristics of the regular cross section are as follows (**Figures 6 & 7**):

- Total tunnel excavated width between tunnel walls: 13.6 m,
- Carriageway has two lanes of 4.50 m width and a central reserve of 1.50 m,
- Vertical clearance of 4.20 m,
- Walkways for pedestrians on each side of width 0.90 m,
- A pressurized pedestrian escape gallery of 1.30 m width and 2.30 height is located within the tunnel cross section,
- Four roundabouts, located on the main crossings with the branches

The **Figures 3, 4 & 5** below show the concept of a crossing with a roundabout and the two portals.



Figures 3, 4 and 5: roundabout in KEHU (3), the west portal (4) and the east portal (5)



Figures 6 and 7: cross section and picture of the service tunnel

2.3 ESCAPE ROUTES

- Pressurized pedestrian galleries lead to vertical stairs (equipped with lifts) and to the outside. The escape doors linking the escape gallery to the tunnel have a spacing of 90 m,
- Signalling of the emergency exits with a spacing of 25 m,
- Safety lighting during at minimum 60 minutes,
- Variable messages system and emergency voice guidance system.

3. TRAFFIC CONDITIONS, TRAFFIC SITUATION

3.1 TRAFFIC CONDITIONS – BREAKDOWNS AND ACCIDENTS

- Traffic inside the tunnel is bidirectional,
- AADT (Average Annual Daily Traffic) of 2,500 veh/day with a peak of 230 cars per hour,
- HGV traffic and dangerous goods are forbidden and the length of the lorries is limited to 12 m,
- Pedestrians and bicycles are not allowed inside the tunnel,
- Speed limit of 30 km/h, enforced by police control,
- No traffic incidents or breakdowns noticed in the tunnel, but one car fire in the parking area.

3.2 TRAFFIC SIGNALS / CONGESTION

- No congestion inside the tunnel,
- Queues of up to 5 cars occur occasionally in the entrance of parking area.

4. VENTILATION

4.1 VENTILATION SYSTEM FOR THE SERVICE TUNNEL

4.1.1 Description of ventilation system

The ventilation of the service tunnel is a longitudinal system, featuring reversible jet fans.

The ventilation system also has 9 vertical shafts with a performance from 80 to 104 m^3/s. They are operated either to supply fresh air or to extract the smoke in the case of fire, (**Figure 8**).

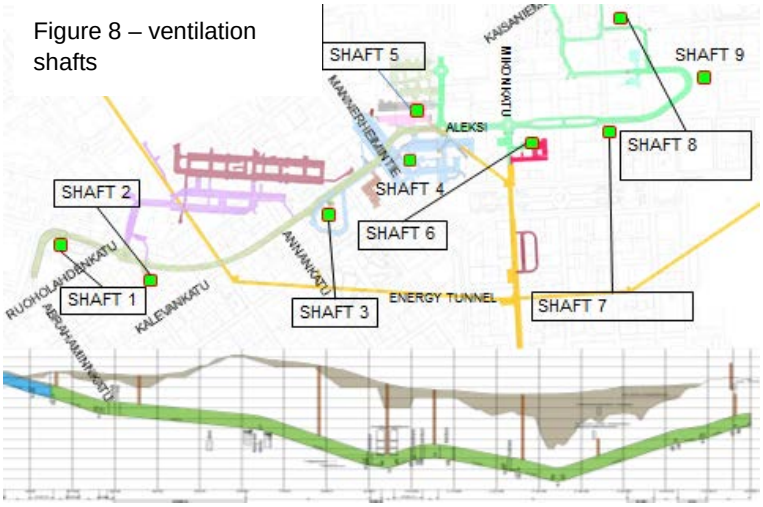


Figure 8 – ventilation shafts

4.1.2 Provisions in the case of fire

The tunnel is equipped with curtains located at the bottom of ventilation shafts (**figure n°9**). They enable compartmentalization of the tunnel in short independent sections, reducing the spread of smoke, and increasing the combined effectiveness of jet fans and ventilation plant for smoke extraction.

There are more than a dozen automatic scenarios (**Figure 10**) depending on the position of the fire. The general concepts are the following:

- linear detection of the fire with a cable,
- Automatic activation of the signalling for tunnel closure and of the VMS (variable message signage) for informing the tunnel users,

Figure 9 – curtain and FFFS at the bottom of a shaft

- Automatic start-up of the ventilation of the escape galleries,
- Automatic start-up of the smoke exhaust ventilation: scenarios implement either longitudinal ventilation to push the smoke to the portals, or longitudinal ventilation in the relevant section, associated with smoke extraction through the shafts, as well as a fresh air supply,
- Automatic activation of the FFFS "fixed firefighting system" in the area concerned,
- The closing of the curtain is activated by the operator (or fire-fighters) after controlling that no more is remaining the section concerned by the fire.

The operators in the control room and firefighters (in radio contact) can adapt the ventilation strategy at any time based on observed conditions

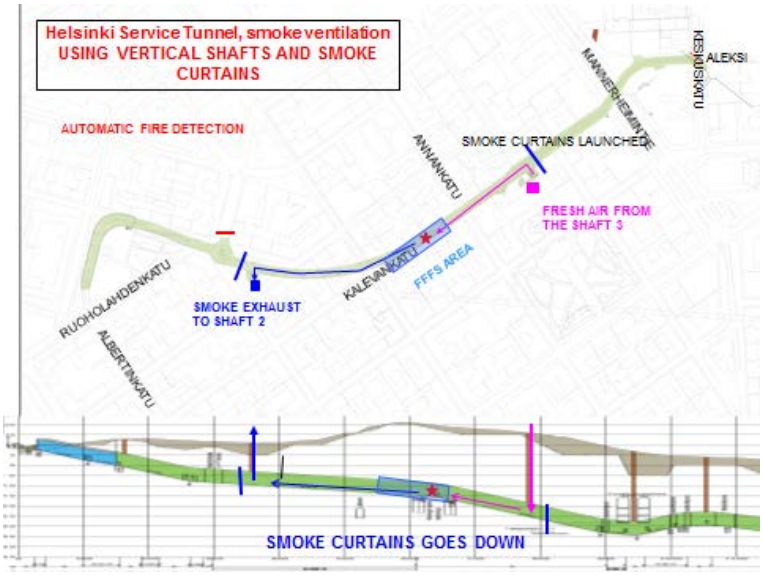


Figure 10 – mix scenario for smoke extraction involving: curtains, smoke extraction, fresh air supply

The intervention of firefighters is done initially via the shafts from the surface using elevators. Vehicles enter the tunnel as soon as conditions make the access possible.

4.2 VENTILATION SYSTEMS FOR OTHER AREAS CONNECTED TO SERVICE TUNNEL

All the other areas have their own independent ventilation systems. Most of them are also equipped with their own FFFS (Fixe Fire Fighting System).

5. OPERATION AND SAFETY EQUIPMENT

5.1 SAFETY EQUIPMENTS

KEHU tunnel has following safety equipments:

Passive fire safety equipments

- The structure of the tunnel is fire rated for 120 min,
- The tunnel is divided into sections that can be closed by doors in case of fire. The door are fire rated for 60 min,
- Fire hydrants with a spacing of 100 m.

Active fire protection

- Automatic fire detection system with cable,
- Fixed firefighting system (FFFS) with Hi-fog,
- Smoke exhaust from the ventilation system,
- Doors that can be closed during a fire in order to limit the extension of the smoke,
- CCTV system.

Protection against flooding risks

- All the entrances are situated higher than the expected flooding level,
- The shape of the entrance is made so that water cannot run easily to the tunnel,
- Large flooding reservoir of 2x300m³ inside the tunnel,
- All large water pipes (water and heating network) are identified and regularly controlled in order to prevent damage due to leakage inside the tunnel. Pipes close to the tunnel entrances are isolated with a barrier.

5.2 OPERATION

The KEHU tunnel is operated by the Traffic Control Centre 24/7. This control centre is situated 300 km north from Helsinki. KEHU has also a local control centre inside the tunnel which is normally unmanned but gives the rescue personnel all possibilities to operate the tunnel,

All the other facilities connected with the KEHU tunnel have their own supervision system. The main facilities have a supervision centre with operator. The smaller facilities have automatic fire detection only.

There are about 40 interfaces between the tunnel and the connected facilities. Each interface is equipped with two fire-rated doors, one operated by the tunnel operator and the other one operated by the facility operator. All the fire alarms from the KEHU tunnel and the facilities are reported to the Traffic Control Centre, which has a global overview of the situation.

The Helsinki city rescue department takes charge of the overall intervention and coordination in case of fire.