Appendix 2.2 - BELGIUM – Brussels – Leopold II Tunnel

1. INTRODUCTION

The Leopold II tunnel is located in the city of Brussels (170,000 inhabitants), the centre of a metropolitan area of about 1,100,000 inhabitants. The Leopold II tunnel also runs through the communities of Molenbeek, Koekelberg and Ganshoren, between the Place de l'Yser and the Basilique de Koekelberg, passing under the Charleroi canal **(Figure 1).**

This structure deserves special attention because of:

- Its length: two separate tunnels 2,534m long, which makes it the longest tunnel in Belgium and one of the longest urban tunnels in Europe,
- Its complexity.

The Leopold II tunnel has indeed several intermediate approaches and exits as shown in **figure 2**:

- In the suburbs direction:
  - One intermediate approach at the level of the Rue du Chœur;
  - One intermediate exit at the level of the Rue de l'Ourthe;
  - One intermediate exit in the Parc Elisabeth;

- In the city direction:
  - One intermediate approach in the Parc Elisabeth;
  - One intermediate approach at the level of the Rue de l'Ourthe;
  - One intermediate exit at the level of the Rue du Chœur;

The Leopold II tunnel is located under the Boulevard Leopold II which is an extension of the Brussels "small ring" in the direction of the E40 motorway to Gand and Ostend. The Boulevard Leopold II has sections with two or three traffic lanes, while the Leopold II tunnel has two traffic lanes throughout except in the side approaches and exits which only have one traffic lane each.

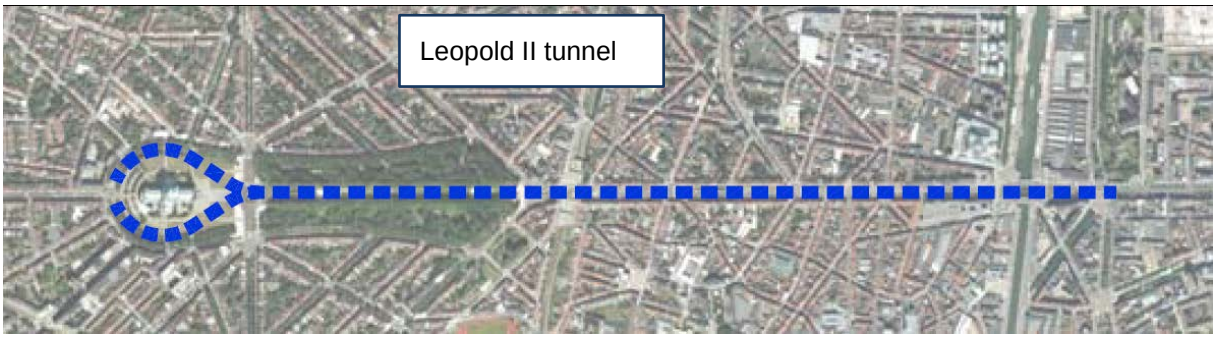

Figure 1 - Leopold II tunnel location

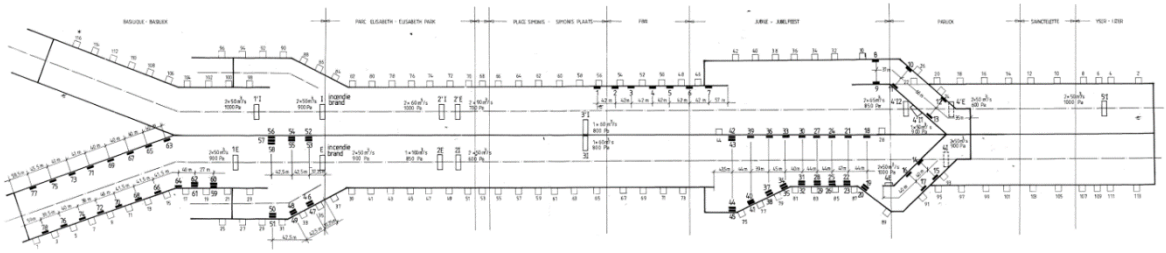

Figure 2 - Leopold II tunnel sketch

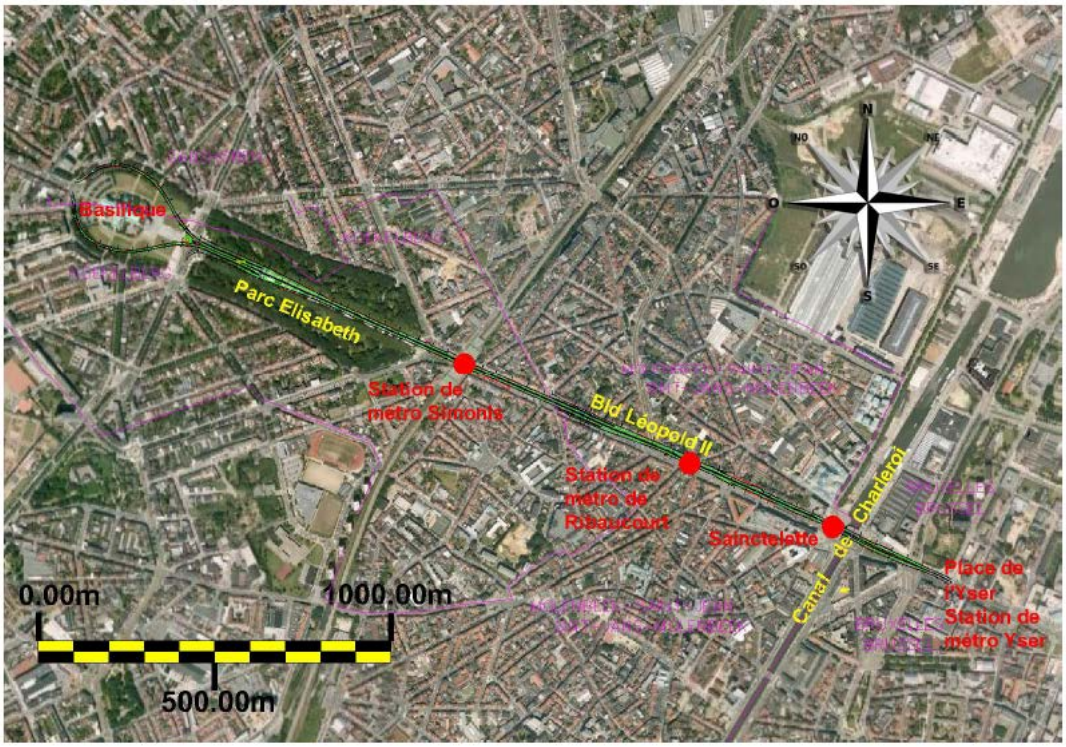

Figure 3 - Leopold II tunnel lay out

The Leopold II tunnel is a shallow tunnel constructed underneath the Leopold Avenue **(Figure 3)** using the "cut and cover" method. The construction works started in December 1980 and the tunnel was put into operation in July 1987.

The tunnel includes two traffic cells separated by a central continuous wall that supports the structure and separates the two traffic spaces. Thus the tunnel has two tubes, one in each direction.

2. CHARACTERISTICS

2.1 GEOMETRY

The overall length of the tunnel is 2,616 m. It includes 8 sections:

- Yser section: length: 215 m
- Sainctelette section: length: 115 m
- Paruck section: length: 325 m
- Jubile section: length: 468 m
- Boulevard Leopold II section: length: 225 m
- Simonis section: length: 200 m
- Parc Elisabeth section: length: 348 m
- Basilique section:
  - North loop: length: 670 m
  - South loop: length: 720 m

2.2 CROSS-SECTION

The main characteristics are:

- Width of the lanes: 3,00 m,
- Two lanes in each direction **(Figure 4),** except in front of the merging or exit lanes **(Figure 5),**
- Width of the roadway between the pedestrian walkways: 6,60 m,
- Only one lane on the ramps,
- Vertical clearance: 4,00 m,

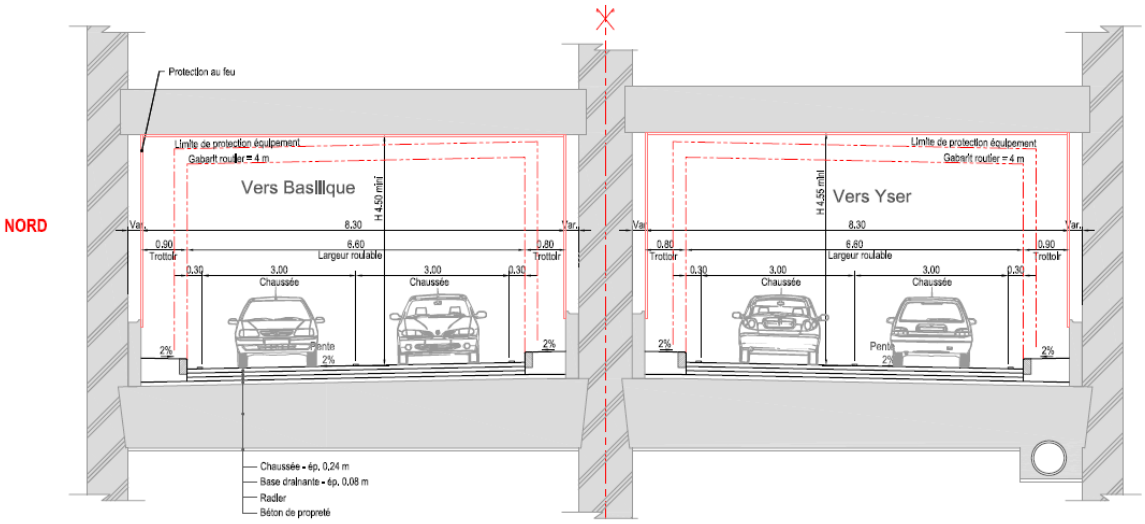

Figure 4 - Leopold II regular cross section

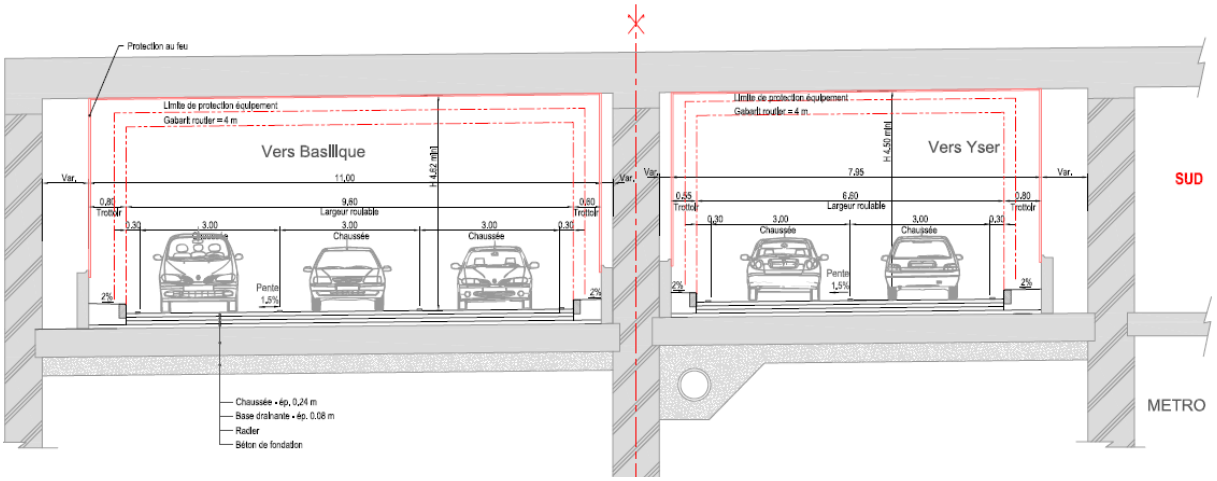

Figure 5 - Leopold II tunnel - cross section near Basilique

2.3 EMERGENCY EXITS

Thirteen emergency exits are distributed in the two tunnel tubes, leading to the outside of the tunnel. These emergency exits are not pressurized.

Exits are provided by stairs. Exits are closed by a remotely operated horizontal trap door.

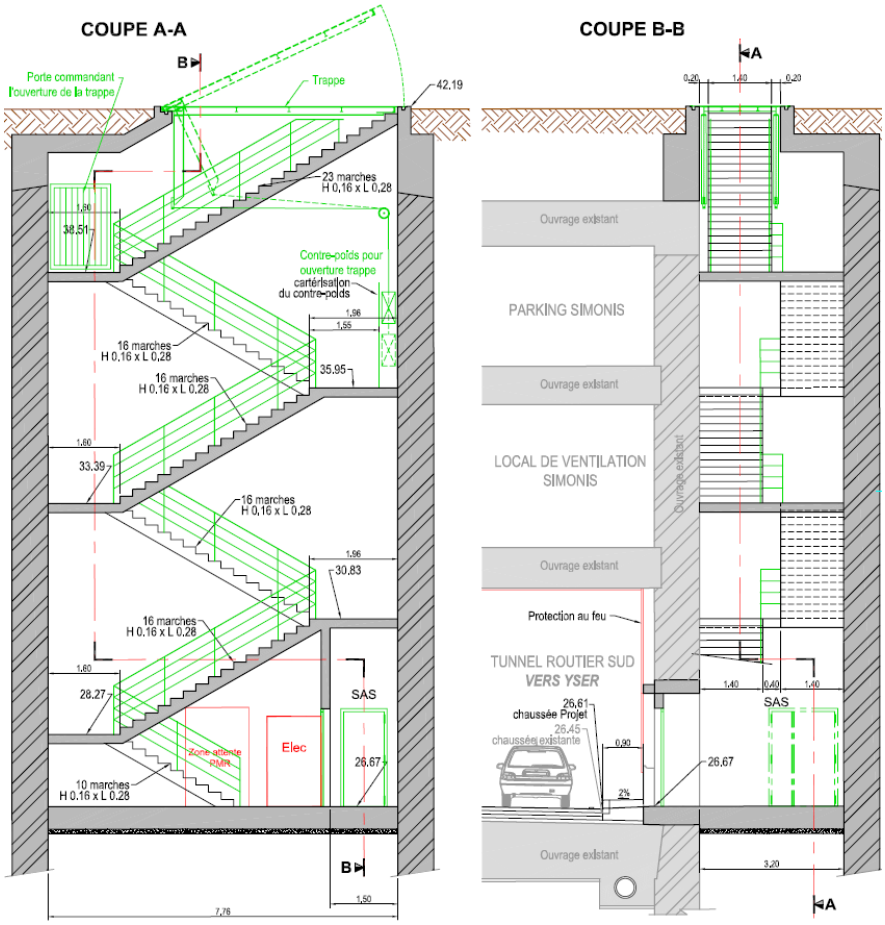

Figure 6 - Sketch of the emergency exit in the Leopold II tunnel

2.4 TRAFFIC CONDITIONS

2.5 TRAFFIC

The AADT (Annual Average Daily Traffic) is 30,000 vehicles in each direction.

2.5.1 Road tunnel

- Speed limit 70 km/h in the tunnel and 50 km/h at the tunnel exits
- With a traffic gauge height of 3.50m and < 3.5T, the tunnel is prohibited to Heavy Goods Vehicles and to the Transport of Dangerous Goods.
- Bicyclists and pedestrians are prohibited.

2.5.2 Incident

- Fire: on average there are 1.5 incidents per year.
- Traffic incidents: on average there are 24 incidents per year.
- On average there are 151 breakdowns.

2.6 VENTILATION

2.6.1 Ventilation system in the road tunnel

The Leopold II tunnel has 12 exhaust fans, 16 supply air fans, and 78 Jet-fans distributed in the two tubes.

The ventilation installation is longitudinal with mass extraction (air renewal) at two points in each traffic direction. The supply of fresh air and the exhaust of foul air is achieved using variable flow supply or exhaust fans combined with the jet-fans.

The incoming fresh air is provided through shafts emerging at the ground surface. These shafts are equipped with sound attenuation and grilles at ground level. Some of these grilles are located on the surface roads.

Some ventilation plants are accessible from outside the tunnel by means of traps in the ground and access ladders. Other ventilation plants are accessible from the tunnel.

Ventilation for pollution control in the tunnel is linked to the air quality monitors and the traffic flow monitoring in the tunnel (TRAFICON link).

2.6.2 Smoke extraction ventilation

The SCADA system enables the automation of the ventilation according to the monitored values in the different tunnel sections.

The fans also perform the mechanical smoke extraction ventilation **(Figure 7)**.

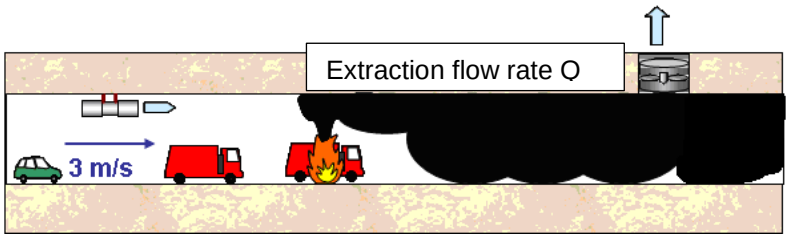

Figure 7 - Fire simulation

SCADA activates the exhaust air mode on the base of the alarm transmitted by the fire detection equipment and the PLC.

2.6.3 Ventilation of the emergency exits

All the emergency exits are connected to the ground surface with no provision for mechanical ventilation.

2.7 ENVIRONMENT

2.7.1 Air quality

The carbon monoxide (CO) content is measured using electrochemical cells (ADOS 592 sensors, arranged in boxes in the refuges). There are 35 sensors in each traffic bore. These are in situ sensors.

Two measurement points for NO/NOx (one in each tunnel bore) provide data recorded by the SCADA system. These different sensors are arranged in ten groups per traffic direction and connected to a central unit that transmits alarms to the SCADA and PLC installations for the following trigger levels:

- 50, 75, 150 and 250ppm of CO
- 400, 600, 800 and 1000µg/m3 of NOx)

The PLC and SCADA systems ensure automatic control of the ventilation according to the monitored levels in the different tunnel sections.

2.7.2 Noise

The Jets-fan and axial fans are all fitted with silencers in order to reduce noise.

2.7.3 Water

Water is collected by a drainage system specific to the tunnel which discharges to a pumping station where with submerged pumps and a mixer pump.

2.7.4 Equipment

The tunnel is equipped with the usual safety systems, i.e. fire detection, CCTV, communication between tunnel and operator 24/7 by means of emergency phones present along the tunnel.

2.8 OPERATION

The Leopold II tunnel is managed by the MOBIRIS control centre (open 24/7) which manages all the tunnels of the Brussels-Capital Region. This control centre is also responsible for the surface traffic of the main roads and motorways.