

Appendix 2.9 - FRANCE – Lyon – Croix-Rousse Tunnel

1. SUMMARY – A NEW MULTIMODAL TUNNEL

The “Croix-Rousse” tunnel is located in Lyons (France). The City of Lyons has about 475.000 inhabitants with 1,31 million in the wider “Grand Lyon” Urban Community. The tunnel passes under a hill between the Rhône and Saone Rivers (**Figure 1**).

The Croix-Rousse tunnel is owned and operated by “Grand Lyon” Urban Community.

The tunnel entered into service in 1952 with a single tube of four lanes (two lanes in each direction). The tunnel is about 1752 m in length.

The tunnel was no longer compliant with the French regulation. The Grand-Lyon Authority decided in 2007: first, to prohibit vans and HGV traffic, and second, to launch an extensive refurbishment programme in order to improve the safety level, comply with the regulation and to refurbish the main operating equipment (previous refurbishment of the ventilation system in 1982).

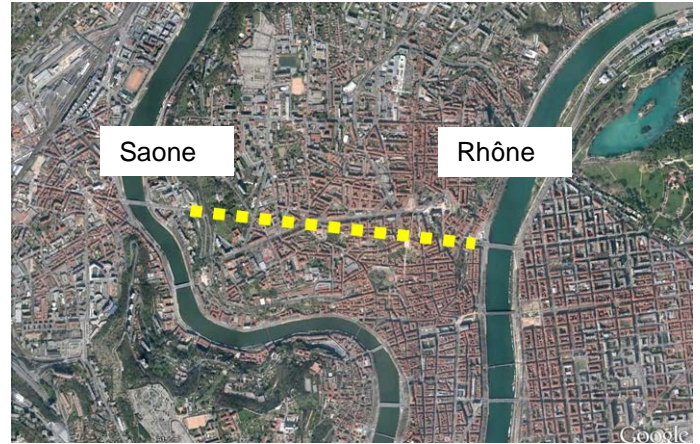


Figure 1 – Croix-Rousse tunnel location

A new tunnel has been excavated parallel to the first one. This new tube is a **multimodal tunnel** with four main functions: (1) as an escape route for the exiting road tunnel – (2) for the passage of pedestrians beneath the “Croix-Rousse” hill – (3) for the passage for bicycles – (4) a new link for public bus transportation with the possibility to implement a tramway link in the future.

The new multimodal tunnel and the upgraded existing tunnel were reopened in December 2013 (**Figure 2**).

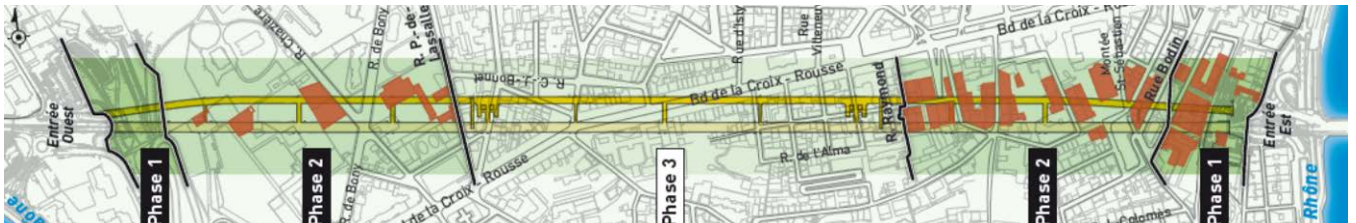


Figure 2 – Croix-Rousse road tunnel and new multimodal tunnel

2. MAIN CHARACTERISTICS

2.1. GEOMETRY

- Tunnel length: 1752 m,
- Horizontal alignment: straight,
- Vertical alignment: 1%.

2.2. CROSS SECTION

2.2.1. Road tunnel (Figure 3)

- One lane 2,95 m width and one lane 3,00 m width in each direction,
- Vertical clearance 3,50 m,
- HGV traffic is prohibited,
- Central concrete barrier 0,30m width – 0,80m high.

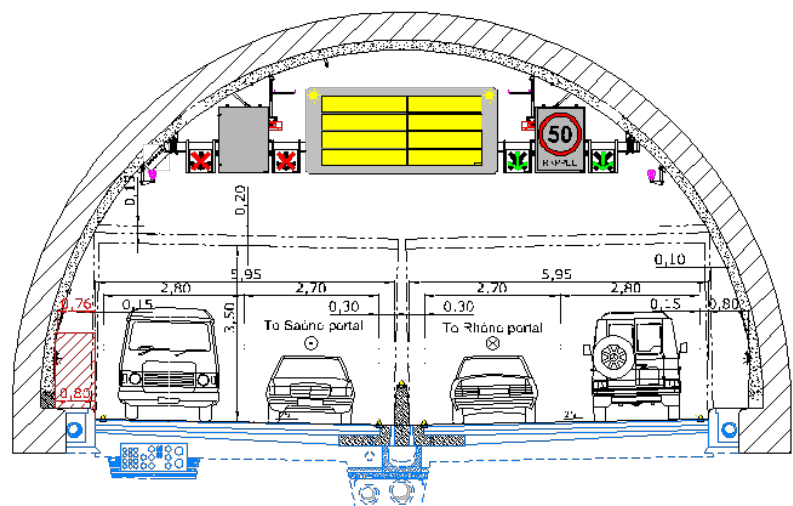


Figure 3 – Cross section of the road tunnel

2.2.2. Multimodal tunnel (Figure 4)

- Sidewalk 1,00 m width – 0,20 m elevation with dropped kerb in front of the cross-passages,
- Bus lane 3,80 m width – 4,30 m height. Bus traffic is unidirectional and managed with a single bus inside the tunnel,
- Space for pedestrian passage: 1,77 m,
- Space for bidirectional bicycle traffic: 3,00 m,
- Protective concrete barrier between the bus lane and the pedestrian space: 0,48 m width – 0,80 m height with an handrail on the top.

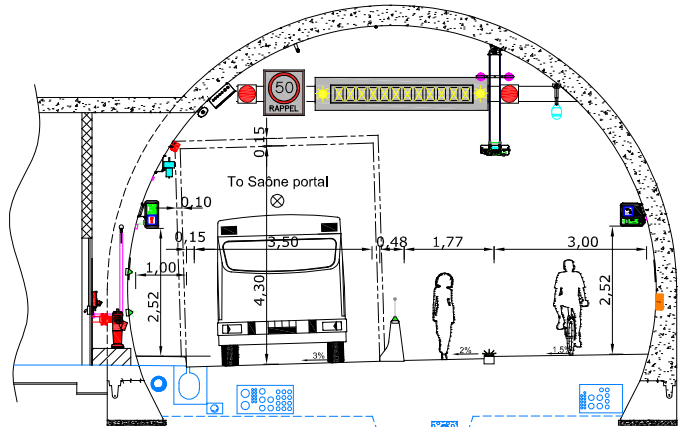


Figure 4 – Cross section of the multimodal tunnel

2.2.3. Escape route

- 11 cross-passages between the two tubes with a spacing of about 145 m,
- Cross-passages have doors and are pressurised.

2.3. TRAFFIC CONDITIONS, BREAKDOWNS AND ACCIDENTS

2.3.1. Traffic conditions before refurbishment

- AADT (annual average daily traffic): 48.000 veh. / day with a growth of about 3,5%
- Hourly traffic distribution during the day (solid lines: working day – dotted lines: week-end) (Figure 5: direction Rhône Saone) – (Figure 6: direction Saone -> Rhône from suburb areas to down town).

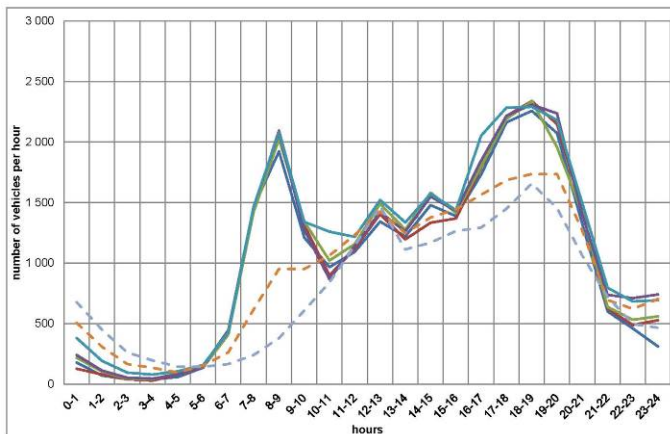


Figure 5 – Hourly traffic distribution – Rhône -> Saone

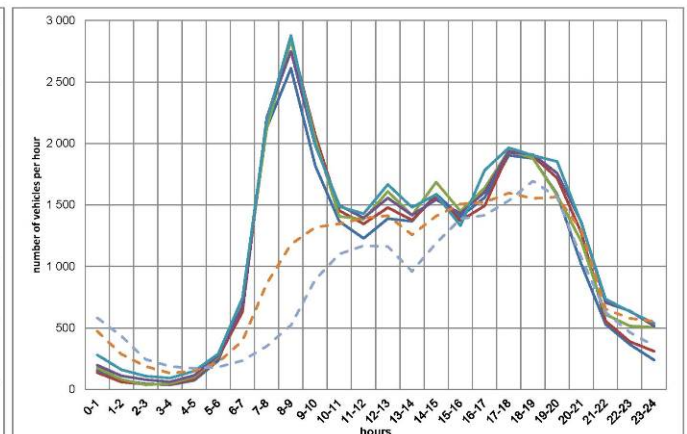


Figure 6 – Hourly traffic distribution – Saone -> Rhône

2.3.2. Breakdowns and accidents before refurbishment

- Average of 150 breakdowns per year,
- Average of 20 accidents per year,
- No fires,
- Analysis of the distribution of events shows that 50% results from the intrusion of pedestrians and cyclists inside the road tunnel (not allowed).

2.3.3. Road tunnel

- Speed limit 50 km/h,
- Vehicles over 3,5 tonnes or higher than 3,5 m are prohibited,
- Bicycles and pedestrians are prohibited,
- Authorised for busses,
- No regular traffic queuing inside the tunnel – only moderate congestion at the Rhône River exit,
- Loops for detection of stopped traffic inside the tunnel with alarms to the operator. Operator manually introduces a special scenario to clear the traffic by giving priority to the vehicles coming from the tunnel (if scenario has not been automatically activated).

2.3.4. Multimodal tunnel

- Bus traffic authorised only for public transportation networks – about 10 busses per hour,
- Bicycles and pedestrians are authorised,
- Motorbikes are prohibited.

2.4. VENTILATION

2.4.1. Former ventilation system in the road tunnel

The former ventilation system was a semi-transverse ventilation system including:

- 5 vertical ventilation shafts with associated ventilation plants on the top of the hill, including fresh air inlet and smoke exhaust,
- Air ducts for fresh air inlet, polluted air and smoke exhaust located above the ceiling of the traffic space,
- The reinforced concrete slab in the ceiling was showing some damage and subject to possible collapse in case of a HGV fire. This led to prohibition of vehicles more than 3,5 tonnes entering the tunnel.

2.4.2. New ventilation system for the road tunnel

The new ventilation system reuses the shafts and the ventilation plants that have been entirely refurbished. The new ventilation is a hybrid system including:

- Reversible jet fans in the crown with the following objectives: (1) regular longitudinal ventilation – (2) control of the longitudinal air flow in case of fire and containment of smoke spread,
- Massive extraction of smoke through the five shafts in case of fire,
- Management of the polluted air extraction according to the traffic and weather conditions: using either longitudinal ventilation, or the extraction shafts, or a combination of both in order to limit the pollution discharge near the housing areas,
- Design fire power of 30 MW with a pressure difference of 80 Pa between the two portals,
- Overpressure inside the 11 cross-passages joining the two tubes.

The ventilation system is managed automatically from the SCADA system, based on pre-defined scenarios for normal, emergency and environmental conditions in order to optimise conditions for the safety and health of the tunnel users as well as the people living in the neighbourhood (**Figure 7**).

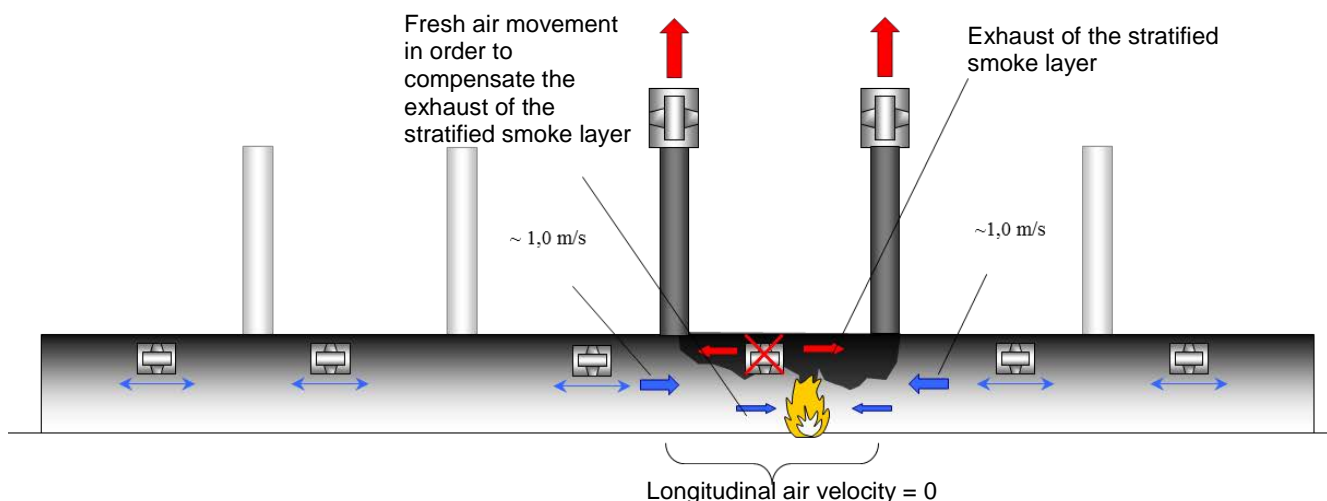


Figure 7 – Smoke exhaust scenario – phase 1: evacuation of the tunnel users

2.4.3. Ventilation of the multimodal tunnel

The ventilation system of the multimodal tunnel is longitudinal and includes:

- Jet fans in the crown for non-emergency ventilation,
- Two cross connections joining the multimodal tunnel to the base of shafts n°2 and n°4 of the road tunnel, in order to enable massive smoke extraction in case of fire.

2.5. ENVIRONMENTAL ISSUES

2.5.1. Air quality

Access to the road tunnel is only allowed for passenger car traffic and vehicles less than 3,5 tonnes. The bus traffic levels inside the multimodal tunnel are very low. As a result, the volume of pollution emission is low. The discharge of polluted air is shared between the two portals and the five ventilation shafts according to the traffic volume and the weather conditions.

2.5.2. Noise

The jet fans are equipped with noise attenuators. Passive noise reduction systems are installed inside the ventilation facilities at the top of the shafts.

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 and remotely operated motorised valves.

2.6. OPERATION AND SAFETY EQUIPMENT

The two tunnels are equipped with all the usual operation and safety equipment. Particular attention has been paid to the communication with tunnel users, the traffic management and the safety and environmental conditions: detectors, CCTV, AID (automatic incident detection), loops, heat detection cables etc.

2.7. OPERATION

The Croix-Rousse tunnel is operated by a central control centre (manned 24h / day) that currently operates present four large existing tunnels in the Lyon urban area. This control centre is being extended in order to be able to manage three additional large tunnels currently in operation, as well as all the existing cut & cover tunnels longer than 300m.

This control centre also controls the urban surface traffic on the main roads and urban highways in the vicinity of the tunnel.

In case of fire, emergency services and fire brigade teams arrive at the two portals in less than 10 min.

3. PARTICULARITIES OF THE MULTIMODAL TUNNEL

The multimodal tunnel is described above. The functions of the multimodal tunnel are as follows (**Figure 8**):

- Escape route for the road tunnel,
- Journey time improvement on public transportation between Rhône and Saone Rivers,
- New link for pedestrians and “soft transportation” in order to offer pedestrians and bicyclists a short and safe route between the two rivers.

Due to the length of the tunnel and the resulting crossing duration for pedestrians (20 to 30 min) it has been necessary to implement systems to provide an attractive, safe and comfortable environment as continuity of the urban space. Specific illumination has been installed as well as animation on the tunnel walls (**Figure 9**) by the projection of pictures, movies and videos. These animations vary with the time of day, the volume of pedestrians and also take into account the bus traffic (see picture and movie below).



Figure 8 – Multimodal tunnel



Figure 9 – Animation of the side walls