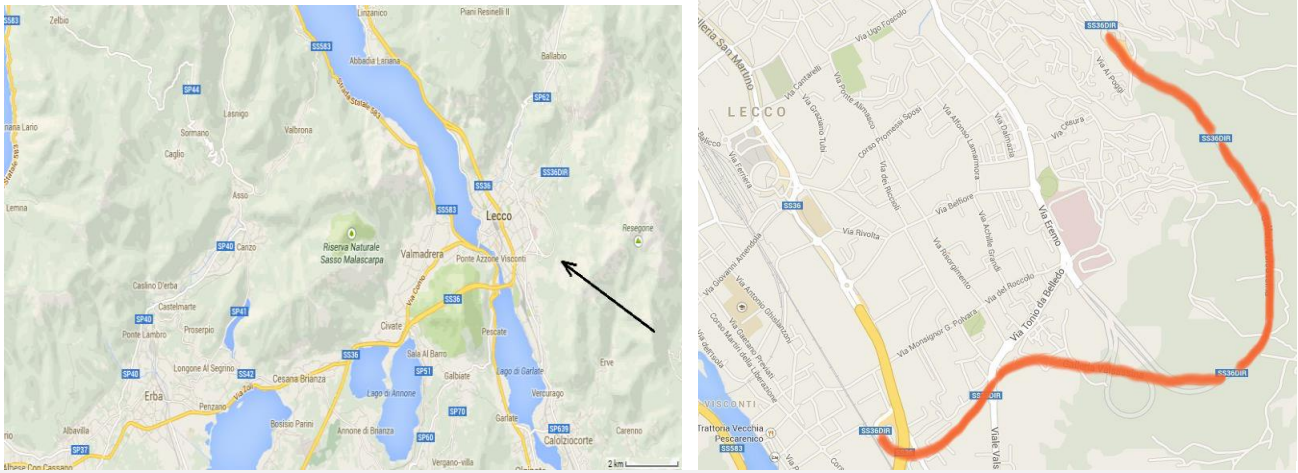


Appendix 2.12 - ITALY – Valsassina Tunnel near Lecco (Lombardy)

1. SUMMARY

The Valsassina tunnel is located along the National Road 36 (SS36), from Milan towards Valsassina in the town of Lecco with about 50,000 inhabitants (Figures 1a and 1b). It started operating in 2006. The construction methods are: (i) cut and cover from Lecco portal to Lecco ventilation shaft – (ii) drill and blast from Lecco ventilation shaft to the Poggi portal.



Figures 1a & 1b: Geographical Location of Valsassina Tunnel

The main tunnel has a single tube operated with bidirectional traffic. The tunnels at the junctions are operated with unidirectional traffic.



Figure 1b: Tunnel entrance in Lecco (google link to visit the inside of the tunnel: https://www.google.it/maps/@45.844505,9.404296,3a,75y,156.75h,86.46t/data=!3m4!1e1!3m2!1sF_ugVL5tRB_Ycuv3IQxoLw!2e0)

https://www.google.it/maps/@45.844505,9.404296,3a,75y,156.75h,86.46t/data=!3m4!1e1!3m2!1sF_ugVL5tRB_Ycuv3IQxoLw!2e0

The layout of the tunnel its interchanges is schematically shown in Figure 2. It is characterised by a main bidirectional tunnel that extends for about 3300 m, connecting the locations denominated Lecco and Poggi (towards Valsassina). At about mid of the tunnel there are two main junctions that allow the access to and from the area called Ospidale (Hospital).

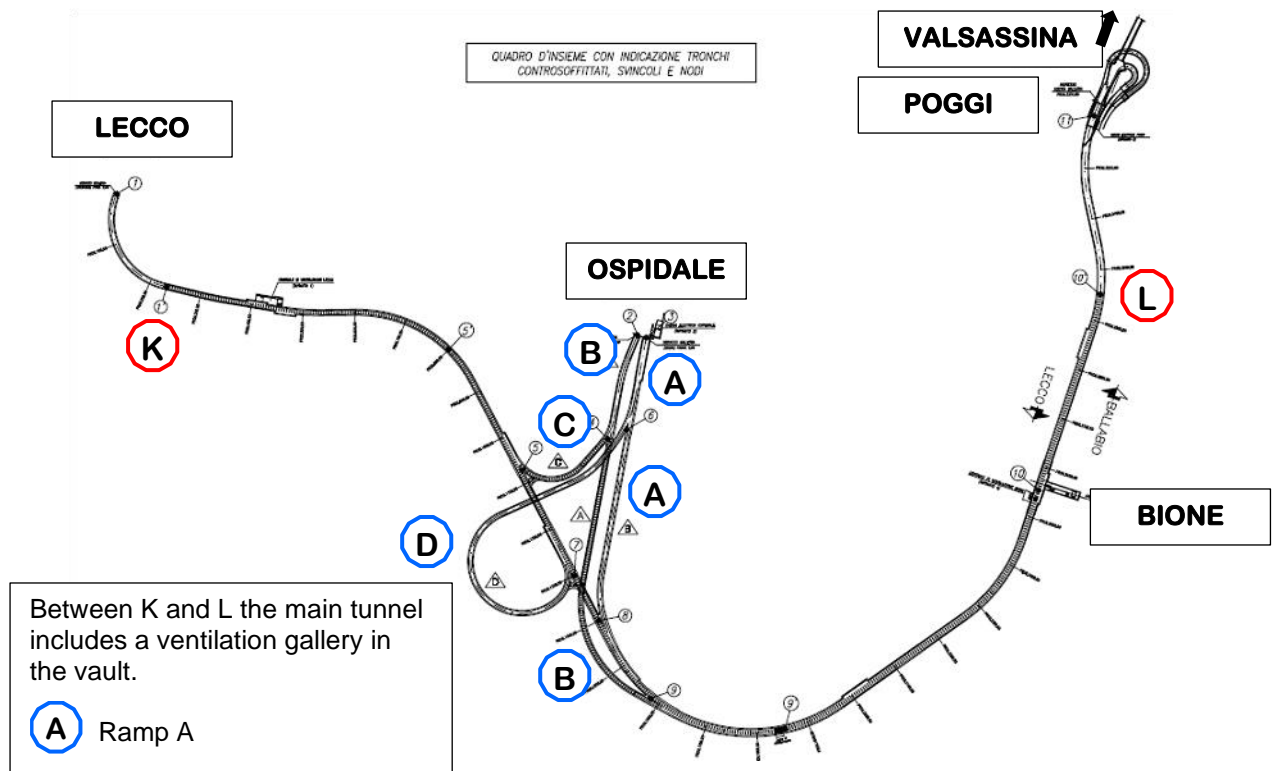


Figure 2: schematic of Valsassina Tunnel

2. MAIN CHARACTERISTIC

2.1 GEOMETRY

□ Main Tunnel

- Tunnel length at the top of the vault (without artificial portions at the entrances): 3,316 m
- Average elevation above sea level: 265 m
- Cross section: 44 m² from Lecco entrance to station 1650 m and 67 m² from station 1650 m to Poggi entrance
- Average slope: 2.8% from Lecco entrance to station 1650 m and 5.0% from station 1650 m to Poggi entrance
- Vertical clearance: 4.75 m
- Number of lanes: 2
- Width of the lanes: 3.75 m
- Pedestrian sidewalks: one for each side, each 0.85 m wide

□ Interchange

The tunnel includes an underground interchange with four ramps between the main tube and the Ospedale portal. The ramps have partly one lane and partly two lanes for a total length of 2,200 m. Its cross section is 38 m² (ramps A and C) and 45 m² (ramps B and D).

□ Cross section

Figure 3a shows the tunnel cross section at Lecco side, with a single duct for air injection and extraction, while figure 3b shows the tunnel cross section at Bione side with separate ducts for air injection and extraction.

The tunnel includes 10 safety shelters and escape routes towards the open air (figure 4) and 5 lay-bys.

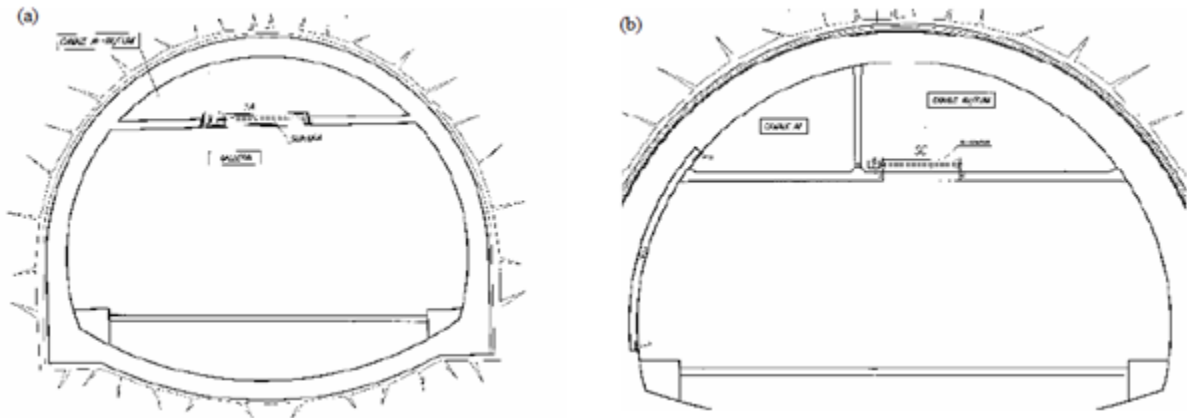


Figure 3: Cross sections of Valsassina Tunnel. 3a Lecco side – 3b Bione side

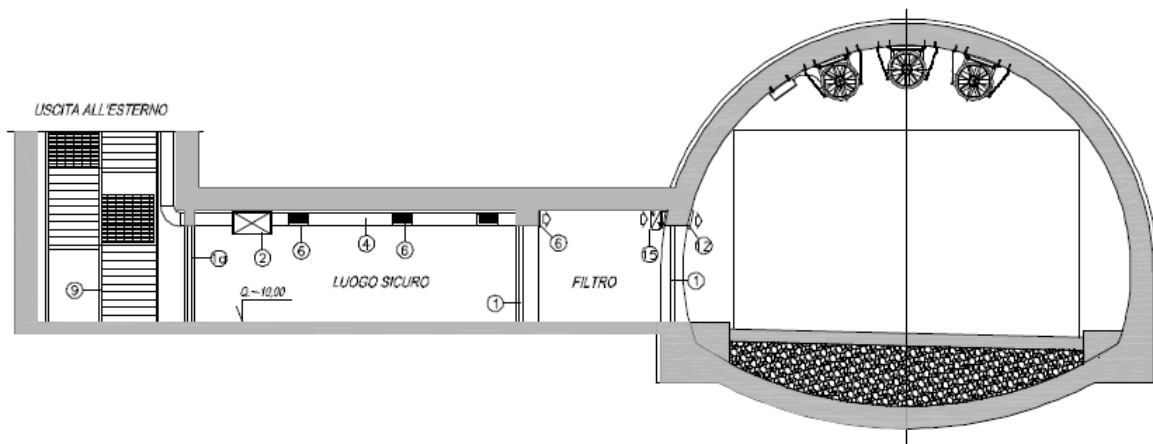


Figure 4: Cross section of Valsassina Tunnel with safety shelter and escape route to the outside

2.2 TRAFFIC CONDITIONS

- Average annual traffic 3,200,000 vehicles, 10% of which are HGV or trucks and 8% busses and light lorries
- Design speed: 70 km/h
- Traffic conditions in the tunnel are monitored through CCTV network and laser scanner systems (8 sections), which allow one to obtain detailed information about the number and type of vehicles, distances between vehicles and speed.

2.3 VENTILATION

The ventilation system includes 20 sections with 3 or 4 jet fans (EV in figure 5) installed on the soffit of the main tunnel and at the junctions. It includes two ventilation plant rooms, called Centrale Lecco and Centrale Bione. Ventilation plant rooms are equipped with axial fans to supply fresh air or extract exhaust air or smokes through stacks installed on the top of the tunnel and 85 dampers. Supply and extraction dampers are calibrated in order to supply and extract the required mass flow rate during the normal operation, and are equipped with actuators.

During the normal operation conditions, the longitudinal ventilation of the main tunnel and of the ramps is sufficient. This is supplied via jet fans from the Lecco, Poggi and Ospedale portals. Air is moved towards the Bione ventilation plant room, where it is extracted from a large extraction point located at the soffit, immediately below the ventilation plant room, and from the extraction point located at the exhaust air ventilation duct upstream and downstream of the ventilation plant room.

In the case of large traffic conditions, it is possible to supply fresh air from the reversible ventilation duct fed by the Lecco plant room, and by using the fresh air channels fed by the Bione ventilation plant room.

In the case of fire, smoke is locally extracted from the exhaust air channel, through the extraction openings close to the fire, while the other extraction openings are closed. In the meantime, the longitudinal velocity is reduced using the jet fans, in order to make the smoke extraction easier and avoid the smoke propagation through the tunnel. The procedure for activating smoke extraction and ventilation as well as the traffic lights to close the tunnel to traffic is automatic and started by the control room in Bellano. A longitudinal velocity measurement system is used to manage the ventilation system in the case of fire.

Fire detection can be performed through CCTV systems as well as linear detection of temperatures through fibre laser thermal sensitive cable installed along the whole tunnel.

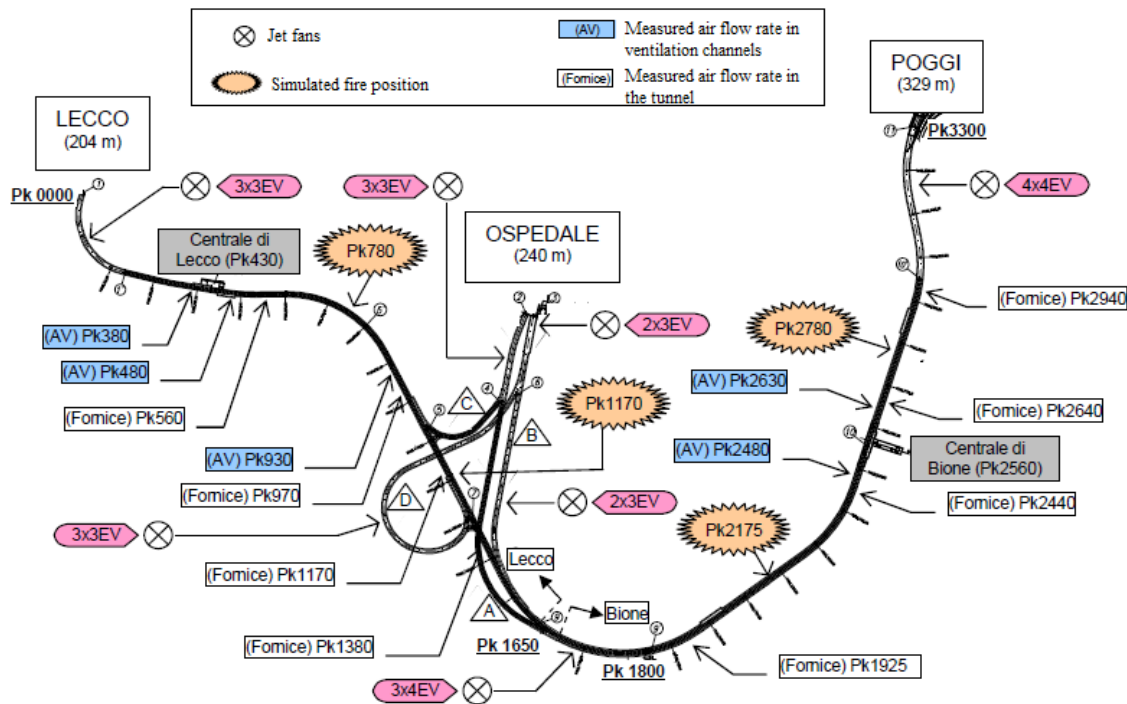


Figure 5: Schematic of the Valsassina tunnel ventilation system

2.4 ENVIRONMENTAL ISSUES

An environment control system is installed, which measures CO, NO, opacity, and longitudinal velocity of the air in the tunnel. A traffic control system is also installed. This system is used to manage the ventilation system for air quality, and to adjust the ventilation system for the various traffic conditions. The automatic system is operated from the control room.

Acoustic attenuators are installed on the soffit and on tunnel walls close to the exits towards the external environment.

2.5 FACILITIES AND OPERATION EQUIPMENT

- Traffic lights with three lights are installed at each portal, light signals with fluorescent lamps (speed escape ways, hydrants, lay-bay, etc.), reflecting signals with visibility indications and roadway separations, LED guiding lights on the kerbs.
- Stainless steel boxes containing the emergency phones and the emergency equipment, fire hose, fire extinguisher and other light signalling devices for emergency and alarm are installed along the tunnel. The maximum distance between boxes is 250 m.
- Water firefighting system fed by pressurisation groups installed at the Ospedale and Bione plant rooms. Five electric transformer cabins that provide electricity to the plants. Emergency electricity generators and uninterruptible power supply units (UPS) installed in the cabins.
- Lighting system, equipped with dimmers, with high-pressure sodium lamps. The safety lighting system installed all along the tunnel in order to provide sufficient light to the users to locate the various paths in the case of failure of the main lighting system.

- Centralised technical management systems (GTC) installed in order to operate the various tunnel plant rooms. The supervision room is located in a building at the Ospedale portal.
- Iso-frequency radio system with external antennas and radiant cable on the vault for communication between the tunnel operators, external maintenance personnel, safety personnel and police.

Figure 6 shows details of the horizontal signals and ventilation system.



Figure 6: Details of horizontal signals (a), ventilation system at a junction (b), ventilation system with acoustic attenuators (c)