Safety in the III Valico Tunnels

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Terzo Valico dei Giovi
High Speed Rail

Country: Italy
Client: RFI S.p.A.
Value of the works: €6,2 billion
Start of work: April 2012
Introduction

The Genoa-Milan High-Speed Railway Line (“III Valico di Giovi”) is characterized by the presence of numerous tunnel sections, including the double-tube Valico tunnel with a length of 27km (not including interconnections, making it one of the longest tunnels in the national territory), and the Serravalle tunnel with a length of 7 km.

The revision of the Technical specifications for interoperability (TSIs) didn’t entirely overturn the security principles already used in the III Valico final design, but rather refine and integrate some of the concepts verifying the design choices through a security design methodology based on the risk analysis.

In light of these changes in the regulatory framework, it has been necessary to re-evaluate the design choices about safety of the III Valico tunnels.
The type of the tunnels planned are consistent with the latest security standards, including the construction of two side-by-side, single-track tunnels with cross-connections, which enable each tunnel to be safe place from any events occurring in the other.
<table>
<thead>
<tr>
<th>Tunnel</th>
<th>Valico</th>
<th>Serravalle</th>
<th>Pozzolo</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tunnel Length</strong></td>
<td>27110 m</td>
<td>7098m</td>
<td>1984 m</td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>Double Tunnel Single Track</td>
<td>Double Tunnel Single Track</td>
<td>Single Tunnel Double Track</td>
</tr>
<tr>
<td><strong>Traffic</strong></td>
<td>221 train/day</td>
<td>221 train/day</td>
<td>97 train/day</td>
</tr>
<tr>
<td><strong>Type of Traffic</strong></td>
<td>Mixed Heavy Freight ≥ 30% + Dangerous Goods</td>
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</tr>
<tr>
<td><strong>Switches in tunnel</strong></td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td><strong>Interconnection in Tunnel</strong></td>
<td>YES EVEN TRACK =1997 m ODD TRACK =3915 m</td>
<td>YES EVEN TRACK =1154 m ODD TRACK =1013 m</td>
<td>-</td>
</tr>
<tr>
<td><strong>Service Tunnel</strong></td>
<td>Vallemme Safety Area Cravasco-Polcevera Castagnola</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td><strong>Fire Fighting Point (FFP)</strong></td>
<td>Vallemme Safety Area</td>
<td>Arquata Libarna Safety Area</td>
<td>NO</td>
</tr>
</tbody>
</table>
SAFETY DESIGN

The method adopted for the safety design is the IRAM-RT methodology, already employed in the safety design of the recently opened to traffic tunnels on the Bologna-Florence High-Speed railway line.

The safety design of a railway tunnel foresees the following operating steps:

- analysis of infrastructure vulnerability, starting from the acquisition of geometric, structural and equipment installation characteristics of the work, traffic and accident data;
- identification, structural and plant design of safety requirements that may prove to be necessary after the vulnerability analysis (Ministerial Decree of 28/10/05);
- risk analysis for the verification of safety targets achievements (Ministerial Decree 28/10/05);
- operating procedures and in particular the preparation of emergency management plans (Ministerial Decree 10/28/05).
The key works for which the new regulations have required the design are:

- the construction of a safety area inside the Valico tunnel provided with suitable exit routes, smoke extraction and automatic shutdown system (Vallemme Safety Area);
- the construction an open-air safety area between the Valico tunnel and the Serravalle tunnels equipped with an automatic shutdown system (Arquata Libarna Safety Area);
- the construction of new cross-passages;
- the upgrading of the system services of the tunnel access;
- the construction of new ventilation shafts and adaptation of fire safety equipment.
VAL LEMME SAFETY AREA

Safety Area

Smoke Extraction Systems

Rest Stop Fire Systems

Exodus

Service Tunnel

Train Tunnel

Rescue Tunnel

Rescue

ADIT
In compliance with STI requirements, the construction of a safety area for passengers and freight trains is planned at a mid-point within the Valico tunnel. This safety area will be accessible by an adit through which a conflagrant train can be driven and which will allow the controlled exodus of travelers and the intervention of rescue teams.

The Val Lemme safety area consists of two evacuation tunnels, which extend 750 m from the axis of the adit, parallel to the tunnel axis, located 35 m between the even and odd track, respectively.

The tunnel safety area will be equipped with the following systems to efficiently and effectively contrast the tunnel emergencies:

- ventilation system/smoke control;
- fire water system;
- automatic extinguishing foam system;
- hazardous liquid collection system.
The system features a distributed fume extraction whereby extraction is carried out by a set of extraction points located at the tunnel access and inside of six distributed cross-passages along the safety area.
The ventilation control unit is located in a tunnel made ad-hoc before the shaft, designed to accommodate four two-stage axial fans able to extract up to 120 m³/s each.
For fires extinguishing of flammable liquids and combustible fuels the design proposes fire protection by means of monitors to AFFF foam additives (Aqueous Film Forming Foam), cooling agent and the formation of a protective film on any liquid fuel (B class).

The protection system provides a high foam flow of up to 3000 l/min directly to the fire location, inhibiting combustion on the surfaces and subsequently cooling them.
The definition of new safety standards has necessitated the creation of an external safety area, 1166 m of length, located near Arquata Libarna with a function of Fire Fighting Point (FFP). This safety area is accessible by emergency vehicles through a special road.

It contains zones equipped with a Triage area, a technological building, a rescue helicopter pitch, and razed pathway for positioning the bimodal tack mechanism.

The area’s external security systems are:

- fire water system;
- automatic foam extinguishing system;
- hazardous liquid collection system.
ARQUATA LIBARNA SAFETY AREA
The escape system of the main tunnel consists of a series of cross-passages link connections between the two single-track railway tunnels (odd and even) every 500 m, in both the III Valico and Serravalle tunnels.
ACCESS TUNNELS (ADITS)

The exodus system with the adit allows for a widened area at the end of each side tunnel, which forms a space that is intended to allow for the reverse gear of rescue vehicles and to accommodate the beginning of the passenger flow from the tunnel towards the outside.

Each of these areas, referred to as "transition chambers" and not safe place, is equipped with a series of doors (on the side railway tunnel and the on the side adit) and a ventilation system capable of keeping the same chamber in slight overpressure with respect to the tunnel.
The quantitative risk analysis in railway tunnels must be set within an overall framework of system logics, adapting it to the specific train-tunnel system.

More in detail, the risk analysis must refer to the division of the train-tunnel system into the sub-systems forming the infrastructure, road and railway network materials and operational procedures.

Some accidents, reference scenarios related to emergency in tunnels, have been identified as derived from the onset of critical events:

- fire;
- derailing;
- collision.
The analyses of accident scenarios was performed using the three-dimensional Fire-Dynamics Simulator calculation code by the simulation of the smoke propagation generated by a passenger train stopped at the Val Lemme safety area.
The simulation of the smoke propagation was coupled with the simulation of the exodus process, conducted through the EVAC code.
The approach adopted in the design led to the definition of a performance benchmark for facilities that allows the safety management in the most likely scenarios. This was verified through the risk analysis methods provided by the Ministerial Decree of 28/10/2005.

The obtained results at the design level, backed up by detailed analyses conducted by means of fire and exodus models and the analysis of probabilistic risk, have led to the definition of the functional layout, and of the performance specifications of security installations, and to the development of a final project that is among the most advanced in Europe from the point of view of safety in the operation phase.