



THE UČKA TUNNEL UPGRADE

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Abstract

A tunnel is an underground passageway, completely enclosed on all sides, with an opening at each end. Due to its “closed & narrow” structure, tunnels call for a high level of safety. Accidents, particularly fires, can have serious consequences. The potential disruption of the transport system following a major fire can cause severe disturbances in the economy. Several disasters have occurred in the last 15 years across Europe. Following these fatalities, The European Commission Directorate-General for Energy and Transport launched a Directive 2004/54/EC of the European Parliament and of the Council on minimum safety requirements for tunnels in the Trans-European Road Network on the 29th of April 2004. These safety requirements apply to all tunnels longer than 500 meters in all phases of design, construction and operation. The Učka Tunnel, consisting of one tube, opened for traffic in 1981. Since 1995, it has been under the operation of Bina-Istra. No major fire accidents have happened in its lifetime. However, the Concessionaire engaged independent consultants to inspect and analyze the tunnel for safety in order to obtain an up-to-date assessment. A comparison with the “Directive” requirements was done and a proposed implementation schedule was submitted. Suggested activities were accepted, previous renewal plans were revised and major improvements have been done. Some of them are described in the following article. Based on the actual Concessionaire’s plans, the second tube is to be completed by the year 2015.

Keywords: tunnel, safety, Directive, requirements, improvements

1 Introduction

1.1 History

Built in 1981, The Učka Tunnel was the longest tunnel in Croatia for 22 years until the opening of Sveti Rok in 2003 (5,727m long) and Mala Kapela two years later (5,780m long), now the longest tunnel in Croatia. A significant period of time has passed since the tunnel was first conceived in the early seventies and when a coordination board for the tunnel’s construction was established in Istria. Its main function was to arrange for financing of the tunnel itself. The Učka Consultancy Company was set up to carry out all the necessary duties pertaining to the required construction, including research and design, surveys, building permits, and land acquisitions etc. Preliminaries started in 1971, and test drilling was performed the following 3 years during which 3km of access roads, permanent water and electrical supply systems, an adjacent viaduct and 2 small tunnels on the Istrian side were completed. The construction of the Učka Tunnel started in 1976, performed by two big state companies: Hidroelektra and Konstruktor. The “break through” was done in 1978. Afterwards, the tunnel was lined with concrete, and works on the portal areas and on the Headquarter building were completed. In all the above-mentioned activities, numerous engineers, designers, contractors and experts were engaged and made a huge effort to connect the Istrian peninsula with the city of Rijeka and the Croatian hinterland, and vice versa, with Rijeka and the city of Trieste in Italy [1].

1.2 Technical elements of the Učka tunnel

- Length: 5062m
- Cross section: 54 m²
- Altitude: 495m above sea level, both portals
- Tunnel overburden: 550m
- Traffic: bi-directional
- Carriage-way: 2 x 3.75m + 2 x 0.8m pedestrian passage
- Vehicle clearance 4.5 m, with a top centre line height of 6.85m
- Concrete lining 30cm; excavation protection through shotcrete and perforation-anchors; PVC foil applied in water seepage zones
- 3 turning-bays; 4 lay-bys
- Double-sided pavement grade towards central line
- Fireplugs placed at southern pedestrian path, water pipe underneath, and HV cable placed at northern side of tunnel
- From 1981 to mid 2009, 46.1 million vehicles have passed through
- AADT in 2008 – 8260 vehicles.

1.3 Operation of the Učka Tunnel

In 1995, The Concession Agreement between the Government of the Republic of Croatia and the Bina-Istra Joint Stock Company was signed for the financing, design, construction and operation of a 145km stretch of road called the “Istrian Y Project,” in which 60km of completed road, together with the Učka Tunnel were included. The Concession Agreement was negotiated for a term of 32 years. Another agreement was established for the same term with Bina – Istra Operation and Maintenance Ltd. (BIOM) for the operation and maintenance of the motorway and the tunnel.

2 Improvements to the Učka Tunnel

2.1 Safety in tunnel structures

Due to its specific structure, traffic regulation in the tunnel is different than that on the open road: the driving speed is modified, and overtaking in one-tube tunnels is prohibited. Moreover, a high safety level is required.

Several tunnel fatalities at the end of the 20th century in Europe, substantiated a need to adopt regulations based on a joint document by EU state members on tunnel safety. The European Commission Directorate-General for Energy and Transport launched the Directive 2004/54/EC of the European Parliament and of the Council on minimum safety requirements for tunnels in the Trans-European Road Network, on the 29th of April 2004 (hereafter called: Directive) [2]. These safety requirements apply to all tunnels longer than 500 meters in all phases: design, construction and operation. However, for tunnels already in use, a period of 10 years has been projected for safety analysis and procedural compliance with the Directive. In Annex I of the Directive, the safety measure requirements are described, and a summary table gives an overview of the structural measures and the tunnel equipment requirements. The basis for the safety requirements takes into account all the tunnel parameters: its length, number of tubes, number of lanes, geometry, alignment, traffic volume, number of heavy goods vehicles, dangerous goods traffic, access time of emergency services etc. The measures and equipment requirements are classified as: mandatory, not mandatory, recommendations with exceptions and equipment which is recommended only. The provisions of Annex II of the Directive apply to the documentation on tunnel safety from the early stages (design phase) to ones which are

already in use. It is recommended that accident analysis be conducted, if any exist, accompanied with regular updates on full scale safety exercises performed under realistic conditions. Annex III prescribes the road signs and symbols which are to be used in tunnels in order to be internationally understood. Although Croatia is not yet a European State Member, its experts and tunnel operators respect the Directive recommendations in all phases.

2.2 Safety assessment for the Učka tunnel

The first assessment was done in 1996 and resulted in a safety measures schedule, which was nearly implemented by the year 2005. An independent consultant was engaged to analyze tunnel safety and present an up-to-date assessment. All the tunnel elements and equipment, management and operations, and fire-fighting procedures were evaluated in detail, and compared to the Directive requirements. An implementation schedule was proposed and the measures classified in three groups: from urgent (to be carried out within a year) up to those needing completion within a reasonable time frame [3]. The suggested activities were accepted and major improvements have been done.

3 Installed systems in the Učka tunnel

3.1 Power supply

The Učka Tunnel is powered by HV cables at the 20 kV voltage level from two independent sources, one from Kvarner, the other from the Istrian side of the tunnel. Altogether, there are 8 substations that feed into the tunnel: one at each portal side, and 6 situated along the tube. In case of a power outage, the diesel generator is activated automatically by the UPS system, that allows power to get to the control and command centre, and remote stations in the tunnel, as well as to the ERT, fire-alarm system, video surveillance and to the water pump. However, the actual condition of the power supply system does not comply with the up-to-date requirements for a tunnel of this size. In 2009, a new power supply study was undertaken in order to identify improvements to the tunnel. This study also took into account recently installed equipment. Proposed technical solutions will ensure reliable power supply within the tunnel in accordance with the technical rules and regulations, and at the same time, the power necessary for the execution of civil works during the construction of a second tube.

3.2 Tunnel lighting

The old tunnel lighting consisted of low pressure sodium lights placed on the tunnel vault, with two bulbs in each light being supplied from a different electrical network. The lighting was renewed in 2005. The existing power supply system was kept up to the distribution cubicles. From the cubicles, new fire retardant cables were laid up to the lights. New high-pressure sodium lights were installed within an existing grid of 12m. The new lights have 2 x 100 w in the middle of the tunnel, and 600 w to 100 w in transition zones [4]. Luminescence was measured and showed results that were in complete compliance with the CIE 88/90 publication regulations requirements.

3.3 Remote control system

The remote control system is a technical unit which controls and supervises all the systems in the tunnel: power and ventilation, traffic signalization, monitoring, automatic incident detection, fire-alarm, water supply tank, UPS, remote meteorological station and receives alarms from the toll system. The remote control system receives and processes a few thousands signals and enables the operator in charge of the control centre to keep a vigilant eye on the

traffic, carry out the safety measures, monitor the work at each facility and manage the equipment being installed. In 2005, complex works on the remote control stations in the tunnel and in the control centre were performed. Three new remote stations were placed in the tunnel and two in the control centre. The stations receive signals from all the tunnel systems, process these signals and send them to the control and command centre. A redundant network has also been established, which enables recovery of the network within 0.3 seconds of a breakdown [5]. The SCADA (Supervisory Control and Data Acquisition) system was upgraded to enable the visualization of all parameters which operators may control. It is shown on the large central monitor and on the PC monitors of each implemented system.

3.4 Ventilation

The “sanitary ventilation” system ensures the reduction of air pollution emitted by vehicles under normal traffic conditions and controls the heat and smoke in the event of a fire. The Učka Tunnel is equipped with a longitudinal type of ventilation system, which consists of 48 groups, each group having three jet fans that are placed at both ends of the tunnel. None are located in the middle of the tunnel. These jet fans are irreversible, so every second group of jet fans blows in one direction. Air quality is controlled by sensors: air flow velocity and direction sensors in addition to sensors for the extinction and measurement of CO. From these sensors, signals are transmitted to remote stations placed in tunnel niches, and by optic cables sent to the remote control system where the pollution grade is read [6]. Previous ventilation procedures were based on empirically-established protocols, where the operator turned on a certain number of ventilation groups, related to the pollution index.

A new ventilation study was arranged in 2006 in order to examine the existing situation and recommend improvements to the ventilation system. Complying with the recommendations, the following activities were performed:

- Two additional sensors were mounted, and the data acquisition system was upgraded;
- The communication network was changed to fibre-optic cable;
- Two new parallel master PLC's were installed, in a redundant configuration, (the most reliable devices are to provide data for the automatic logarithms ventilation in the event of fire);
- The separate start of each jet fan unit within the group of three was enabled, as an important prerequisite for the management of air flow and smoke stratification in case of an incident in the tunnel;
- New software for managing the automatic ventilation system was put into effect; and
- All the preparatory work for the automation of the ventilation system in case of a fire has been completed with full automation to be completed in a few months.

3.5 Fire alarm system

The previously installed fire-alarm was the point fire alarm system. The decision to start with the modernization of the old system was made in 2007. Its main purpose was to provide fast and reliable information on the location of a fire in the tunnel. Consisting of optic sensor cables, the system is based on optical waveguides, which are insensitive to electromagnetic disturbances. Temperatures are measured and recorded along the sensor cable as a continuous profile. A high accuracy of temperature determination is achieved within a short time frame. Furthermore, the system shows precise information about fire location, size and spreading direction. The tunnel temperature profile helps the rescue team make decisions on extinguishing tactics. The electric signal is transmitted to the control and command centres, where surveillance and the visualization of signaling zones are enabled [7]. When a fire-alarm sounds, the closest cameras react, signaling the zone and accurate fire-alarm address on a monitor, together with the image of the emergency area. The new fire alarm system in the Učka Tunnel was implemented in the spring of 2009.

3.6 Video detection of incidents

In 2008, Bina-Istra implemented a modern automatic detection video system, which continuously transmits tunnel images to the control centre and stores these images for future investigative purposes if necessary. The AID system detects the incident, processes data and forwards the information to the operator. The AID system in the Učka Tunnel detects the following emergencies: smoke in the tunnel, stationary vehicles, obstacles on the pavement, vehicles moving at unexpectedly low speeds, or those moving in the opposite direction or overtaking, and debris. In order to obtain a highly efficient system, 83 cameras have been mounted, 6 of which have been placed within the turning bays, and one rotating camera with a zoom lens which can be found at each portal area. Inside the control centre, 12 monitors serve to display any emergencies and 8 cameras constantly show traffic conditions. On the central monitor, the schematic AID matrix is displayed in such a way that each camera is presented by a lighted point and marked by a number. In the case of an actual occurrence, the correspondent light blinks, and a warning device sounds. The incident is shown on three monitors on the video wall [8]. The AID system is connected to all emergency stations and to the fire-alarm system, so that the alarm from any system automatically activates the closest cameras, which in turn, record the exact position of an emergency in the tunnel. This system has significantly improved the safety of road users in the tunnel.

3.7 Radio communication

Implemented in 2007, the radio system enables radio connections between two or more radio stations within the tunnel as well as with those outside of the tunnel. The main purpose of a VHF/UHF radio connection is for: tunnel maintenance services, police, fire-fighters, first aid attendants, and 112 emergency staff. Apart from this, the system transmits an FM radio programme within the tunnel (3 channels are available). The operators in the control centre dispose of an operating console, so that in case of an emergency, they are able to interrupt radio broadcasting and give audio information to users in the tunnel. The system also allows for the submission of predefined messages or digital information (RDS) [9].

3.8 Emergency stations

All emergency stations contain a telephone for emergency situations (ERT) and 2 fire extinguishers placed in a niche next to it. ERT enables the road/tunnel user to communicate with the operator in the control centre in case of an emergency. The 38 units were placed in niches at a distance of 300m, on both sides of the tunnel. ERT reconstruction took place in 2007 when the old devices were replaced with new ones at the pre-existing locations, and new in-between devices were built in. Now the new distance between two units has been shortened to 150m, in compliance with Directive recommendations. At these new positions, telephones were placed directly on the tunnel lining, while new niches for 2 fire extinguisher cabinets had to be precisely cut and built in the concrete lining. By pushing the button at the ERT, users can communicate with an operator in the control centre. The operator may then forward the call to other services. It is also possible to check the work of the system graphically on the monitors. During every call, the conversation is automatically recorded, so that the stored data can be used later for investigative purposes [10].

3.9 Traffic signalization

The existing traffic signs and equipment were old, and the communication network was outdated. Consequently, in 2008, the Concessionaire decided to renew the signs and to connect the control system with the new SCADA. The new design also included replacing the old dynamic

traffic signs in both tunnels, at both toll stations and traffic portal areas. New dynamic traffic equipment was added. All improvements were based on the “Directive” recommendations. Variable message signs inside the tunnel and gantries with information panels at the portal areas were also erected, with the purpose of offering tunnel users immediate and clear access to information [11]. The reconstruction of the entire signalization system and its communication with the control centre was completed in February 2010.

4 Organization of works

All the afore-mentioned works in the tunnel were carefully planned and organized, taking place mostly at night, between 10.00p.m. and 6.00a.m., when traffic volume was lower than normal. The contractor would use one lane, while traffic moved in the adjacent lane, changing directions at 15 minute intervals. It was not an easy job, neither for the contractor, nor for the tunnel operator, who had to be constantly at the disposal of the contractor. Only by the meticulous organization, and coordination on the part of both subjects, were such good results achieved. The tunnel users were informed about any traffic delays or construction in a timely manner at both points of entry. All staff in the toll booths, together with the operator in the control centre, jointly worked to ensure safety traffic conditions were met.

5 Conclusion

In the last 6 years, significant work on the modernization of the Učka Tunnel has been undertaken. Comprehensive improvements were done based on “Directive” recommendations, but there are still more to be arranged. Since 1995, the renewal of the Učka Tunnel has been financed by the Concessionaire, while Bina-Istra Operation and Maintenance Ltd has been in charge of tunnel operation and management. BIOM’s staff care about maintenance and the provision of high level services to tunnel users. They have successfully fulfilled their main duty of ensuring safe transport through the tunnel and to finding optimal solutions for any deficiencies arising out of construction. In the end, it is important to note that an Environmental Impact Assessment study is in progress for the entire road section on which the Učka Tunnel is placed and on which the second tube will be placed in the future. As per today’s plan, the completion of the second tunnel tube is predicted by 2015.

References

- [1] De Boutray, E. & Ladavac, A.: Učka road tunnel, Istarska naklada Pula, Pula-Pazin 1981
- [2] Croatian National Gazette No 11/2009: The Regulation of the Tunnel Minimum Safety Requirements; it will go into effect when Croatia is recognized as an European State Member
- [3] Vergnault, J.M. & Boncour, A.: Safety Audit of the Učka Tunnel, setec tpi, Paris 2006
- [4] Kranjec, M. & Perušić, Lj.: Lighting Power Supply System of the Učka Tunnel, IPT inženjering, Zagreb, 2004
- [5] Gorupec, D. & Jakobović, V. & Vusanić, M.: Remote Control System Upgrade, Exor, Zagreb, 2005-2007
- [6] Drakulić, M. & Lozica, M. & Ventilation Study of the Učka tunnel, Brodarski institute & setec tpi Zagreb, Paris, 2006 & 2007
- [7] Lozica, M. & Crnković, M.: Fire-alarm system of the Učka tunnel, Brodarski institut Zagreb, 2008
- [8] Vujović, Z.: Video Incident detection, Promel projekt Zagreb, 2007
- [9] Čimaš, B.: Radio communication system in the Učka tunnel, TEВ inženjering, Zagreb, 2006
- [10] Palac, N.: Emergency stations in the Učka tunnel, Telegra, Zagreb, 2007
- [11] Bukvić, I. & Brezak, D. & Martinović, A.: Traffic design of the Učka tunnel, Promel projekt Zagreb, 2008