Engineering xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Engineering

journal homepage: www.elsevier.com/locate/eng

Research
Tunnel Engineering—Article

The Ceneri Base Tunnel: Construction Experience with the Southern Portion of the Flat Railway Line Crossing the Swiss Alps

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ARTICLE INFO

Article history:
Received 5 April 2017
Revised 11 August 2017
Accepted 22 September 2017
Available online xxxx

Keywords:
Deep and long tunnel
Difficult ground conditions
Support design
Risk management
Tunnel monitoring
Large caverns
Low overburden
Overpass tunnel
Numerical analysis
Excavation in urban area

ABSTRACT

This paper summarizes the experience that was gained during the construction of the 15.4 km long Ceneri Base Tunnel (CBT), which is the southern part of the flat railway line crossing the Swiss Alps from north to south. The project consisted of a twin tube with a diameter of 9 m interconnected by cross-passages, each 325 m long. In the middle of the alignment and at its southern end, large caverns were excavated for logistical and operational requirements. The total excavation length amounted to approximately 40 km. The tunnel crossed Alpine rock formations comprising a variety of rock typologies and several fault zones. The maximum overburden amounted to 850 m. The excavation of the main tunnels and of the cross-passages was executed by means of drill-and-blast (D&B) excavation. The support consisted of bolts, meshes, fiber-reinforced shotcrete and, when required, steel ribs. A gripper tunnel boring machine (TBM) was used in order to excavate the access tunnel. The high overburden caused squeezing rock conditions, which are characterized by large anisotropic convergences when crossing weaker rock formations. The latter required the installation of a deformable support. At the north portal, the tunnel (with an enlarged cross-section) passed underneath the A2 Swiss highway (the major road axis connecting the north and south of Switzerland) at a small overburden and through soft ground. Vertical and sub-horizontal jet grouting in combination with partial-face excavation was successfully implemented in order to limit the surface settlements. The south portal was located in a dense urban area. The excavation from the south portal included an approximately 220 m long cut-and-cover tunnel, followed by about 300 m of D&B excavation in a bad rock formation. The very low overburden, poor rock quality, and demanding crossing with an existing road tunnel (at a vertical distance of only 4 m) required special excavation methods through reduced sectors and special blasting techniques in order to limit the blast-induced vibrations. The application of a comprehensive risk management procedure, the execution of an intensive surface survey, and the adaptability of the tunnel design to the encountered geological conditions allowed the successful completion of the excavation works.

1. Introduction

The Ceneri Base Tunnel (CBT) is the southernmost portion of the New Railway Link through the Alps (NRLA) crossing the Swiss Alps from north to south [1]. The client is the AlpTransit Gotthard Ltd., on behalf of the Swiss government. The NRLA is designed to create a continuous flat-rail connection from Basel to Milan, which will reduce travel times, increase the efficiency and sustainability of freight traffic, and connect Switzerland to the European high-speed railway network (Fig. 1) [1]. Along with the CBT, the main elements of the NRLA consist of the Lötschberg Base Tunnel (34.6 km total length), which was constructed from 1999 to 2006 and opened in 2007, and the Gotthard Base Tunnel (57 km total length), which was begun in 1999 and opened in December 2016.

The CBT is characterized by a twin tube system with a single-track railway tunnel with a length of 15.4 km linked through cross-passages that are spaced approximately 325 m apart (Fig. 2) [1]. The total excavation length amounts to approximately 40 km and had an excavation volume of approximately 4×10^6 m^3. The cost of the works was about 2.1 billion Euro.

The construction works started in 1997 with the drill-and-blast (D&B) excavation of the geological exploratory tunnel (3.1 km in

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https://doi.org/10.1016/j.eng.2017.09.004

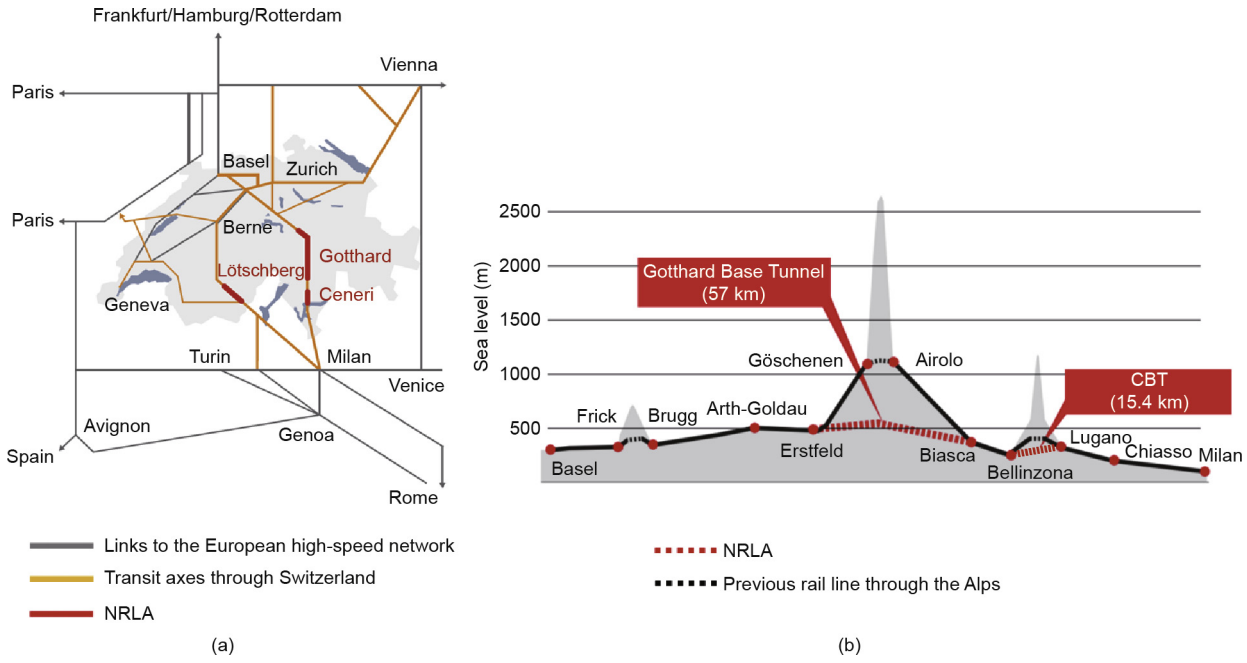

Fig. 1. (a) The layout of NRLA project; (b) the profile of the Gotthard axis [1].

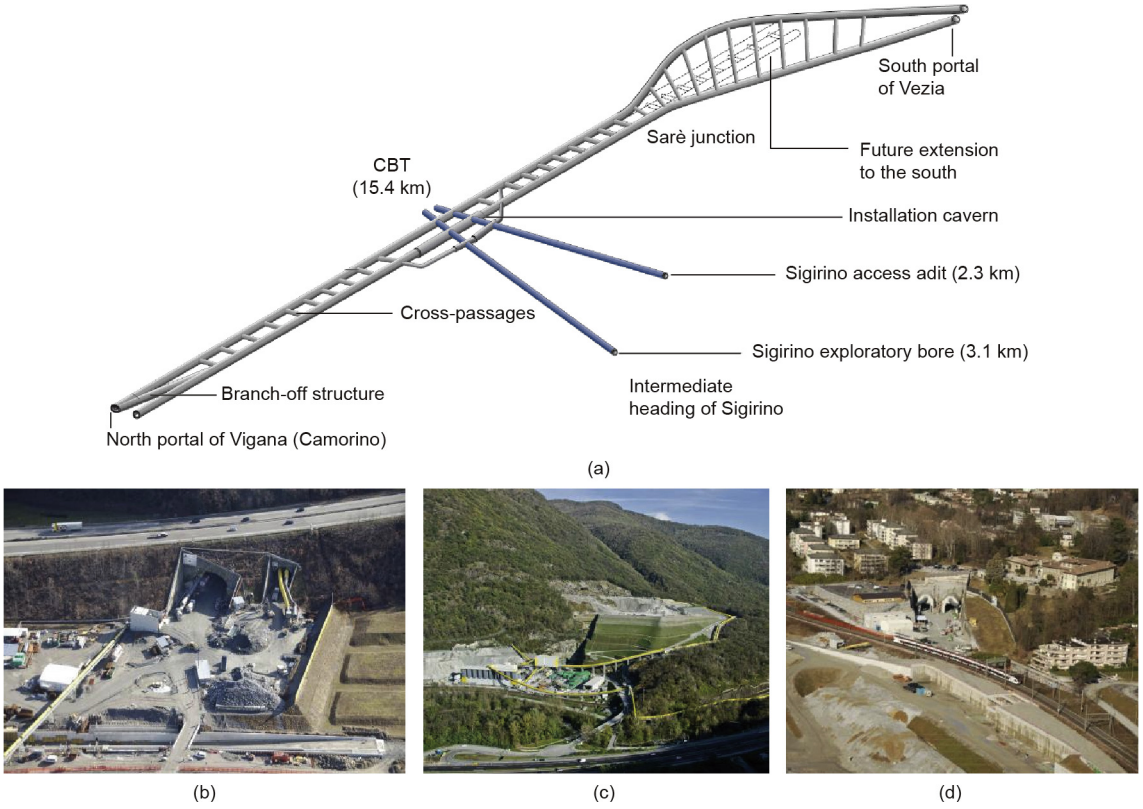

Fig. 2. (a) Layout of the CBT [1] with photographs of (b) the north portal of Vigana (Camorino), (c) the intermediate heading of Sigirino, and (d) the south portal of Vezia.

length), which was located approximately in the middle of the alignment (Sigirino). In 2008, an intermediate access adit (2.3 km)—running almost parallel to the exploratory tunnel—was excavated using a gripper tunnel boring machine (TBM) (Fig. 3(a)). Two large caverns (with a cross-section of about 270 m^2) were excavated for logistical and operational reasons. The caverns were connected to the end of the intermediate access adit and of the exploratory tunnel.

The excavation of the main tunnels started in 2010 from the intermediate heading of Sigirino. The north (approximately 8.3 km) and south (approximately 6.3 km) tunnels were excavated simultaneously using D&B method (Lot 852, about 90% of the total

Please cite this article in press as: Merlini D et al. The Ceneri Base Tunnel: Construction Experience with the Southern Portion of the Flat Railway Line Crossing the Swiss Alps. Eng (2018), https://doi.org/10.1016/j.eng.2017.09.004