TUNNELS HOSTĚRADICE (SO 604), VRŠKY (SO 605) AND KRŇANY (SO 606) ON SECTION D3 0303 – HOSTĚRADICE – VÁCLAVICE

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ABSTRACT: The paper presents the design of three motorway tunnels – Hostěradice (SO 604), Vršky (SO 605) and Krňany (SO 606) – located on section D3 0303 Hostěradice–Václavice of the future D3 motorway. The design was developed at the level of the Detailed Design for Building Permit (DUSP-DI). The tunnels are situated in open countryside, predominantly within forested areas, and pass through the rock mass of Sázava granodiorites belonging to the Central Bohemian Plutonic Complex. The geological environment exhibits various degrees of weathering, ranging from completely decomposed to intact rock conditions.

All three tunnels are designed as twin-tube structures, each tube accommodating one traffic direction. The mined sections are to be constructed using the New Austrian Tunnelling Method (NATM), while short cut-and-cover sections are proposed at both portals. The waterproofing system is designed as open, and the tunnel cross-section has a horseshoe shape without an invert. The load-bearing structure, represented by the secondary lining, is designed for a service life of 100 years, whereas the internal civil structures are designed for 30 years and the technological equipment for 15 years.

The Hostěradice Tunnel has a total length of 360 m, the Vršky Tunnel 140 m, and the Krňany Tunnel 408 m (LTT) and 436 m (PTT). According to ČSN 73 7507, all three tunnels are classified as short tunnels and meet the requirements of safety category TC and TP 98. The design speed within the tunnels is 120 km/h, with a maximum permitted speed of 100 km/h.

The paper focuses on the overall design concept of the tunnels, addressing geotechnical and structural solutions, excavation sequencing in relation to varying ground conditions, the selection of lining and waterproofing systems, and the integration of safety equipment. Furthermore, it discusses design adjustments made compared to the previous documentation stage, particularly in the coordination of tunnel technology and associated structures.

1. INTRODUCTION

The D3 motorway represents a key southern transport axis of the Czech Republic, connecting Prague with the state border with Austria via Tábor and České Budějovice. In continuity with the Austrian expressway S10 and motorway A7, it will form a continuous high-capacity connection between Prague and Linz, which is also part of the Trans-European Transport Network (TEN-T).

After completion of the currently under-construction section Kaplice nádraží – Dolní Dvořiště, state border, the South Bohemian part of the D3 motorway will be fully completed. The remaining key section to be constructed is the approximately 58.5 km long Central Bohemian section, whose implementation will not only enable a fully functional southern motorway connection, but will also significantly relieve traffic on the D1 motorway between Spořilov and Mirošovice. This section is currently heavily burdened by traffic heading towards the southern part of the country, as well as on Road I/20 between Písek and České Budějovice, which has become an alternative route following the completion of the D4 motorway in December 2024. Ensuring a continuous motorway connection to the south is therefore essential not only from a transport perspective, but also in terms of improving the living conditions of residents in municipalities affected by transit traffic, particularly along Road I/3.

For this reason, the project investor, the Road and Motorway Directorate of the Czech Republic, has adopted a parallel preparation approach for all five missing sections of the Central Bohemian part of the

D3 motorway. Due to the rugged terrain, this part of the route includes a total of seven tunnel structures. A unified preparation approach enables standardisation of the technical solutions for individual tunnel structures across the sections.

Valbek is preparing the documentation for the issuance of a Joint Permit for Transport Infrastructure Construction (DUSP DI) for Section 0303 Hostěradice – Václavice (Figure 1). This section includes three tunnel structures – Hostěradice (SO 604), Vršky (SO 605) and Krňany (SO 606) – whose design documentation is being prepared by V-CON. These tunnels constitute the main focus of this paper.

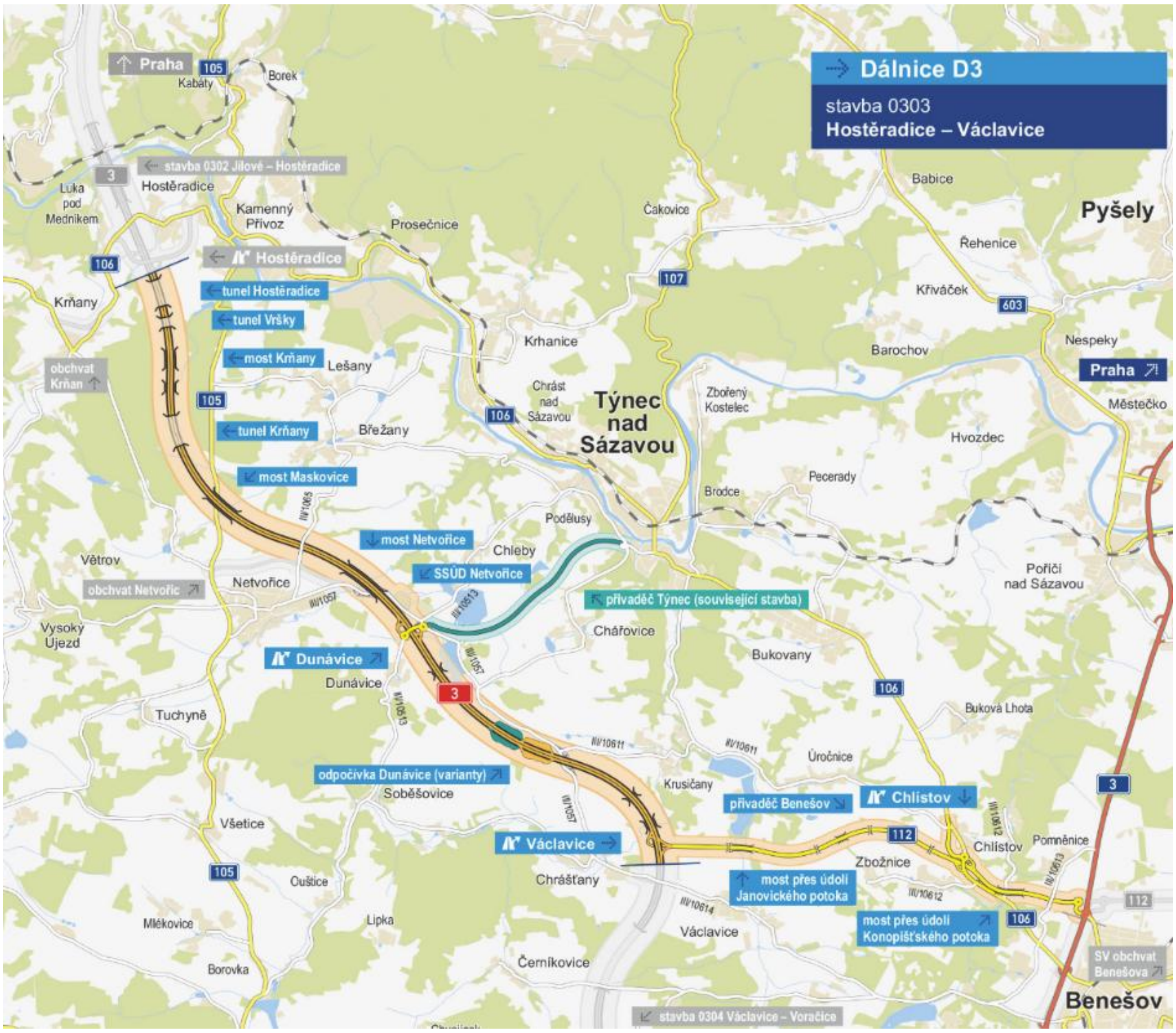


Figure 1 Schematic map of the section D3 0303

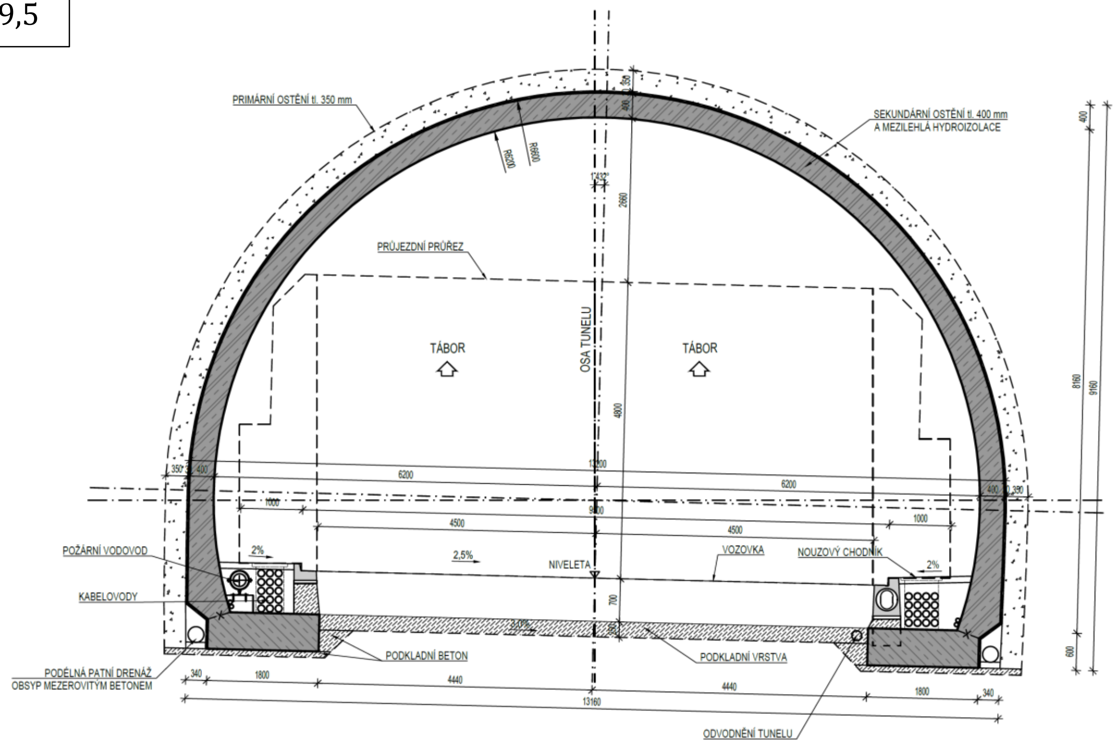
2. GENERAL CHARACTERISTICS OF THE TUNNELS

Section D3 0303 Hostěradice – Václavice comprises three twin-tube, directionally separated motorway tunnels. All tunnels are shorter than 500 m, are located at relatively short distances from one another, and are situated in similar geological conditions. For these reasons, their basic technical and geological characteristics can be described collectively.

According to ČSN 73 7507, all tunnels are classified as short tunnels and, from a safety perspective, fall into category TC in accordance with ČSN 73 7507 and TP 98. The design speed in the tunnels is 120 km/h, while the maximum permitted speed is 100 km/h.

The tunnel cross-section is designed with a horseshoe-shaped profile without an invert arch along the entire length of the mined sections as well as in the areas of cross-passages. The basic width category is T 9,5, with the exception of the left tunnel tube of the Hostěradice Tunnel, where category T 11,5 is designed due to the presence of an acceleration lane (Figure 2).

T-9,5



T-11,5

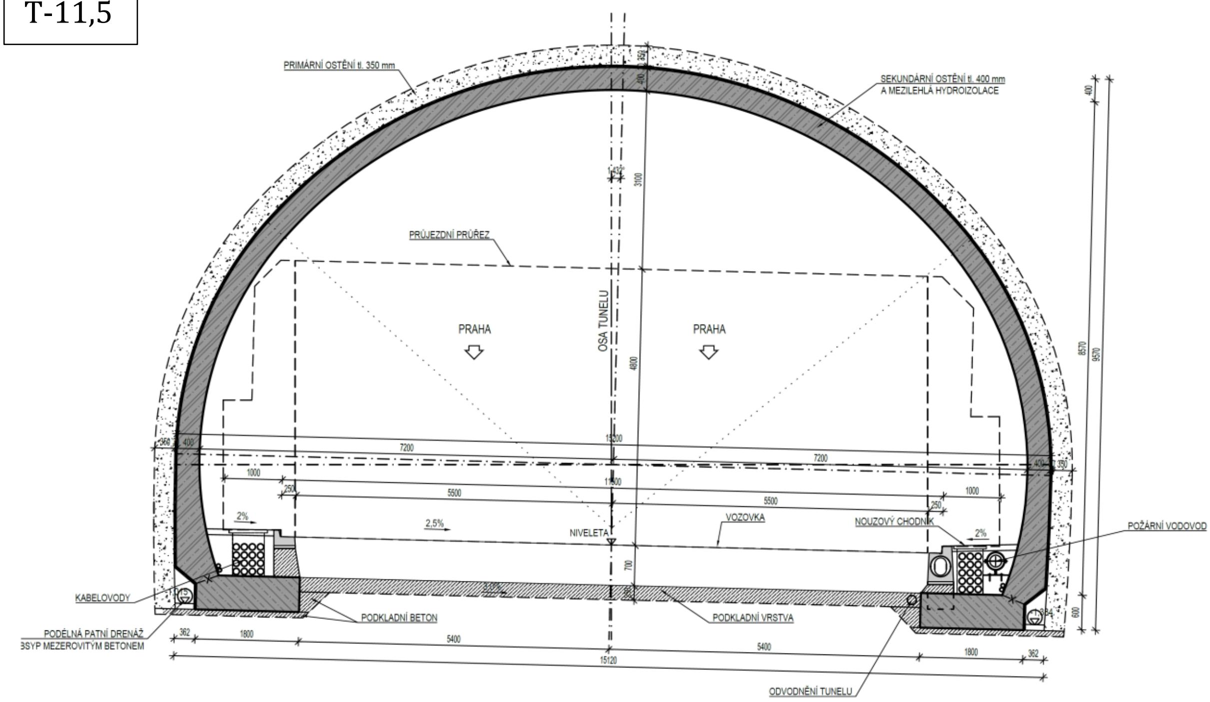


Figure 2 Typical cross-sections of categories T 9,5 and T 11,5

At both portals, the tunnels include short cut-and-cover sections, which transition into mined sections constructed using the New Austrian Tunnelling Method (NATM). The primary lining consists of sprayed concrete reinforced with welded KARI meshes in combination with additional support elements according to the respective excavation support classes. The waterproofing system is designed as an open system. The tunnels are founded along their entire length on strip foundations.

The mined tunnel sections are equipped with an umbrella-type waterproofing system with side drainage, while the cut-and-cover sections feature a vault made of watertight concrete, also with side drainage. Drainage from the pavement subgrade and the drainage system is led into common inspection and cleaning manholes spaced at maximum intervals of 50 m, with the drainage system connected to portal manholes.

The secondary lining of the tunnels is designed as reinforced concrete, generally constructed in 10 m long blocks, with non-standard sections at the transitions between the cut-and-cover and mined parts. The design service life of the load-bearing structure is 100 years, that of internal civil structures 30 years, and that of technological equipment 15 years. An overview of the basic variable parameters of the tunnels is provided in Table 1.

Table 1 Tunnel parameters on the D3 0303 section

Tunnel	TT	Category	Length [m]	Cut-and-cover section [m]	Mined section [m]	Cross passages	ESC prediction [m]					
							3	4	5a*	5aM	5b*	5bM
SO 604 Hostěradice	LTT	11,5	360	30 (Pra) + 30 (Táb)	300	1	98	42	40	0	84	34
	RTT	9,5	360	30 (Pra) + 30 (Táb)	300		25	102	70	0	67	34
SO 605 Vršky	LTT	9,5	140	20 (Pra) + 20 (Táb)	100	1 (technical room)	0	0	20	0	44	34
	RTT	9,5	140	20 (Pra) + 20 (Táb)	100		0	23	20	0	21	34
SO 606 Krňany	LTT	9,5	408	30 (Pra) + 48 (Táb)	330	2 (one technical room)	0	0	295	0	35	0
	RTT	9,5	436	68 (Pra) + 80 (Táb)	288		0	0	288	0	0	0

* The parameters of TTV 5a and 5b differ for the Krňany Tunnel (SO 606) compared to the other two tunnels.

2.1 TUNNEL TECHNOLOGICAL EQUIPMENT

The technological equipment of the tunnels is designed in accordance with ČSN 73 7507 and TP 98. An operational and technical facility (OTF) is located at the Prague-side portal of the Hostěradice Tunnel, providing local control of the Hostěradice and Vršky tunnels. Due to their short mutual distance and the limited length of the Vršky Tunnel, both tunnels are conceived as a single operational unit in terms of traffic management and technology control, with the option of remote control from a superior traffic control centre. For this reason, the tunnels are interconnected by a cable route.

The Krňany Tunnel has a separate OTF located at the Tábor-side portal.

Additional designed technological systems include emergency call points, monitoring of physical quantities, variable message signs, CCTV surveillance, electrical fire alarm systems, and a fixed gaseous fire suppression system. Traffic offence detection systems are also installed in the Hostěradice and Krňany tunnels. The OTF includes provisions for telecommunications operators' technologies and backup power supplies for emergency operating conditions.

2.2 TECHNICAL ROOMS AND OPTIMISATION OF CROSS-PASSAGES

During preparation of the documentation at the DUSP DI stage, the layout of tunnel cross-passages and technical rooms was optimised. The main reason was the concentration of high-power technological equipment in the portal areas, particularly adaptive lighting systems. The Hostěradice Tunnel also supplies power to the Vršky Tunnel, where lighting is again the dominant electrical load.

Due to the high power demand, it was desirable to minimise the lengths of power supply cables and to unify their types at both portals, which brings advantages both in terms of structural design of cable ducts and installation and future maintenance. The standard solution involves placing substations within tunnel cross-passages, serving the technological equipment in their vicinity.

In the Hostěradice Tunnel, the existing walk-through cross-passage containing technological substations was relocated closer to the centre of the tunnel (Figure 4). In the Vršky Tunnel, a new non-walk-through tunnel cross-passage was designed in the form of a technical room containing two separate substations, one for each tunnel tube, allowing their independent electrical disconnection (Figure 5).

In the Krňany Tunnel, the cross-passage was designed asymmetrically closer to the Tábor-side portal in accordance with the zoning design documentation (DUR), from which most of the technological equipment is supplied. To ensure power supply to the equipment at the Prague-side portal, two separate substations were designed in the cut-and-cover section of the Prague-side portal, again in the form of non-walk-through tunnel cross-passages – technical rooms (Figure 6).

2.3 GEOLOGICAL CONDITIONS

All three tunnels pass through similar geological conditions, characterised by alternation of various rock types beneath Quaternary cover deposits. The subsoil consists of rocks of the Central Bohemian Plutonic Complex, primarily Sázava granodiorites with varying degrees of weathering.

The tunnels are located in an extra-urban area, and there are no structures above them that would require a special monitoring regime.

3. EXCAVATION CONCEPT

Tunnel excavation is designed using the New Austrian Tunnelling Method (NATM). The basic support elements include:

- sprayed concrete C25/30,
- auxiliary lattice girders,
- welded KARI reinforcement meshes,
- self-drilling grouted rock bolts (IBO, SN),
- pre-drilled spiles and self-drilling grouted bars,
- face stabilisation using sprayed concrete with KARI mesh.

The extent of use of individual elements depending on the excavation support classes is presented in Table 2. Most classes are conventionally subdivided into top heading, bench, and invert. An exception is excavation support class ESC 5b in the Krňany Tunnel, where vertical subdivision of the excavation into smaller parts is also designed (Figure 3).

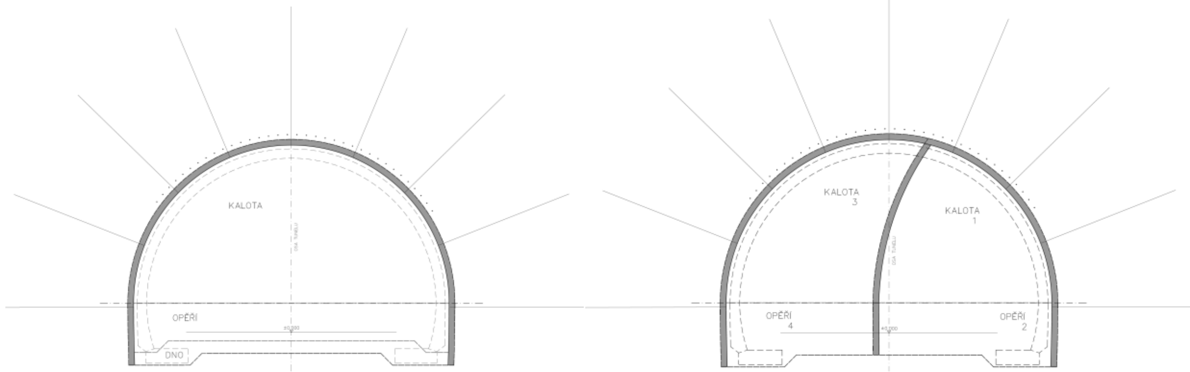


Figure 3 Horizontal subdivision of excavation for most ESCs and combined horizontal and vertical subdivision of ESC 5b (SO 606)

The applied excavation support classes can be summarised as follows:

- ESC 3 – slightly difficult conditions, predominantly rock class R2,
- ESC 4 – moderately difficult excavation conditions,

- ESC 5a – difficult conditions, tectonically disturbed zones,
- ESC 5a (SO 606) – low overburden of the Krňany Tunnel, without the assumption of rock arch formation,
- ESC 5aM – excavation start under a micropile umbrella,
- ESC 5b – difficult conditions with chemical pressure grouting,
- ESC 5b (SO 606) – area of the walk-through cross-passage in the LTT of the Krňany Tunnel with local depressions of less competent rock,
- ESC 5bM – combination of a micropile umbrella and chemical pressure grouting.

Table 2 Parameters of excavation support classes

ESC	Length of top heading's advance[m]	Length of bench's advance [m]	Min. faces distance [m]	Primary lining	Radial rockbolts	Face support
3	2,0	6,0	18	C 25/30 len. 150 mm + 1x KARI ø8/150	Len. 3,0 m, per 2,5 m IBO R25	No support
4	1,5	4,5	12	C 25/30 len. 200 mm + 2x KARI ø8/150	Len. 4,0 m per 2,0 m IBO R25	If needed shotcrete 80 mm + mesh, otherwise support wedge
5a	1,2	2,4	8	C 25/30 len. 250 mm + 2x KARI ø8/150	Len. 6,0 m per 2,7 m IBO R32	Shotcrete 120 mm + mesh
5a (SO 606)	1,0	2,0	8	C 25/30 len. 250 mm + 2x KARI ø6/150	Len. 6,0 m per 1,5 m IBO R32	Shotcrete 120 mm + mesh
5aM	1,2	2,4	8	C 25/30 len. 250 mm + 2x KARI ø8/150	Len. 6,0 m per 1,5 m IBO R32	Shotcrete 120 mm + mesh
5b	1,0	2,0	6	C 25/30 len. 250 mm + 2x KARI ø8/150	Len. 6,0 m per 1,5 m IBO R32	Shotcrete 120 mm + mesh
5b (SO 606)	0,5	1,0	6	C 25/30 len. 250 mm + 2x KARI ø10/100	Len. 6,0 m per 2,7 m IBO R32	Shotcrete 120 mm + mesh
5bM	1,0	2,0	6	C 25/30 len. 250 mm + 2x KARI ø8/150	Len. 6,0 m per 1,5 m IBO R32	Shotcrete 120 mm + mesh

4. HOSTĚRADICE TUNNEL

The Hostěradice Tunnel is named after the municipality through whose cadastral territory it passes. Excavation will predominantly take place in rocks of strength class R2, with local transitions to less competent R3 rocks, particularly outside the portal areas where deterioration of rock mass quality is expected. Tectonic faults along the tunnel alignment were confirmed by geophysical investigations.

The tunnel overburden is approximately 18 m. The stabilised groundwater level was identified at depths of 13.3–19.7 m below ground level.

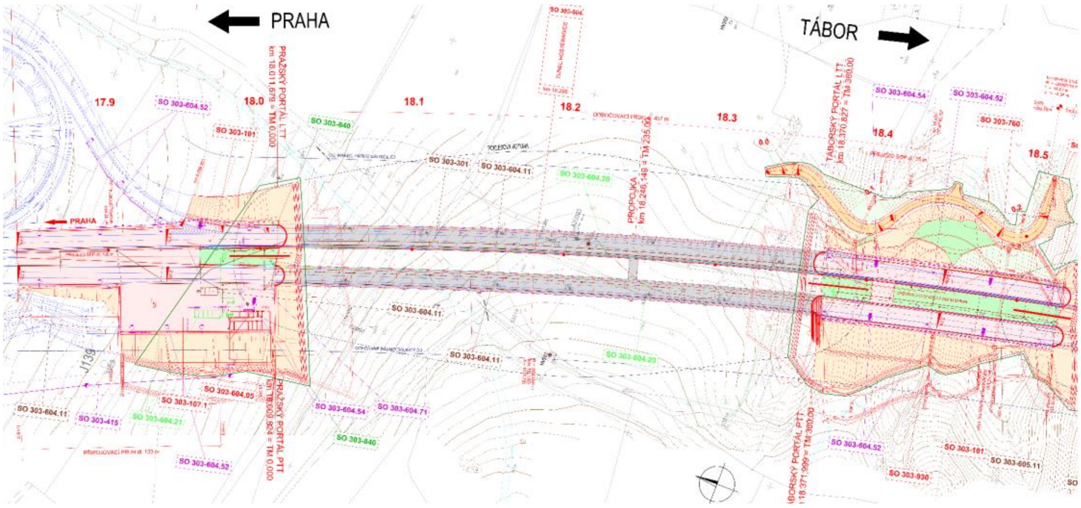


Figure 4 Hostěradice tunnel (SO 604)

5. VRŠKY TUNNEL

The Vršky Tunnel is named after the hill through which it passes. From a geological perspective, excavation will mainly take place in rocks of strength classes R2 and R3, with reduced rock quality in the portal areas. Tectonic faults along the tunnel alignment were also confirmed by geophysical surveys. The tunnel overburden reaches approximately 18 m, and the stabilised groundwater level was measured at depths of 13.8–21.7 m below ground level.

From the drainage system perspective, the Hostěradice and Vršky tunnels are interconnected. Drainage water from the Vršky Tunnel is conveyed through the inter-tunnel section and the Hostěradice Tunnel as a roadway underdrain, and together with drainage water from this tunnel is led to sedimentation and cleaning tanks at the Prague-side portal of the Hostěradice Tunnel. From there, the water is discharged into the adjoining Section 0302 and subsequently into the receiving water body.

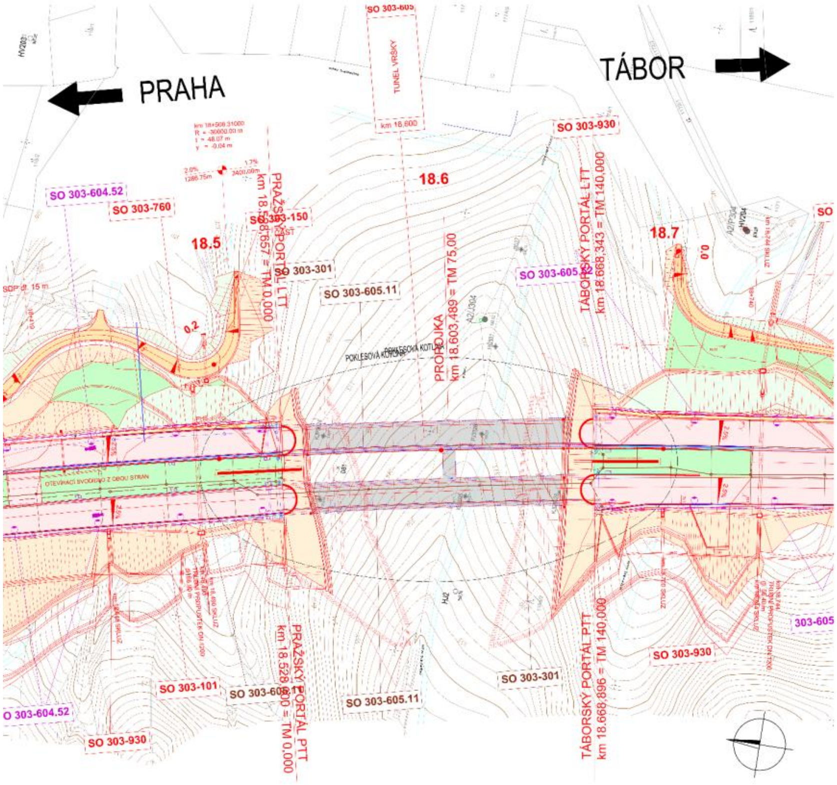


Figure 5 Vršky tunnel (SO 605)

6. TUNEL KRŇANY

The Krňany Tunnel is the longest tunnel of Section 0303 and is named after the municipality within whose cadastral territory it is located. From a geological perspective, the tunnel is predominantly situated in rocks of strength class R3, with local depressions of poorer-quality rock extending into the top heading. Overburden along a substantial part of the alignment is below 10 m, locally reaching approximately 14 m, which does not allow formation of a stable rock arch or utilisation of the self-supporting capacity of the rock mass.

For this reason, excavation support class ESC 5a is designed along the entire tunnel length, with local transitions to ESC 5b. Tectonic faults were confirmed along the tunnel alignment, and the stabilised groundwater level was identified at a depth of approximately 10.0 m below ground level.

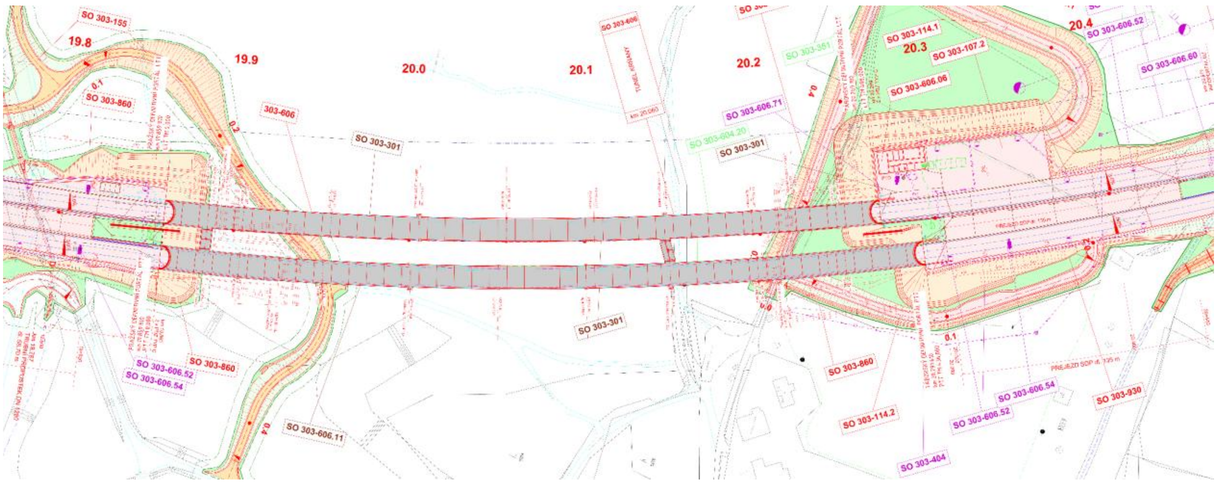


Figure 6 Krňany tunnel (SO 606)

7. CONLUSION

The tunnel design project for Section D3 0303 Hostěradice – Václavice represents a typical example of a comprehensive solution for short motorway tunnels in a hilly terrain with complex geological conditions. A unified design concept, applied across the three tunnel structures, allowed for optimisation of the technical solution, particularly in the areas of technological equipment, power supply, and operational and technical facilities (OTFs).

The chosen excavation concept using the New Austrian Tunnelling Method, combined with a flexible system of excavation support classes, provides the basis for safe and economical construction while respecting the local geological peculiarities of each tunnel. The optimisation of cross-passages and substations contributes not only to a reduction in investment costs but also to the simplification of operation and maintenance of tunnel technologies throughout the service life of the infrastructure.

The implementation of Section 0303 is an important step towards completing the Central Bohemian part of the D3 motorway, which will bring significant transport and environmental benefits to the entire region and strengthen the role of this corridor within the international transport network.

LITERATURE

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PRAGOPROJEKT, a.s., *D3 0303 Hostěradice – Václavice, Podrobný geotechnický průzkum*: Pasport SO 604 – Tunel Hostěradice (10/2023); Pasport SO 605 – Tunel Vršky (10/2023); Pasport SO 606 – Tunel Krňany (10/2023).

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