

# TUNNELS ON THE PROJECT I/33 NÁCHOD BYPASS

Ing. Michal Maričák

*Marti a.s.*

Ing. Boris Čillik

*Marti a.s.*

**Abstract:** The Dolní Radechová Tunnel and the Kramolna Tunnel represent significant engineering structures within the I/33 Náchod Bypass project, the aim of which is to improve traffic conditions in the town of Náchod and its surrounding area. The paper presents basic information on the technical design, applied technologies, and the organization of tunnel construction, and last but not least, addresses the importance of these structures for regional transport infrastructure.

## 1. INTRODUCTION

The town of Náchod, located near the Czech–Polish border, has long been facing excessive traffic loads that negatively affect both the quality of life of its residents and traffic flow. The international first-class road I/33, connecting Hradec Králové with the Polish town of Kudowa-Zdrój, is an important transport artery; however, its routing through the centre of Náchod results in traffic congestion, increased noise levels, and higher emissions.

The construction of the Náchod bypass represents a strategic solution to this situation. The project involves a linear road infrastructure development providing a north-western bypass of the town. Its main objective is to divert transit traffic away from the town centre, thereby improving road safety, reducing noise and exhaust emissions for residents, and increasing overall travel comfort. Road I/33 is designed in category S 11.5/70 with a total length of 6.465 km, while road I/14 is designed in category S 9.5/80 with a length of 0.923 km.

The project also includes a number of additional structures addressing the rerouting of roads and local communications, bridge structures, cycle paths, access roads to adjacent plots, operational facilities, noise barriers, utility networks, landscaping works, and two tunnel structures: the 100-m-long cut-and-cover Kramolna Tunnel and the Dolní Radechová Tunnel. These tunnel structures are being constructed by Marti a.s.

Client for the project is the Road and Motorway Directorate of the Czech Republic (Ředitelství silnic a dálnic, s.p.), and the contractor is the “Společnost obchvat Náchoda” consortium, comprising EUROVIA CZ a.s., Stavby mostů a.s., Marti a.s., and EUROVIA SK, a.s.

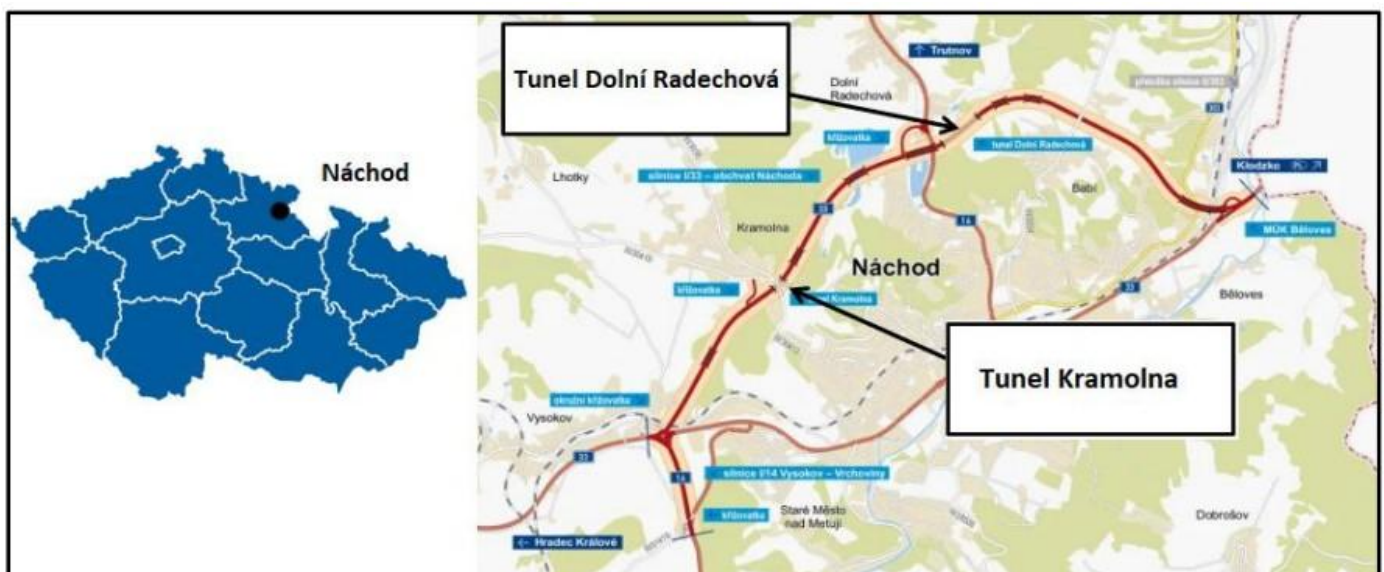


Figure 1: Overview of the construction site

## 2. DOLNÍ RADECHOVÁ TUNNEL

### 2.1 BASIC INFORMATION ABOUT THE TUNNEL

The main reason for the design of the Dolní Radechová Tunnel on the alignment of road I/33 is the need to overcome a geomorphologically complex area southeast of the village of Dolní Radechová. The tunnel passes beneath two ridges with maximum elevations of 391.1 m and 394.0 m a.s.l., with overburden locally reaching up to 25 m. Between these ridges, approximately at the midpoint of the tunnel, there is a transverse valley where, due to the low overburden and unfavourable geological conditions, the tunnel was originally planned to be constructed in an open excavation.

Based on the actual geological conditions encountered during excavation, as well as a conflict between a 100 kV high-voltage power line and the lifting equipment, the shape of the construction pit was modified during the works and a so-called false primary lining was designed. As a result, the tunnel tube is divided into two mined sections, two cut-and-cover sections, and one cut-and-cover section constructed beneath the false primary lining.

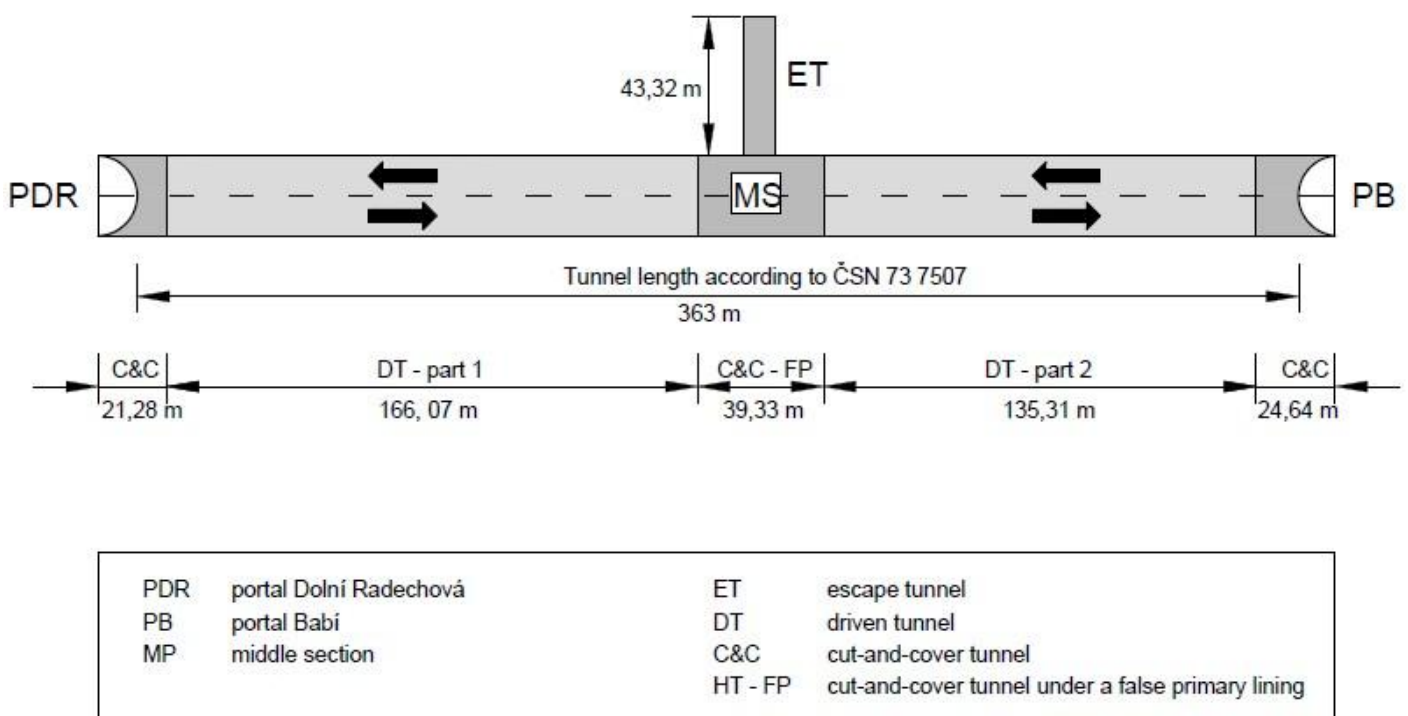


Figure 2: Schematic representation of the Dolní Radechová tunnel

According to ČSN 73 7507 *Design of Road Tunnels*, the Dolní Radechová Tunnel is classified as a short tunnel. The tunnel tube will operate in one direction with a design speed of 70 km/h. The total length of the tunnel tube (the distance between the outer faces of both tunnel portals) is 363 m.

The tunnel includes an emergency adit approximately 44 m long, located roughly at the midpoint of the tunnel tube and oriented perpendicular to it. The monolithic section of the adit (connection to the cut-and-cover tunnel) is approximately 4.4 m long. The remaining section is composed of 16 prefabricated system segments. At the portal of the emergency adit, an approximately 13.6 m-long escape route in an open trench continues. The trench walls will be reinforced on both sides with gabion retaining structures, with heights varying between 2.50 and 3.50 m.

The escape route leads to an assembly area measuring 5.3 m in width and 13 m in length, with an access road 2.5 m wide and 60.3 m long. The tunnel tube also contains 8 niches for drainage inspection shafts (4 on the right, 4 on the left), 4 combined niches (2 on the right, 2 on the left) for the installation of SOS cabinets, drainage inspection shafts, and, in the niches on the left side in the direction of chainage, fire hydrants will be installed. The basic technical parameters of the tunnel are presented in Table 1.

Table 1: Basic technical parameters of the Dolní Radechová tunnel

Number of tunnel tubes	1
Traffic flow	bidirectional
Tunnel category (ČSN 73 7507)	T - 9,5
Design speed	70 km/hod
Total tunnel length (ČSN 73 7507)	363 m
Length of mined sections (part 1 / part 2)	166,07 m / 135,31 m
Length of cut-and-cover sections (Dolní Radechová portal / central section / Babí portal)	21,28 m / 39,33 m / 24,64 m
Longitudinal gradient	variable from 0.07% to 3.95%
Cross slope	one-sided camber: 2.5–3%; two-sided camber: 2.5%
Escape gallery	1 piece, perpendicular to tunnel tube
Number of emergency bays	0
Clearance height	4,8 m
Sidewalk width	1,0 m
Headroom above sidewalk	2,2 m

## 2.2 CONSTRUCTION ORGANIZATION

The Dolní Radechová Tunnel consists of a construction section and a technological section. The construction section comprises 23 structures, while the technological section includes 15 structures. The tunnel excavation is carried out top-down from the Dolní Radechová portal. Since the mined section consists of two relatively short segments, and due to the technical and time demands of the pit in the central section, construction of the central excavation pit was started first. Subsequently, the excavation pit at the Dolní Radechová portal was constructed, and finally, the pit at the Babí portal will be built. All three pits were planned to be ready well in advance to avoid any restrictions on tunneling works.

After completing the excavation pit at the Dolní Radechová portal, the tunnel excavation began. During the excavation of the first tunnel segment, work on securing the central pit was completed, and construction of the Babí portal excavation pit started. After breakthrough of the first tunnel segment, the temporary ventilation duct was dismantled and the fan, part of the separate ventilation system, was relocated to the central pit. This allowed work on profiling the primary lining in the first (already excavated) segment to begin, and, after convergence stabilization, the construction of the foundation strips of the secondary lining.

After breakthrough of the second tunnel segment, the first tunnel segment will be prepared for installation of the drainage system and waterproofing layers, which precede the construction of the secondary lining. Subsequently, slot drains and curbs will be installed, creating space for the installation of the fire dry riser and cable ducts. After completion of these works, the sidewalks, roadway, lining coating, operational and technological buildings, as well as cable conduits on both sides of the tunnel, can be constructed. Once the construction section structures are built—or concurrently with their construction—the technological section of the Dolní Radechová Tunnel will commence.



Figure 3: View of the Dolní Radechová Tunnel alignment (foreground: Dolní Radechová portal)

### 2.3 DRIVEN SECTION OF TUNNEL

The construction of the driven tunnel consists of a two-layer lining (primary and secondary) with an intermediate drainage and protective layer and a continuous waterproofing membrane. Excavation will be carried out in accordance with the principles of the New Austrian Tunneling Method (NATM). Table 2 presents a comparison of the anticipated and actually applied excavation classes during the excavation of the first tunnel segment. Table 3 shows only the anticipated excavation classes; the actual values were not known at the time of writing this paper.

Table 2: Part 1 – Tunneling classes – comparison of assumption / real

Part 1	Assumption		Real	
	Tunneling class	Length	Share	Length
TT 2	74,3	45%	53,6	32%
TT 3	56	34%	93,4	56%
TT 4	0	0%	0	0%
TT 4P	30	18%	15,6	9%
TPŠ – tunel forepoling	5,77	3%	3,47	2%
Total	166,07	100%	166,07	100%

Table 3: Part 2 – Tunneling classes –assumption

Part 2	Assumption		Real	
	Tunneling class	Length	Share	Length
TT 2	0	0%	-	-
TT 3	50	37%	-	-
TT 4	49	36%	-	-
TT 4P	30	22%	-	-
TPŠ – tunel forepoling	6,31	5%	-	-
Total	135,31	100%	-	-

For all tunneling classes, the tunnel face is divided into a canopy and a bench. Within the TT 4P excavation class, a lower arch is also constructed if necessary; however, in the first tunnel segment, this is not required. Figure 5 shows a representative cross-section of the mined tunnel section.

The primary lining consists of shotcrete, reinforcement elements (reinforcing bars, welded steel meshes, BRETEX-type steel trusses), systematic radial rock anchors, and measures for stabilizing the excavation profile, overburden, and tunnel face (anchoring, spiling, and micropile umbrellas). Based on geological conditions, it is expected that rock fragmentation will be carried out primarily using drill-and-blast methods. In the portal sections, especially in TT 4P, it was anticipated that rock fragmentation could be done mechanically; however, explosives were still required even in these sections.



Figure 4: Bench excavation in Section 1

The definitive load-bearing structure of the mined tunnel is provided by the secondary lining, which consists of two main parts: the foundation structures and the upper arches. Considering the expected geological conditions at the foundation level (weathered to intact Permian sandstones, conglomerates, and siltstones), reinforced concrete foundation strips of class C 30/37 XA2 are designed along the entire length of the tunnel. The foundation strips are 1,500 mm wide and 750 mm high. The upper arches of the secondary lining are designed using reinforced concrete of class C35/45 XF4, XA2, XD3. The concrete is reinforced with B500B reinforcing steel and KARI meshes  $\varnothing 8/150/150$  mm. The standard block length is 12.5 m. The minimum thickness of the secondary lining is 400 mm, increasing up to 600 mm at the base slabs.

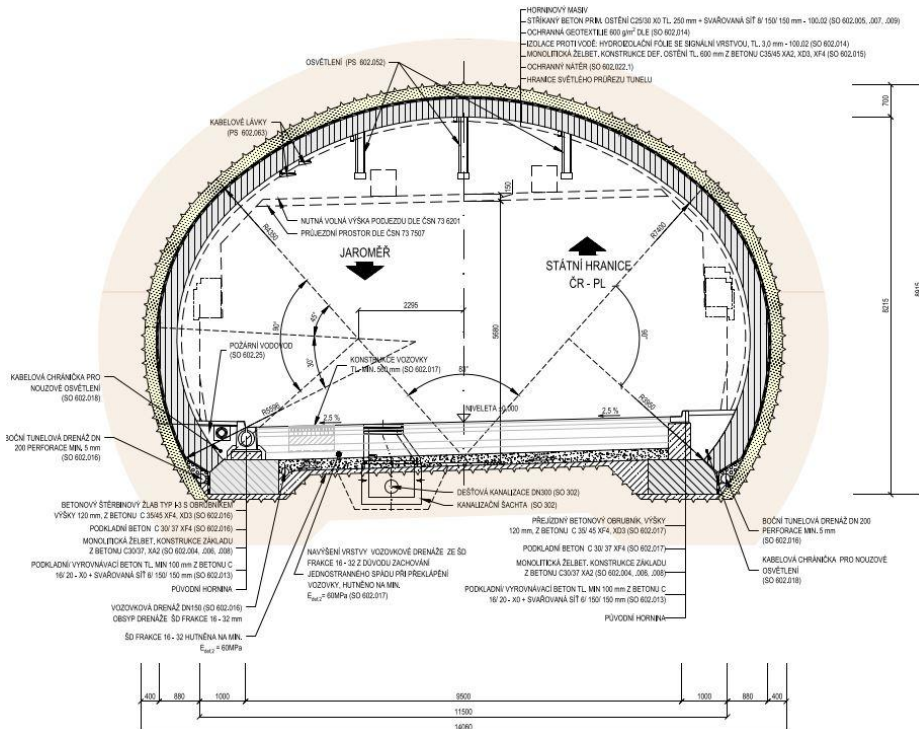


Figure 5: Typical cross-section of the mined section of the Dolní Radechová Tunnel

## 2.4 CUT-AND-COVER SECTION OF THE TUNNEL

The load-bearing lining structure in the cut-and-cover sections of the Dolní Radechová Tunnel (sections at both portals as well as in the central pit beneath the false primary lining) is, as in the mined section, designed from reinforced concrete of class C35/45 XF4, XA2, XD3. The concrete is reinforced with B500B reinforcing steel and KARI meshes  $\varnothing$  8/150/150 mm. Compared to the mined section, the minimum lining thickness is 600 mm, increasing up to 1,300 mm at the foundations.

The cut-and-cover sections at the portals will be constructed after the completion of the upper arch concreting in the mined section. The same formwork carriage will be used for their construction, to which the reinforcement is tied and then closed with counterformwork. The cut-and-cover section beneath the false primary lining will be constructed continuously in coordination with the progress of concreting in the mined section. A representative cross-section of the cut-and-cover section is shown in Figure 6.

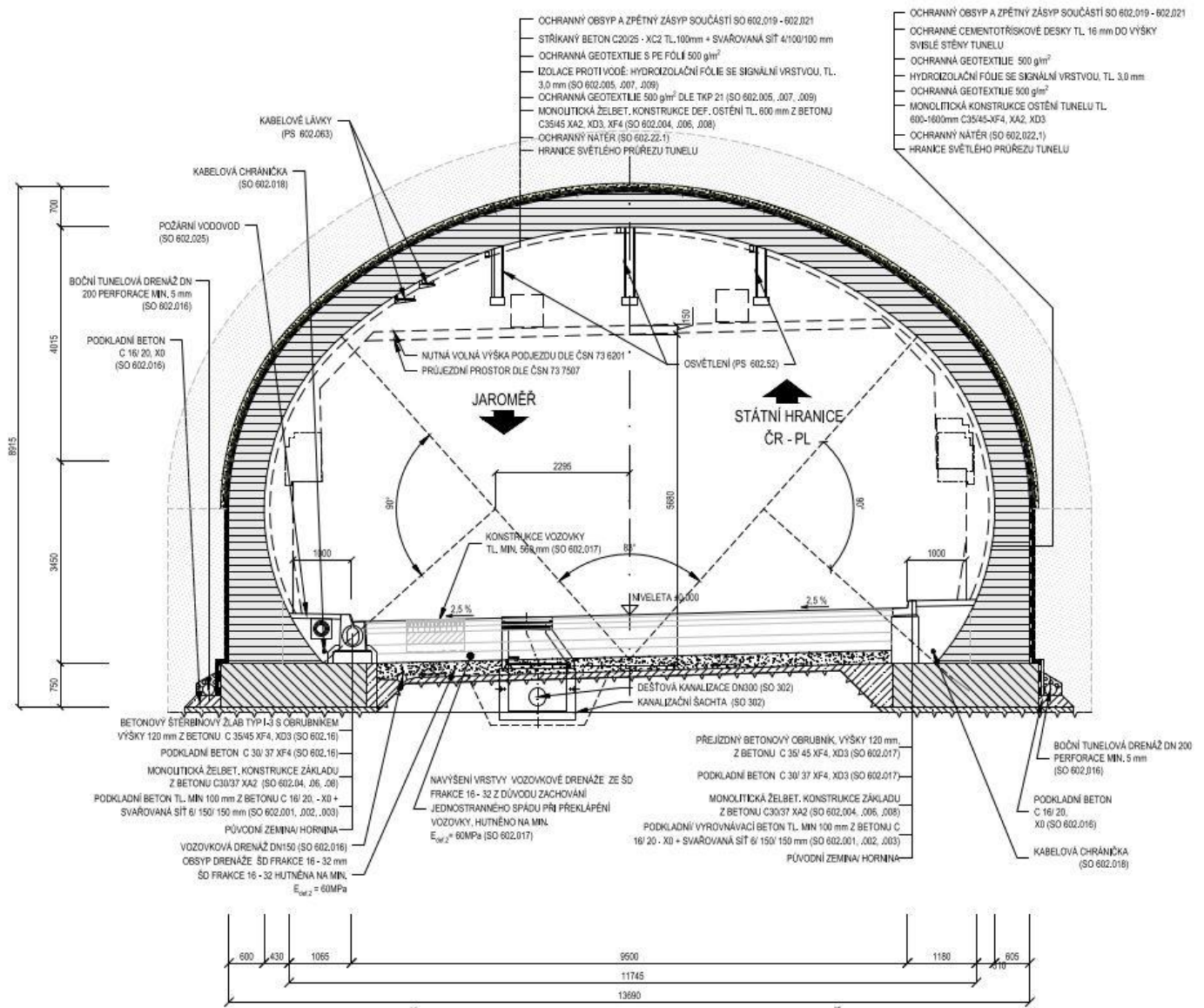


Figure 6: Typical cross-section of the cut-and-cover section of the Dolní Radechová Tunnel

## 2.5 FALSE PRIMARY LINING

During the construction of the central excavation pit of the tunnel, geological conditions different from those predicted by the geological survey were encountered. The contract documentation assumed that the excavation would be carried out predominantly in rock mass classes I (77%) and II (23%). In reality, the Quaternary layer, which was expected to reach a thickness of more than 5 m, was much thinner (0.5–1 m). Beneath it, the bedrock consisted of red-brown Permian sandstones and conglomerates. As a result, the excavation work was more difficult than anticipated and proceeded at a slower pace.



Figure 7: Excavation works in the central trench area – direct transition from Quaternary cover to bedrock

At the same time, a 110 kV high-voltage power line is located above the central excavation pit of the tunnel. At the start of the works, the contractor discovered that during the construction of the secondary lining in this section using counterformwork, the power line would be in direct conflict with the lifting equipment.

In view of this situation and also considering the challenging rock excavation in the central pit, the contractor, in cooperation with the designer, proposed a solution to optimize the shape and volume of the excavation pit while simultaneously addressing the issue with the high-voltage line.

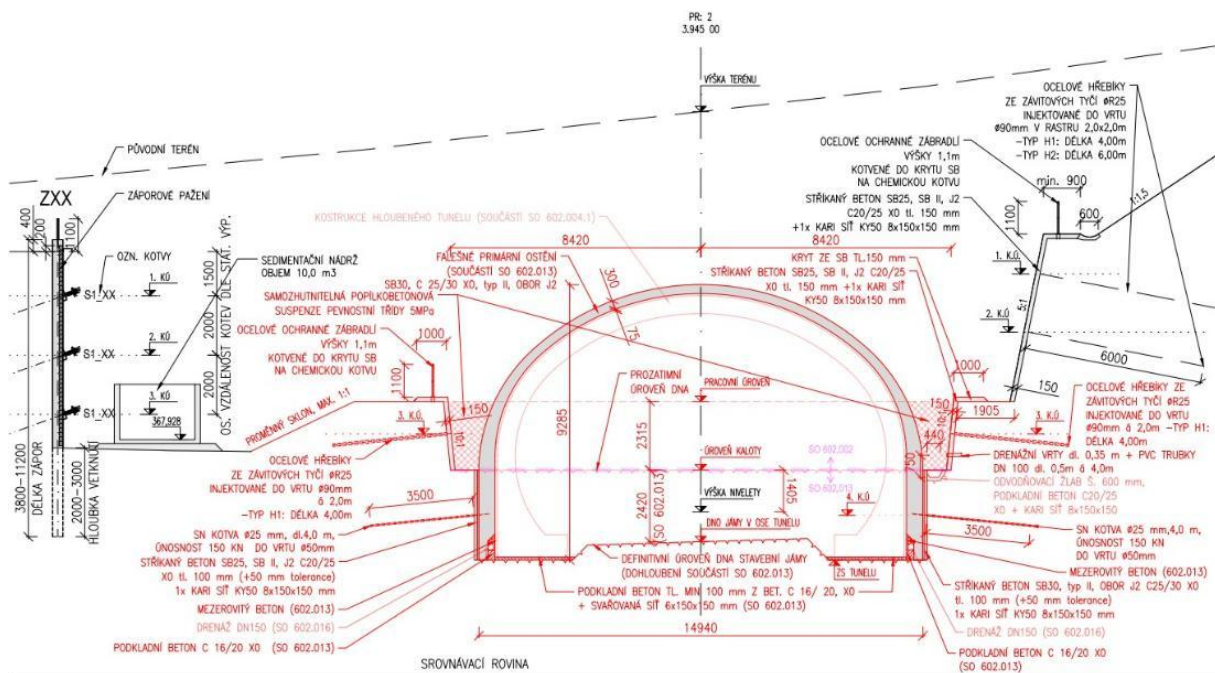


Figure 8: Typical cross-section – false primary lining

The false primary lining consists of a combination of truss beams, welded reinforcement meshes, B-system elements, and shotcrete. This solution reduces the amount of rock that needs to be excavated in

the construction pit and simultaneously eliminates the conflict with the high-voltage line, as no lifting equipment is required for the installation of counterformwork segments.



Figure 9: View of the excavation pit – middle section

## 2.6 OTHER CONSTRUCTION OBJECTS

After the concreting of the cut-and-cover section of the tunnel at the Babí portal and the subsequent relocation of the formwork carriage to the Dolní Radechová portal, the contractor will begin installing curbs and slot drains. These elements are part of the roadway and its drainage system. The construction of these structures creates space for the installation and subsequent concreting of cable ducts, as well as forming a channel for the fire dry riser.

The fire dry riser supplies water for firefighting and, in the event of a fire, will be activated—that is, filled with water from the fire tank to the required pressure within 240 seconds of receiving the signal from the fire alarm. For firefighting, a water supply of 30 l/s must be ensured for at least 60 minutes. The fire tank, with a volume of 117 m<sup>3</sup>, is part of the basement of the operational and technological building.

The roadway in the Dolní Radechová Tunnel is identical to the adjacent roadway of the main Náchod bypass route (SO 102). The structure is designed in accordance with TP 170 with the following composition (Table 4).

Table 4: Pavement structure composition in the Dolní Radechová tunnel

Structural Layer	Layer Thickness	Standard
Stone mastic asphalt with pre-coated aggregate, SMA 11S PMB 45/80-65	40 mm	ČSN EN 13108-5 ČSN 73 6121
Bonding spray of polymer-modified cationic asphalt emulsion, 0.35kg/m <sup>2</sup> , PS-CP	-	ČSN EN 13808 ČSN 73 6129
Modified asphalt concrete for base layers, ACL 22S PMB 25/55-60	80 mm	ČSN EN 13108-1 ČSN 73 6121
Bonding spray of polymer-modified cationic asphalt emulsion, 0.35kg/m <sup>2</sup> , PS-CP	-	ČSN EN 13808 ČSN 73 6129
High-stiffness asphalt mix, VMT 22 TSA 20/30	90 mm	ČSN EN 13108-1 ČSN 73 6140
Infiltration spray of cationic asphalt emulsion, 0.6kg/m <sup>2</sup> with HDK aggregate 2/4mm (3.0kg/m <sup>2</sup> ), PI-C	-	ČSN EN 13808 ČSN 73 6129
Mechanically stabilized aggregate, 0/32mm GA, MZK	200 mm	ČSN 73 6126-1, ČSN EN 13285, ČSN EN 3242+A1
Crushed stone base, 0/32mm GB, ŠDA m	min. 150 mm	ČSN 73 6126-1, ČSN EN 13285, ČSN EN 3242+A1
Total	min. 560 mm	

### 3. KRAMOLNA TUNNEL

#### 3.1 BASIC INFORMATION ABOUT THE TUNNEL

The alignment of the Kramolna Tunnel on the I/33 road route arises from the need to overcome a significant geomorphological feature in the form of a short ridge or saddle located south of the village of Kramolna. The highest point of the terrain in this area reaches approximately 448 m above sea level, while the road alignment is situated at an elevation of 435 m above sea level.

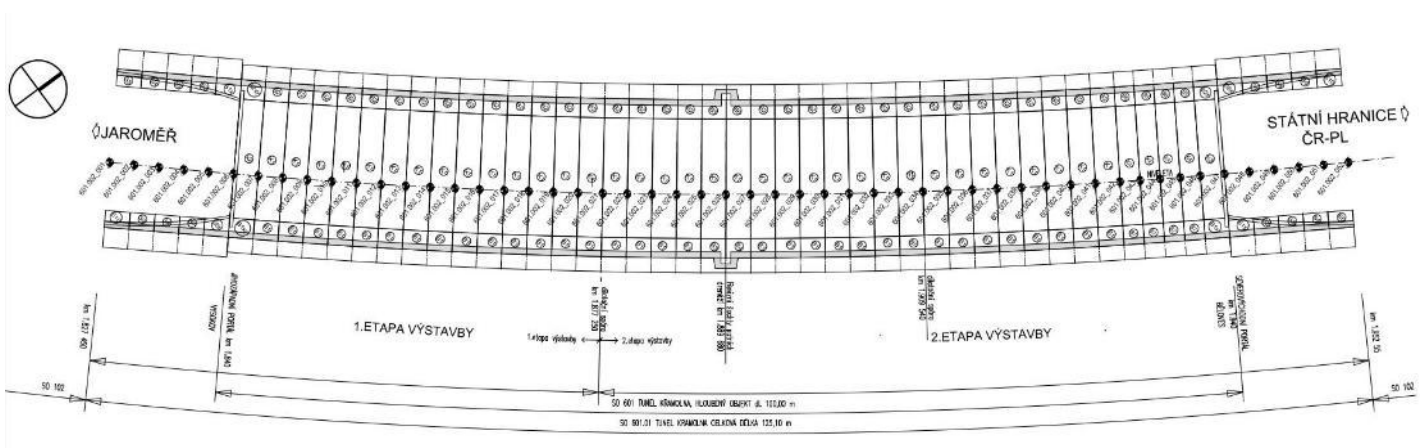


Figure 10: Schematic representation of the Kramolna Tunnel

According to TP 98 (*Technological Equipment of Road Tunnels*) and ČSN 73 7507, due to its length, the Kramolna Tunnel does not qualify as a tunnel in terms of technological and safety equipment, and therefore cannot be categorized as such. However, the tunnel cross-section follows the principles of the documentation for the zoning decision (DÚR) and is designed in accordance with ČSN 73 7507, with a clearance height of 4.80 m.

The tunnel cross-section is designed as a two-way, two-lane road with an additional climbing lane. Due to the overall width, no emergency lanes are included. The width arrangement in the tunnel is as follows: 0.50 m + 2 × 3.50 m + 3.25 m (climbing lane) + 0.50 m. Sidewalks with a minimum width of 1.00 m are provided on both sides, separated by a raised curb 120 mm high. The main technical parameters of the tunnel are presented in Table 5.

Table 5: Basic technical parameters of the Kramolna tunnel

Number of tunnel tubes	1
Traffic flow	bidirectional
Šírkové usporiadanie	0,50m + 2×3,50m + 3,25m (stúpací pruh) + 0,50m
Design speed	70 km/hod
Total tunnel length (ČSN 73 7507)	100 m
Longitudinal gradient	variable from d 0,96 % to 2,07 %
Cross slope	one-sided camber :2,5 %
Escape gallery	-
Number of emergency bays	0
Clearance height	4,8 m
Sidewalk width	1,0 m
Headroom above sidewalk	2,2 m



For the Kramolna Tunnel, excavation and stabilization of the first part of the construction pit are currently in progress. This will be followed by the construction of the prefabricated tunnel structure.



Figure 12: View of the Babí portal

## 5. CONCLUSION

Although the Dolní Radechová and Kramolna tunnels are relatively short, they represent a technically demanding project for the contractor. All types of tunnel construction are used: the mined tunnel, the monolithic tunnel in an excavation pit, the monolithic tunnel under a false primary lining, and the prefabricated tunnel in an excavation pit. This is a unique situation where the contractor is implementing four construction technologies simultaneously on a single site. Another challenge is that high- to very high-voltage power lines run above all the construction pits of the Dolní Radechová Tunnel, complicating the use of lifting equipment and machinery with greater height. The Dolní Radechová portal is located in close proximity to an industrial area that will remain fully operational during construction. Blasting works therefore need to be carried out in a manner that minimizes seismic impacts and avoids affecting surrounding structures. The construction pit in the central section borders a cemetery, requiring a sensitive approach and adaptation of work procedures with respect for the site's solemn character. The Kramolna Tunnel alignment passes near gardens and residential areas, and some structures had to be demolished, which has heightened the attention and sensitivity of the affected residents. The contractor believes that, thanks to the professional approach of all parties involved, the tunnels will be completed on schedule and to the required quality.

## 6. ACKNOWLEDGEMENTS

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## LITERATURE

*Construction Execution Documentation (PDPS)* prepared by the company "Společnost ŘSD BIM MAX 2020 – SAS4RP," with its registered office at Pod Pekárnami 878/2, 190 00 Prague 9 – see <https://tenderarena.cz/dodavatel/seznam-profilu-zadavatele/detail/Z0003026/zakazka/711131>

*Construction Implementation Documentation (RDS)* prepared by the company "I/33 Náchod – 4ROADS-SATRA-VALBEK-PONTEX," with its registered office at Malá 542/3, Střešovice, 162 00 Prague

**Ing. Michal Maričák**

**Marti a.s. – project I/33 Náchod bypass**

[Michal.maricak@martias.sk](mailto:Michal.maricak@martias.sk)

**Ing. Boris Čillik**

**Marti a.s. - organizational bránach in the Czech Republic**

[Boris.cillik@martias.sk](mailto:Boris.cillik@martias.sk)