

# PILOT ADIT FOR THE MALEŠICE TUNNEL

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**ABSTRACT:** The Malešice road tunnel forms part of the remaining, yet unrealised, north-eastern section of the Prague City Ring Road (MO), construction No. 0094 in the Balabenka – Štěrboholská Radial (Rybníčky junction) section. This paper follows up on a previous conference contribution that presented the technical solution of the tunnel itself, and it focuses on the proposed detailed engineering-geological investigation in the form of a 450-metre-long pilot adit. Owing to the limited space within dense urban development above the tunnel alignment, access to the pilot adit will be provided by a 19.2 m deep shaft with an adjacent, very confined site compound.

## 1. INTRODUCTION

The Malešice Tunnel is part of the group of structures of the Prague City Ring Road and the Libeň Link Road. This group represents roughly 30 % of the City Ring Road; upon completion, the ring will be continuous. Together, the structures form an extensive tunnel complex of interconnected and independently operable tunnel sections.

The Malešice Tunnel is included in section No. 0094 of the City Ring in Prague, between Balabenka and Rybníčky, prepared by the SATRA spol. s r.o. and Mott MacDonald CZ, spol. s r.o. joint venture.

The tunnel alignment runs from the north, starting at Českokobrodská Street in the Hrdlořezy cadastral area, southwards to Černokostelecká Street in the cadastral areas of Malešice and Strašnice. The Malešice and Strašnice areas are highly urbanised—both residential development around Malešice Square and industrial development—together with numerous major utility corridors. In Černokostelecká Street there is also a tram line serving the Public Transport Company's central workshops, where extended service closures are not feasible.

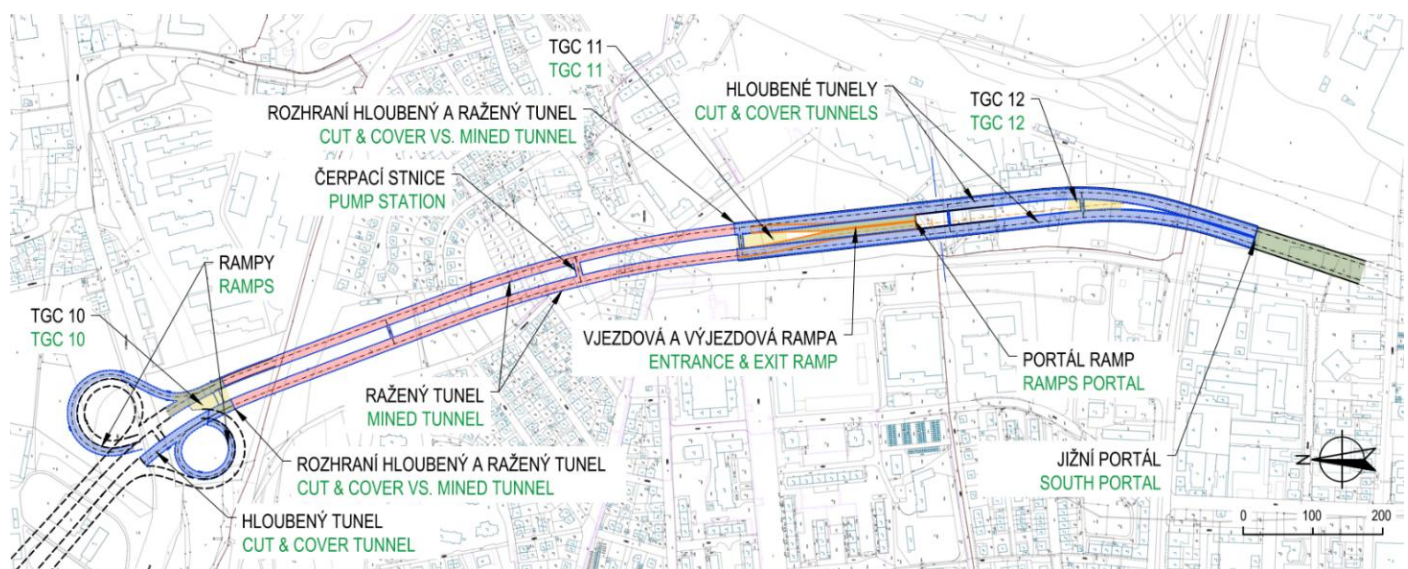


Figure 1: Schematic of the Malešice Tunnel

To the north, the Malešice Tunnel connects to the Jarov Tunnel at the Českokobrodská grade-separated junction; the southern portal is located approximately 100 m south of the intersection with Černokostelecká Street. The total lengths of the two tunnel tubes are 1660 m and 1599 m, respectively. The clearance height of the main-line tunnel is 4.5 m; cross-section class T-11.5 in a width arrangement with three 3.5 m lanes, 0.5 + 0.5 m guidance strips and 1.0 m sidewalks. Part of the main-line tunnels is

designed as mined, while the remainder, including the on- and off-ramps, is designed as cut-and-cover (see Figure 1). The mined tunnels will be excavated using the conventional NATM. Excavation is expected to commence from the southern portal and proceed uphill. The transverse profile of the mined tunnel is designed with an invert and horizontally divided into top heading, bench and invert. Maximum overburden reaches 29.2 m.

## **2. GEOTECHNICAL INVESTIGATION**

### **2.1 PRELIMINARY INVESTIGATION PHASE**

Within the preliminary investigation (SGG-PUDIS MO, 11/2021), cored engineering-geological boreholes were drilled to obtain samples for laboratory testing. Downhole logging and deformability tests of the rock mass were carried out. Selected boreholes were completed as hydrogeological wells and used to verify hydraulic parameters of the mass. The hydrogeological wells will subsequently serve to monitor long-term fluctuations in groundwater level and quality. The investigation also included surface geophysics using shallow seismic refraction and electrical resistivity tomography.

### **2.2 DETAILED INVESTIGATION PHASE**

Given the very complex geotechnical conditions along the mined section of the Malešice Tunnel—confirmed by partial conclusions from the preliminary programme (numerous tectonic discontinuities in the mass, alluvial depressions near the southern mined portal, excavation beneath historic buildings in old Malešice and in the vicinity of the Malešice Château)—it was decided to construct an pilot adit. With respect to stratigraphy, terrain morphology and the constraints described above, the adit is located in the southern part of the western MO-B tunnel tube. The adit will be used to verify geological structure, rock properties, degree of weathering and loosening, character of discontinuities, degree of tectonic disturbance, geotechnical parameters of the rock mass, excavation behaviour of the encountered rocks, and magnitudes of groundwater inflows. In addition, attention will be paid to verifying and refining the areal and depth extent of Quaternary cover soils and weathered zones of the rock mass. Hydrogeological conditions across the wider area will also be refined: groundwater level and its temporal variability, principal flow directions, and yields of individual aquifers. The results will be used to estimate expected inflows and to assess the project's impact on the natural hydrogeological regime.

## **3. ENGINEERING–GEOLOGICAL CONDITIONS**

The engineering-geological conditions in the tunnel route were surveyed within the framework of the preliminary geotechnical survey for the upcoming construction (SGG-PUDIS set of structures MO 11/2021). In the route of the tunnel, the Letná shales are expected from the north, the Vinice shales in the area of old Malešice and the Zahořany shales are expected in the southern portal. The cut and cover part of the tunnel will be built in the dusty Zahořany shales and, near Černokostecká Street, in the clayey Bohdalec shales. The Letna shales have been reached largely in a monotonous sequence of dusty shales, only in the central part of the Malešický ridge and in a typical flysch pattern with a change of dusty shales, shales and clasts.

The mined part will be built in more bearable and in generally, within the prague's geology, qualitatively better prague shales. However, their geotechnical parameters are locally reduced by extensive tectonics. The phase of prepared detailed survey using pilot adit will be focused to its identification.

The entire construction will be carried out below the groundwater level. Long-term monitoring of the groundwater level in chosen hydrogeological boreholes and wells will be carried out to capture the natural situation and fluctuations in the level depending on rainfall.

## 4. TECHNICAL DESIGN

### 4.1 BASIC PARAMETERS OF THE PILOT ADIT

To perform the detailed engineering-geological investigation of the future excavation, an pilot adit approximately 450 m in total length has been designed.

Access to the excavation level will be provided by a 19.2 m deep shaft. The shaft location reflects the limited footprint available for a site compound accommodating all the technologies required for the adit excavation.

From the shaft, the pilot adit will be driven within the top heading of the MO-B tunnel both southwards and northwards. Immediately adjacent to the shaft, the excavation will be widened to the full top heading profile of MO-B over a length of 40 m. This space will be used for temporary spoil storage and transfer to vertical handling to surface, and for stabling equipment and storing materials.

From the top heading space, the adit will continue 60 m to the south towards the location of the future mined southern portal. To the north, a total length of 350 m is designed, including two passing bays, each 25 m long, at approximately 100 m intervals. Based on preliminary investigation results, the passing bays are longitudinally positioned outside zones of elevated tectonic disturbance; during construction, their positions will be verified by probe drilling and adjusted to suit encountered conditions if necessary.

### 4.2 HORIZONTAL AND VERTICAL ALIGNMENT

The adit alignment follows the future MO-B tunnel tube (see Figure 2). The gradients match the final tunnel only in the immediate top heading area. Other adit sections run within the future top heading envelope but adopt constant grades—3% towards the south and 1% towards the north—both sloping towards the MO-B top heading. Excavation will therefore proceed uphill in both directions. Chainage of the exploratory work starts at 0.0 m at the base of the shaft and increases northwards to +370.0 m; southwards, chainage is negative, ending at -80.0 m.

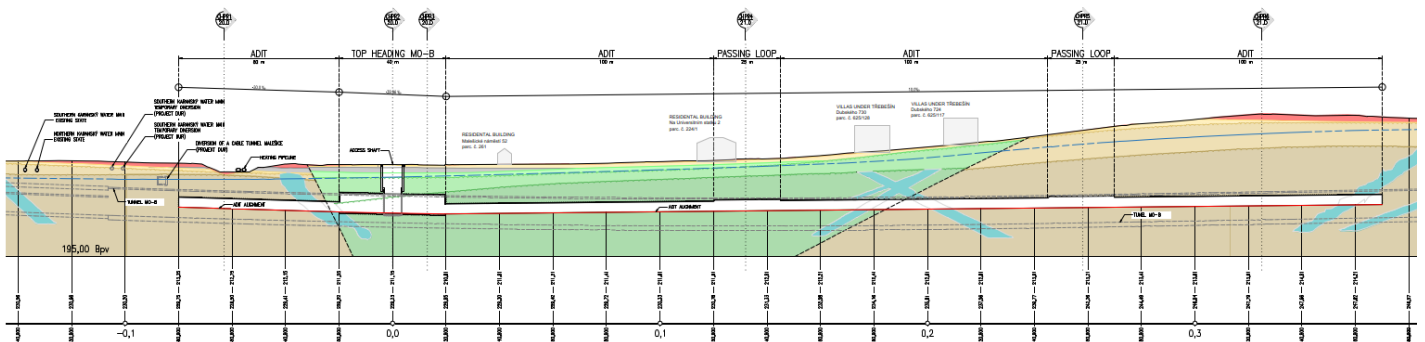


Figure 2: Long-Section of the Pilot Adit

### 4.3 CONSTRUCTION DRAINAGE

The overall gradients drain both the southern and northern adit arms towards the MO-B top heading. A sump and pump well at the lowest point will collect water for pumping to surface via a rising main in the shaft. On the surface, water treatment will be provided in the site compound prior to discharge to the sewer.

### 4.4 ACCESS SHAFT

The shaft provides vertical access to the pilot adit (see Figure 3). In layers of fill, Quaternary cover and highly to completely weathered Vinice shales, the shaft support is designed as overlapping drilled piles of 9.7 m length. Drilling will terminate just above the intersection with the MO-B top heading so that the actual intersection can be executed in shotcrete. The shaft support consists of 62 piles  $\varnothing$  630 mm at 510 mm centre spacing, installed alternately as unreinforced and reinforced. For enhanced stability, the piles will be tied with a reinforced-concrete ring beam  $0.8 \times 0.8$  m at the top; after excavation down to 1 m above the base, a lower ring beam  $0.5 \times 0.5$  m will be cast.

After excavation under the protection of the piles and completion of the ring beams, construction will proceed by NATM methods. The complex intersection of the shaft and the MO-B top heading will be executed using shotcrete support of the rock mass. The shaft, 8.4 m in diameter with an excavation area of 60.82 m<sup>2</sup>, will be driven in Excavation Class (TTV) 3, corresponding to weathered to sound Vinice shales in the intersection zone with the MO-B heading.

Before starting excavation of the MO-B top heading beneath the shaft, a micropile umbrella will be installed from the shaft over the future heading profile. The umbrella will consist of micropiles around the perimeter at about 350 mm spacing, connected by a 0.2 m thick concrete ring beam reinforced with two layers of welded mesh 6/100×6/100. Micropiles will be of two lengths and drilled at inclinations of 3° to 20° below horizontal so that they do not intrude into the future heading profile of MO-B.

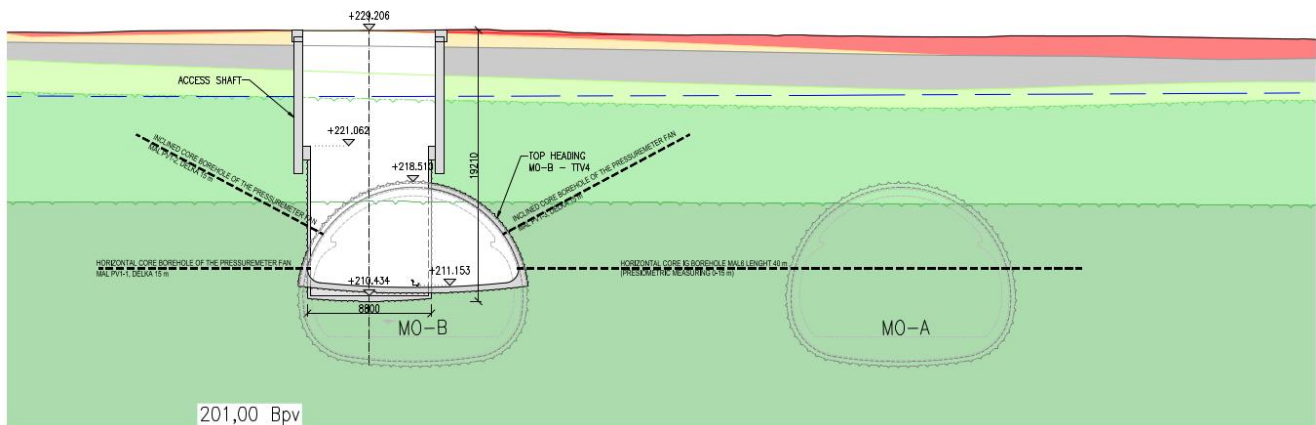


Figure 3: Cross-Section of Access Shaft with Geology

#### 4.5 MO-B HEADING

The transverse profile matches the top heading of the future three-lane MO-B tunnel (see Figure 4). The standard top heading section is raised by 110 mm so that, once enlarged to full profile, it forms part of the primary lining of the MO-B tunnel, onto which waterproofing and a secondary lining will subsequently be installed. The heading is approximately 7.9 m high and 16.3 m wide, with an excavation area of 98.05 m<sup>2</sup>. Two excavation classes are proposed: TTV 4 for predominantly sound Vinice shales with weathered zones near the crown, and TTV 5 for weathered to sound shales in zones of expected strong tectonic disturbance at the Vinice–Zahořany contact.

From the shaft, the top heading will be opened by progressive widening at each step (a total of eight steps) until the full profile is achieved. The partial excavation will be supported by standard primary lining in the final top heading portion, while the temporary enlargement—later to be redriven—will be supported with 200 mm shotcrete reinforced with welded mesh 8/100×8/100 and supplemented by 4 m radial rock bolts at 1.5 m spacing. First, the enlargement will be driven to the north and south; after reaching the end of the top heading drive, a backdrive will remove the central part, including the portion of the shaft primary lining intruding into the top heading.

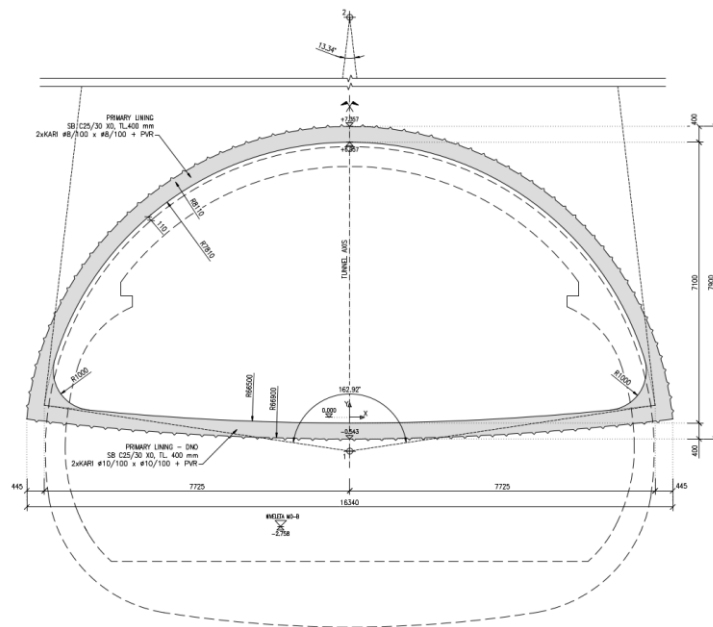


Figure 4: The Top Heading of the Future Three-Lane MO-B Tunnel

#### 4.6 ADIT AND PASSING BAY

The adit profile is designed for small plant: excavation height about 3.9 m, width about 4.3 m, excavation area 13.9 m<sup>2</sup> (see Figure 5). To allow passing of equipment, a passing bay is provided every 100 m. Each bay is an asymmetric widening of the adit with a height of about 4.3 m, width 6.6 m and excavation area 23.9 m<sup>2</sup> (see Figure 6). Both the adit and the bays include a 50 mm construction tolerance; no additional over-height is provided because no waterproofing or secondary lining is applied here.

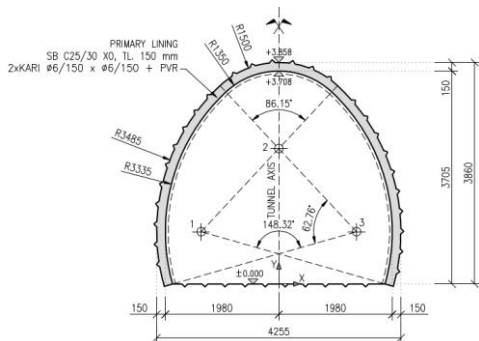


Figure 5: Cross-Section of Adit

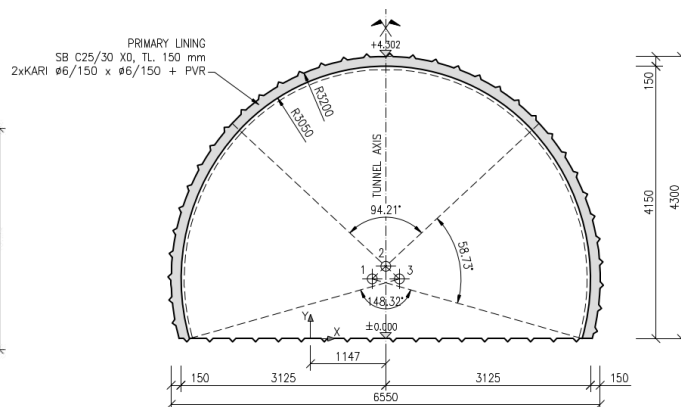


Figure 6: Cross-Section of Passing Bay

Excavation of the adit and bays is designed in two excavation classes, TTV 3 and TTV 4, without further subdivision given the small profile. TTV 3 applies to weathered to sound Vinice and Zahořany shales without significant tectonic disturbance. TTV 4 applies to weathered to sound Zahořany shales at the Vinice–Zahořany contact where significant tectonic disturbance is expected, and to weathered to sound Letná shales, which are predicted to be significantly tectonised along their entire extent in the project area.

At each proposed passing bay, a horizontal probe will be drilled prior to excavation to verify geological conditions and to confirm the final location of the bay. This probe is included in the investigation programme.

Excavation of a passing bay will begin by unilateral widening of the adit profile; this enlargement will be supported with shotcrete and radial bolts as per the relevant TTV class. An overview of all profiles and excavation classes (TTV) is provided in Table 1.

Table 1: Excavation Classes Summary

Profile	TTV	Primary Lining	Rock Bolting	Forepoling/Pre-support	Advance Step [m]
<b>Adit</b>	TTV 3	Shotcrete 150 mm + 2× mesh 6/150	Radial bolts, L=3 m @ 1.5 m	Spiles @ 350 mm, L=3 m (as required)	1.5–2.0
<b>Adit</b>	TTV 4	Shotcrete 200 mm + 2× mesh 6/100	Radial bolts, L=3 m @ 1.2 m	Spiles @ 350 mm, L=3 m	1.2–1.5
<b>Passing bay</b>	TTV 3	Shotcrete 150 mm + 2× mesh 6/150	Radial bolts, L=3 m @ 1.5 m	Spiles @ 350 mm, L=3 m (as required)	1.5–2.0
<b>Passing bay</b>	TTV 4	Shotcrete 200 mm + 2× mesh 6/100	Radial bolts, L=3 m @ 1.2 m	Spiles @ 350 mm, L=3 m	1.2–1.5
<b>MO-B top heading</b>	TTV 4	Shotcrete 400 mm + 2× mesh 8/100; invert 2× mesh 10/100	Radial bolts, L=6 m @ 1.5 m	Spiles @ 350 mm, L=4 m (as required)	1.0–1.2
<b>MO-B top heading</b>	TTV 5	Shotcrete 400 mm + 2× mesh 8/100; invert 2× mesh 10/100	Radial bolts, L=6 m @ 1.2 m	Spiles @ 350 mm, L=4 m; face bolts L=6 m + 100 mm face shotcrete	0.8–1.0
<b>Shaft</b>	TTV 3	Shotcrete 200 mm + 2× mesh 6/100	Radial bolts, L=4 m @ 1.5 m	—	2.0–3.0

## 5. SITE FACILITIES

### 5.1 DESCRIPTION OF THE SITE COMPOUND

The site compound provides technical facilities for the investigation works. It is located in the Prague–Malešice district in a green triangular area bounded by Dřevčická Street (to the east), Malešická Street (to the north) and an unnamed one-way road connecting these two streets, currently used mainly as a parking area (see Figure 7).

Facilities will include welfare and administrative units, an emergency and safety store, water connection, sewer connection, 22 kV HV connection, transformer substation, site LV distribution and lighting, oil separator, sedimentation tank, and site water and sewer distribution. No explosives magazine is planned; explosives will be supplied daily from a central store.



## 5.2 SITE TRAFFIC

The compound operates one-way traffic, with entry from the north via Malešická Street and exit to the south via Dřevčická Street. Passage through the compound uses the existing western branch of Dřevčická Street, approximately 70 m long.

The key operation is spoil removal during adit excavation. Underground, spoil will be transported from the face to the shaft using dumpers or front-end loaders. At the shaft, spoil will be transferred into a container suspended from a crane, hoisted to the surface and discharged to a temporary stockpile. From there it will be loaded by loader or excavator onto trucks and hauled out via the southern exit of the compound (without reversing or turning) to public roads and then to a disposal site. A wheel-wash is provided at the exit to remove soil or spoil contamination.

## 6. PRESERVATION OF THE WORKS

Upon completion of the detailed investigation, the exploratory works are expected to be mothballed. The stability of the entire adit will be ensured and access restricted until construction of MO No. 0094 commences. The site compound will be downsized to the minimum required for operation and maintenance of the adit, enabling restoration of surface roads as far as practicable.

Ventilation plant and ducting must be maintained to allow safe personnel entry for inspections. Ventilation output may be reduced provided a full air exchange is ensured prior to any entry.

The exploratory works will be inspected regularly for stability and durability. If construction of MO No. 0094 does not commence within two years of completing the adit, a structural assessment of the temporary linings of all parts will be required.

If the ongoing maintenance of the mothballed works is not desirable, full decommissioning may be undertaken. This would comprise backfilling the adit to within 2 m of existing ground level using ash-cement stabilised fill placed in 0.3–0.5 m layers, pressure-grouting the site drainage, removing surface structures to 2 m below ground, backfilling the remaining void and reinstating the surface.

## 7. CONCLUSION

The construction of the pilot adit will be another, modest yet important, step towards completion of the Prague City Ring Road works. The capital will finally obtain a complete inner ring road which, like preceding sections, will significantly simplify urban traffic and, above all, calm surface traffic.

## LITERATURE

SGG-PUDIS soubor staveb MO, Předběžný geotechnický průzkum Soubor staveb č. 0081 Pelc/Tyrolka – Balabenka, č.0094 MO Balabenka – Štěrboholská radiála a č. 8313 Libeňská spojka, 11/2021

Společnost SATRA – MMD – Městský okruh, DŮR, stavba MO č. 0094 v úseku Balabenka – Rybníčky, 09/2022

Společnost SATRA – MMD – Městský okruh, projekt GP, F.1.7 Projekt podrobného GTP, 09/2023

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