New drainage tunnel of the tunnel Višňové – design and excavation

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Abstract. The actual pilot tunnel dated to the period of geological and hydrogeological survey, is designed as a part of the tunnel Višňové, which is located at the section of the D1 motorway Lietavská Lúčka – Višňové – Dubná Skala in Slovakia. Drainage tunnel will be used for the drainage of the main tunnel tubes, where the maximum inflow from the eastern portal is greater than 250 l.s⁻¹. Overlapping of the initial pilot tunnel with the profile of the southern tunnel tube led to the demolition of the portal sections of the pilot tunnel during the excavation of main tunnel tubes. These sections were replaced by new drainage tunnels, with the lengths of 288.0 meters from west portal and 538.0 meters from eastern portal, to ensure access from both portals. The new drainage tunnel is excavated under the level of the two main tunnel tubes. Drainage pipes with a diameter of 250 mm will be installed from cleaning niches in the main tunnel tubes to the new drainage tunnel.

1. Introduction to tunnel Višňové

Tunnel with a total length of 7424.9 meters in the northern tunnel tube and 7462.0 meters in the southern tunnel tube is a challenge for contractor from technical, logistical and design point of view. Due to complicated geological and hydrogeological conditions, this tunnel belongs to the most difficult line structures in the history of engineering works in Slovakia.

Višňové tunnel consisted of two separate tunnel tubes, each for one driving direction. According to the width category of the tunnel, the Višňové tunnel belongs to the category of 2T 7.5. Pursuant to Slovak technical standard – STN737507, it is characterized as a long tunnel. The speed limit is 100 km/h.

Portal sections were performed by using new Austrian tunnelling method. For continuity of works, full face profile method ADECO-RS was and is still currently used. The advances of excavation and section types are determined by the designer, based on the actual geological conditions in tunnel [1], [3], [4].

2. The purpose of new drainage tunnel

The initial pilot tunnel (PT), dated to the period of geological and hydrogeological survey of 1998-2002, was redesigned to be used as a part of tunnel construction.

Mentioned PT is designed to perform drainage function for both tunnel tubes. The horizontal alignment of the main tunnel is adjusted, so that the pilot tunnel will be located approximately
in the middle between tunnel tubes. Vertical alignment is performed with the position of tunnel tubes above of the new drainage tunnel.

Because of mutual interference between PT and southern tunnel tube (STT) in the portal sections (both west and east portal), it was designed to proceed to the partial liquidation of the PT in length of 538.0 meters from the east portal (EP) and 288.0 meters from the west portal (WP).

These sections had to be replaced with new parts of drainage tunnel, which will be connected to the original PT and will provide continuous access from both portals.

The primary lining of new drainage tunnel will be used as a permanent structure, which serves to ensure the stability of the excavation and to limit the deformations of rock mass during excavation works and the use of these objects [1], [3], [4].

3. Geological settings
For excavation of the new drainage tunnel from WP, two basic types of rock mass were identified (Figure 1). First one is complex of Flysch formation (until 90.0 meters from portal) build with Paleogene rocks – claystones, siltstones, sandstones, which was moderately to highly weathered and tectonically disturbed. Second rock mass type was made up of a complex of Mesozoic rocks – dolomites, dolomitic limestones, limestones and clayed limestones. The rocks are moderately weathered to unweathered, often faulted.

![Figure 1. West portal – longitudinal profile and proposed section types [1].](image)

Rock mass from EP (Figure 2) is formed exclusively with basement rocks – granodiorites, pegmatites, tonalites. Rock mass was strongly desintegrated with very small values of RQD, also very often strongly weathered especially in close to portal sections [1], [3], [4].

4. Construction of new drainage tunnel
The excavation of relocation of drainage tunnel at the portal sections was carried out by full face method, known as ADECO-RS from WP and also from EP. From east portal, the relocation of the drainage tunnel was excavated upwards with rising of circa 1.0 %. At the chainage
of 8+060.47 km, the rise increases to 9.0 %, until the chainage of 7+933.62 km, where the new drainage tunnel is intended to connect to initial pilot tunnel. From west portal, the new drainage tunnel was excavated with rising of circa 0.2 % until the chainage of 1+279.96 km, on following section of 33.0 meters, the rising increases to 9.0 % until the chainage of 1+312.99 km, where the new drainage tunnel will be again connected to initial pilot tunnel.

The situation at WP and EP as designed is pictured in Fig.3 and Fig.4. In Fig.5, the typical cross section with secondary lining and the position of new drainage tunnel is pictured.

The excavation is conducted as a full profile, and immediately after the cut, the reinforcement of primary lining is installed according to corresponding section type. For the reinforcement, two section types were designed, DT-B0V a DT-B0. Additionally, for initial portal parts, specific section type which is based on DT-B0V was designed. Simultaneously, the excavation under the cross passage No.1 at WP was conducted according to special design, which is described below.

The mechanical means and drill&blast works were used during the excavation. Blasting works were carried out mainly in rigid rock.
Figure 3. New drainage tunnel and its connection to initial pilot tunnel at west portal [1].

Figure 4. Part of new drainage tunnel and its connection to initial pilot tunnel at east portal [1].

Mechanical means of excavation were intended for parts with appropriate geotechnical conditions, or for parts, where strict measures has to be respected, for instance connection of the tunnels or restrictions regarding the seizmical impact, or under conditions, where blasting could possibly disrupt the rock directly around the face.

The machinery used during the excavation is limited by the dimensions of the tunnel, so basically small machinery has to be used. That was small excavator with pick hammer, robot for shotcreting, mobile mixer for concrete transport into the tunnel, skid-steer loader, special mining loader with bigger bucket, special mining dumper and drill rig with one boom and a platform. The ventilation system was based on suitable fan with flexible air duct of diameter of 600 mm.
Figure 5. Typical cross section of secondary lining at east portal (view from the tunnel towards portal) with the position of the drainage tunnel [1].

5. Section types, connection to initial pilot tunnel, interference with the cross passage No.1 at west portal and installation of temporary drainage pipes at east portal

For the excavation of new drainage tunnel, two section types as mentioned in previous chapter were designed, DT-B0 and DT-B0V (Figure 6), where mainly at portal areas, the section type with reinforcement made of micropile umbrella DT-B0V was used. The rounds in these sections were defined as maximum of 1.0 meter for section type DT-B0V and maximum of 1.5 meter for section type DT-B0. The reinforcement within both section types includes steel ribs HEA120, wire mesh 150 mm x 150 mm of diameter 6 mm (this is partial modification compared to initial design, where shotcrete with steel fibers was intended to use) and finally, concrete of type C30/37 applied by shotcreting.

Figure 6. Comparison of cross section for DT-B0 and DT-B0V, indicating difference in reinforcement for both section types of new drainage tunnel [1].
The works on excavation of new drainage tunnel started in september of 2015 and after the excavation of circa 220.0 meters, the excavation at EP started due to some operational reasons, where until the august of 2016, some 535.0 meters were excavated (Fig.7). After the excavation, the installation of temporary drainage pipe DN500 into the invert of new drainage tunnel was carried out along its whole length (Figure 8 and Figure 9).

In february of 2017, the interrupted works at WP continued by passing the cross passage No.1, in the invert of which the reinforced concrete slab was installed. In the section between the chainage of 1+266.33 km and the chainage of 1+279.96 km, the new drainage tunnel is interfering with cross passage No.1, which obviously connects NTT with STT of main tunnel. As it is stated in the documentation, the distance between the bottom of the cross passage No.1 and the new drainage tunnel is less than 2.0 meters, thereby distinctive technical solution to this issue was designed to cope with mutual interference (Figure 10). The actual connection of both tunnels, even on WP did not avoid the filling of some part of the tunnel with filling concrete in the volume of circa 400 m$^3$ (Figure 11).

6. Conclusion and current state of new drainage tunnel
Currently, the completion of excavation at west portal in length of circa 15.0 meters is prepared, as the curing of concrete filling in its part is necessary for proper and safe continuing in excavation. Consequently, at the east portal, the connection of drained water from initial pilot tunnel into the temporary drainage pipe which was placed into new drainage tunnel in september and october 2016, will be done. In the context of initial pilot tunnel, the remediation of the primary lining, as well as subsequent temporary ventilation of main tunnel tubes through the pilot tunnel, which would require excavation of vertical shafts is planned in near future.
**Figure 8.** Drawing of crosssection of new drainage tunnel, with detail for technical solution of drainage pipe DN 500 laying into the invert of the new drainage tunnel [1].

**Figure 9.** Picture of temporary drain pipe DN 500 installation from section, where the excavation was stopped. In the upper part, the initial pilot tunnel is visible, also as the shotcreted pipe in which drained water is collected nowadays [2].

**Figure 10.** Cross section of interference of new drainage tunnel with cross passing No.1 at west portal of tunnel Višňové [1].
Figure 11. Formwork in pilot tunnel before filling up its short section with concrete [2].

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