Overcoming Challenges: Small Overburden, Acidic Water, Construction Under a National Road

— The Yamagata Zao Tunnel, Tohoku Chuo Expressway —

Kazuo MIYAZAWA ▶ Vice President, Yamagata Construction Office, Tohoku Branch, East Nippon Expressway Co., Ltd.

Project overview

The Tohoku Chuo Expressway is an approximately 270km highway that connects Fukushima and Akita Prefectures. The Yamagata Zao Tunnel is an approximately 944-meter tunnel at the foot of the Yamagata Prefecture side of the Zao mountain range, famous for rime on trees. This tunnel has an overburden of 9.9 ~ 24.5 m and is almost entirely covered by small overburden of 1.5 D (D = 12.4 m) or less. Right above the tunnel cross a golf course, a river and a national road and near them are amusement parks and houses, so the impact of the tunnel excavation on those structures were concerned. The soil, composed of Quaternary mudflow sediments and Neogene tuff and tuff breccia, is, overall, less solidified and soft. Therefore, as the excavation system, the mechanical excavation was adopted, and as the main excavation method and auxiliary method, the full-face early closure and the injection type long steel pipe forepiling (AGF) were selected. The construction started in March 2016, and the tunnel was completed safely about one and a half years later, in September 2017.

Fig. 1 Conditions surrounding the tunnel

Boulders in the tunnel face

When the excavation of the mudflow sediment section started, boulders appeared in the tunnel face. The fall of large gravels may cause ground subsidence and cave-in, so as a countermeasure, the boulders at the top and side wall of the tunnel were sewn with lock bolts. AGF applied to the top was also very effective for sewing the boulders. Since many hard boulders could not be broken by a breaker, blasting was used each time.

Excavation under a river

We assumed influenced range under the 45° spread borderline from the river crossing as the range of influence, carried out the advanced horizontal boring of 113 m from the tunnel face and checked the soil quality and water quality condition. As a first step judgment based on the result, the possibility of drawing river water into the tunnel pit was judged to be low. As the second step, river water was analyzed according to the flood situation from the long steel pipe in AGF construction. The spring water from the long steel pipe was at most about 3 L/min per hole, which was stopped by grouting. Although the spring water from the cutting face was a little high (20 L/min), the tunnel face was stable enough and the river water was not drawn in and the tunnel passed safely under the river.

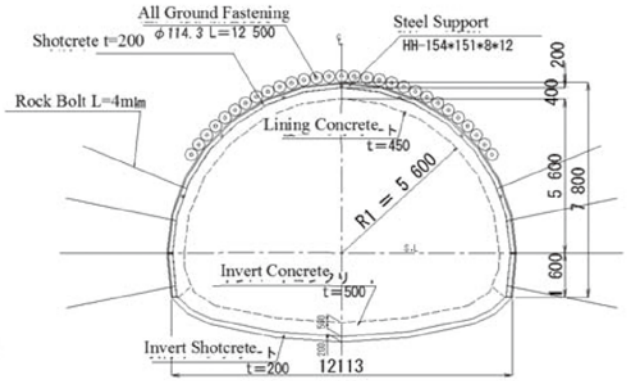

Fig. 2 Support pattern DⅢa-1-1-K

Construction under the national road

The point where the national road crosses has a small overburden of 12.5 m, and problems such as uneven ground were of concern, thus to improve the soil, chemicals were injected from the surface. The range of countermeasures for soil improvement was set as 18.4 m in width, 9.2 m in height, and 55.4 m in extension of the influenced range of 45° spred borderline from the edge of national road. Ultrafine blast furnace slag was used as the chemical, and the injection ratio was 24.0%. The pressure was set to 2.0 Mpa based on the test injection, but when the injection started, the surface uplift was larger than expected at the initial stage, so limited injection was applied instead, concentrating on fragile part. The countermeasure construction from the ground surface was complete when the injection quantity reached about 48% for the designed quantity. Also, the amount of land surface subsidence at the point where the national road crosses was constantly calculated by the total station. It turned out that the ground subsidence of maximum 14 mm was confirmed, but it was within expected level.