Mountain Tunnel Construction in Fragile Ground in Volcanic Regions

— National Highway 57th Takimurozaka Road, East Takimurozaka Tunnel Construction (Phase I) —

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1. Introduction

The Kumamoto 57th Takimurozaka Tunnel is a 4.8 km long road tunnel located on the east side of the Aso Caldera in Kyushu which located at the south-western end of Japan's four main islands. It was successfully penetrated in June 2023, but significant deformations occurred in the fragile geological sections unique to volcanic regions. Measures were taken against the deformations that occurred in the fragile geological section, which is composed of unconsolidated volcanic ash from Quaternary pyroclastic flow deposits, including those to prevent leg settlement, those to reduce water pressure using drainage boreholes and lining reinforcement in anticipation of future loading on the lining. This report specifically describes the measures to prevent leg settlement.

2. Status of the deformation

This tunnel is a large-section tunnel with a flat shape and an excavated cross-sectional area of more than 100 m2, as shown in Fig. 1. In the fragile geological section, cracks appeared in the shotcrete, the main support member, and a crown settlement, which exceeded the control value of 45 mm, was measured inside the tunnel. In this section, a sand and gravel layer were distributed in the lower half of the section, as shown in Fig. 2. The uniaxial compressive strength of this layer was less than 0.2 MPa, and softening due to ground water was also evident.

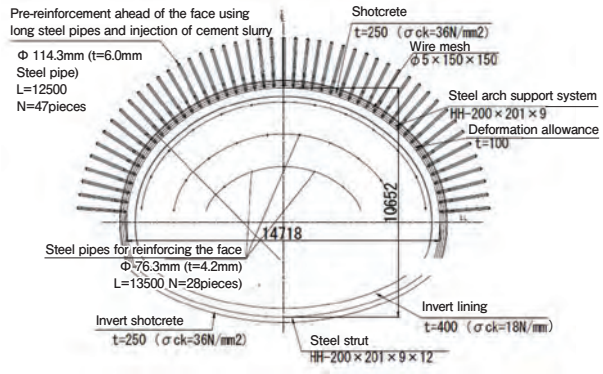

Fig. 1 Support structure in fragile geological section

Fig. 2 Geological conditions of the face in the section where the deformation occurred

Fig. 3 shows the settlement displacement measured at a cross section located in the section where the deformation occurred and 459 m away from the portal. A significant settlement due to excavation was observed in the 12 m to 23 m section away from the face after the primary invert completion and before the leg piles described below were installed, especially in the crown, left shoulder and left leg areas.

3. Countermeasure works and effects

Even after primary invert completion as a countermeasure againt settlement, displacement continued to increase with the progress of excavation. Based on geological investigations, geological observations and displacement trends, it was concluded that the ground bearing capacity was insufficient, particularly on the left side. To prevent settlement, leg reinforcing piles shown in Fig. 4 were constructed on the left side leg areas with an extension of 86 m.

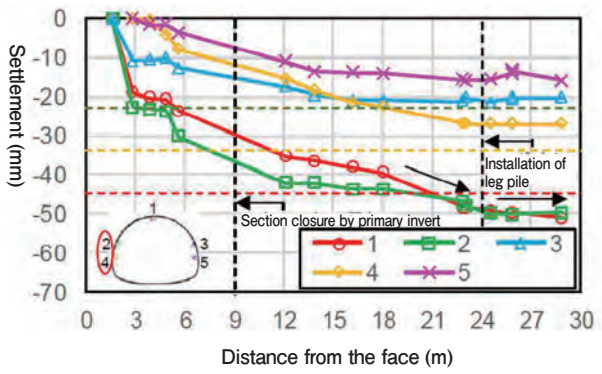

Fig. 3 Settlement measured in fragile section

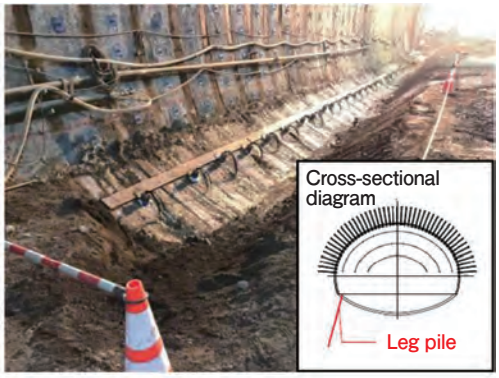

Fig. 4 Construction of leg piles

The need for leg piles was judged based on the displacement speed trend after the primary invert completion and whether the amount of settlement exceeded the control value of 34 mm before displacement converges. As can be seen from Fig. 3, after the leg pile installation, the displacement generally showed a trend of convergence, especially at the points 24 m or farther away from the face, confirming the effectiveness of this countermeasure work.