Tunnel Construction through Ground with Landslide Potential Adjacent to the Median Tectonic Line with Various Countermeasures from Inside and Outside the Tunnel

—Matsuyama Expressway Myojinsan Tunnel Phase II —

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1. Introduction

The Phase II line of the Myojinsan Tunnel on the Matsuyama Expressway is 2,545-meter long and was constructed as the second line of the in-service expressway. Its construction was performed under severe conditions and constantly required carefulness, where the in-service line was very close. In addition, the tunnel crosses the Median Tectonic Line near the exit, and the affected ground around the tunnel has geologically been subjected to substantial structural changes and exhibits its landslide potential (Figure 1). Furthermore, prefectural roads and houses are scattered on the above ground, making it essential to control the sliding of the ground and minimize its impact on the roads and houses as well as the in-service line. Therefore, stabilization measures and displacement measurements were carried out from both inside and outside the tunnel with the aim of controlling the impact of the tunnel excavation.

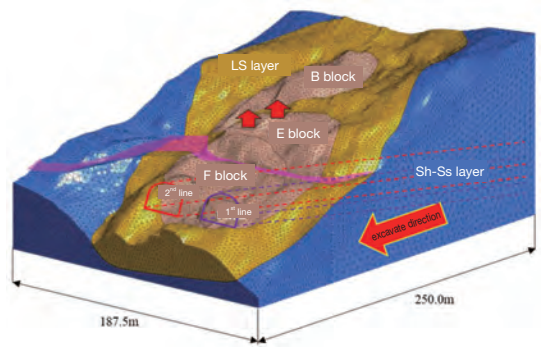

Fig. 1 Aerial view of the three-dimensional FEN model around the tunnel portals

2. Countermeasures from Outside the Tunnel

When excavating a tunnel through ground with landslide potential like this tunnel, it is necessary to perform landslide countermeasures from outside the tunnel before excavation to prevent landslides.
We employed 90 steel pipe piles (⌀ 550, L = 30 m) as landslide control piles, as shown in Figure 2. In addition, in order to monitor landslide movement and ground surface displacement associated with the tunnel excavation, a number of measurement items were set up as shown in Figure 2, including three-dimensional automatic measurement using a total station. A large monitor was installed in our office for real-time monitoring of various measurement results and early detection of abnormalities. A system that clearly and constantly displays measurement graphs in a consolidated manner and automatically updates them was utilized to create an environment that facilitates the prompt identification of signs of abnormalities.

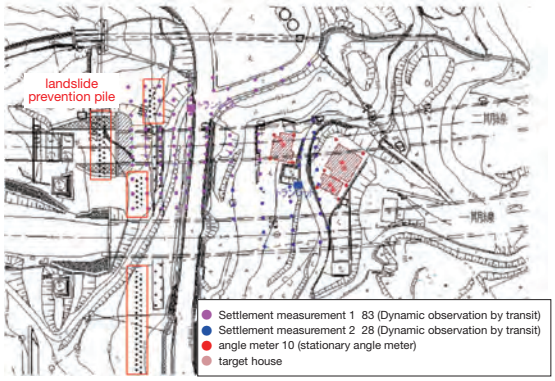

Fig. 2 Landslide countermeasures and measurement positions

3. Countermeasures against Poor Ground Conditions

The ground with landslide potential around the tunnel is composed of alternate layers of sandstone and shale. Folds and strong weathering were observed, and therefore, it was necessary to take measures to stabilize the cutting face so that they could cope with rapid changes in the ground. Because of the close proximity of the construction site to the in-service line, it was also necessary to take measures to control displacement as well. Therefore, we adopted long steel forepoling pipes (L = 12.5 m, 180° , ⌀ 114.5 mm) and long face bolts (L = 13.5 m) as measures to stabilize the face, and constructed an upper half temporary invert as a displacement control measure as shown in Photo 1.

Photo 1 The temporary invert

4. Measurement Results

Figure 3 shows the results of Measurement A in the Phase II line construction. Although the final subsidence at the right shoulder showed a relatively large tendency of about 67 mm, it was within the management standard value of 119.7 mm and showed a trend of settlement in about 20 days after lower half and primary inverts were constructed. As a result, we confirmed that the tunnel construction was successfully completed without any impact on the surrounding area, based on the results of ground surface observation, measurement at various locations including the in-service line using underground displacement gauges, and visual inspections.

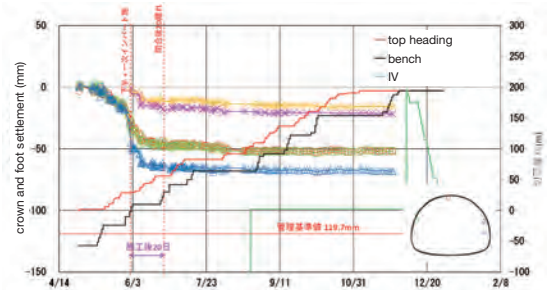

Fig. 3 LResults of the Measurement A