Results of Tunnel Construction in Swelling Grounds

— Hokkaido Shinkansen, Tateiwa Tunnel (Tateiwa), etc. —

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1. Introduction

The Hokkaido Shinkansen is a line connecting from Aomori City to Sapporo City, and the 211.9 km-long section between Shin-Hakodate-Hokuto Station and Sapporo Station is currently under construction. Tateiwa Tunnel, with a total length of 17,040 m, is located between Shin-Yakumo Station (tentative name) and Oshamambe Station of the Hokkaido Shinkansen line currently under construction. The construction area of Tateiwa Tunnel (Tateiwa), etc. falls under the area to be constructed for 5,015 m from the portal opening on the starting point side. (Figure-1)

2. Characteristics of the Tunnel / Countermeasures

1) Geological conditions

Concerning the geological conditions, the assumed distribution is as follows: andesite tuff breccia (LMt) for approx. 400m from the portal opening; basaltic pyroclastic rock (LMb) for the following approx. 1,200 meters; mixture of shale, tuffaceous breccia, and green tuff (LM　LMt) for 1,600 m after that; and basaltic pyroclastic rock (LMb) for the subsequent area. (Figure -2)
Also, according to the existing geological surveys, a swelling ground containing a large amount of smectite has been assumed from around the 208-km and 600-m point from Shin-Aomori. In the actual construction, the condition includes a ground with the smectite content of 39% from the 207-km and 411-m point, with the competence factor of around 2, with the moisture content of 2 ~ 10%, and with the overburden of over 200 m, which makes a swelling ground where earth pressure is likely to occur. Thus, there has been a concern over an increase in the inner space displacement and heaving.

2) Countermeasures

As a countermeasure to restrain inner space displacement in a swelling ground, the support pattern is established by the competence factor and the elastic wave velocity and it is changed according to the face condition and the result of inner space displacement measurements. Furthermore, reinforcement works have been implemented as needed according to the inner space displacement measurements. Since these stepwise countermeasures according to the measurement results affect the progress of construction works, selecting of an appropriate support pattern in an early stage has become one issue to ensure more efficient execution of works. (Figure-3) Therefore, by focusing on the relation of the final displacement amount to the competence factor and the initial displacement amount for each support pattern, we have formularized a prediction expression to estimate the final displacement amount by using the inner space displacement in 24 hours after the start of measurement as the initial displacement, and the competence factor, and the smectite content.
As a result, we have obtained a high correlation with the actual final displacement amount and confirmed the validity of each support pattern in an early stage of displacement. (Figure-4)
Also, as works to prevent heaving were implemented even after the completion of construction for some sections already in service, countermeasures in the construction stage are necessary. Accordingly, we have selected inverted shapes according to the ground sample test indicators (such as the competence factor and the smectite content) in an advanced survey boring.

3. Knowledge and Results Obtained

By selecting the support pattern by utilizing the prediction expression, the final displacement amount has been kept under the control standard value. By identifying the initial and final displacements including the inner space displacement and the crown settlement, and further by appropriately predicting the final displacement amount according to the prediction expression, we have been able to implement the effective construction method. We will further improve the accuracy of prediction expression by utilizing the measurement results of other swelling grounds.
As a result of selection of inverted shapes based on the ground sample testing indicators, there is no heaving phenomenon at present and we consider that appropriate selection has been made.

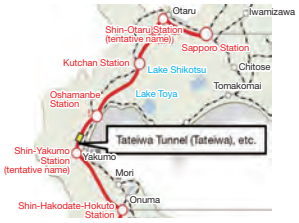

Fig. 1 Construction area map

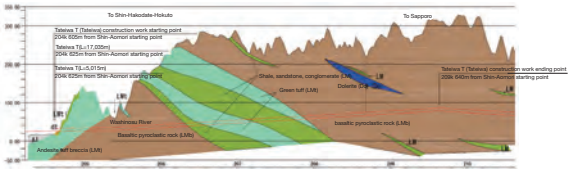

Fig. 2 Geologic cross section of Tateiwa Tunnel (Tateiwa) and other construction sections

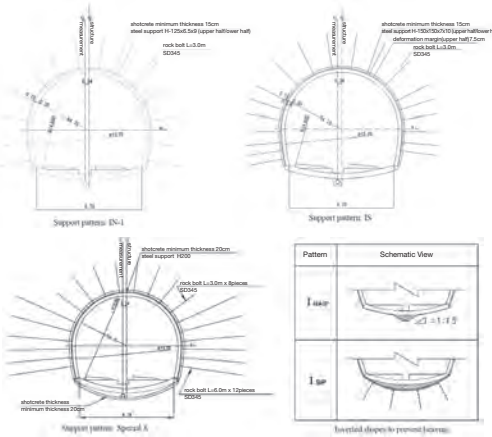

Fig. 3 Support patterns and inverted patterns

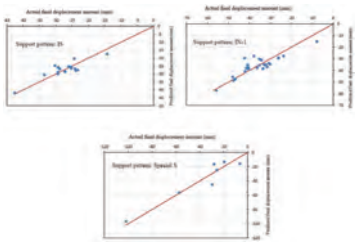

Fig. 4 Relation between the actual final displacement amount and the predicted final displacement amount for each support pattern