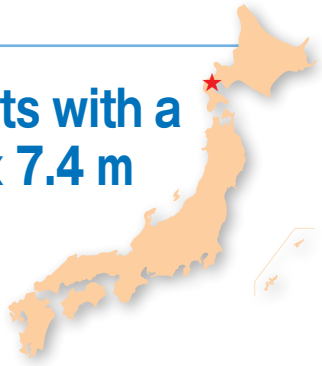
Construction of a Mountain Tunnel which Intersects with a Highway, with the Minimum Overburden of Approx 7.4 m

— Hokkaido Shinkansen, Kunnui Tunnel —



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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. Kunnui Tunnel, a mountain tunnel with the total length of 1340 m, is located between Shin-Yakumo Station (tentative name) and Oshamambe Station, after the start of tunneling by NATM in December 2020, it was completed in October 2022.

2. Characteristics of the Tunnel / Plans

This tunnel is characterized by the intersection with a highway in service, with the minimum overburden of 7.4 m (Figure-1). According to the assumed distribution of low-consolidated layers mainly of conglomerate, sand and clay in the highway intersection part, it was estimated that excavating of these layers might cause surface settlement or collapse of the highway over the ground and that this would make tunnel excavation a very difficult work.

To ensure safe excavation directly below the highway in service, we have predicted displacement of the Shinkansen tunnel and the highway during excavation by a numerical analysis (FEM) in advance and decided the excavation method with reference to the results of similar construction works. Although we have examined an open cut method and a shield method as well in view of the geological features and overburden, we have adopted a plan of excavation by the NATM taking account of the on-site conditions, the construction period and the economic performance. We have preliminarily implemented a test construction in a section with a similar geological features and overburden in this construction area to confirm the safety of excavation by the NATM, and we have established the construction method for the highway intersection part by analyzing and evaluating the results obtained from the test construction.

Also, for the measurements during the excavation of highway intersection part, monitoring of the ground surface settlement has been implemented by using a ground-mounted measuring instrument, in addition to a common displacement measurement inside the tunnel. Upon consultation with the highway administrator, we have established three-stage control standard values concerning the ground surface settlement to implement measures according to each stage; we have decided to stop excavating in an event of settlement identified as the control level III which affects running vehicles; and thus, we have developed a structure to secure the safety of regular vehicles running on the highway.

3. Results of Construction

In the test construction, the displacement occurred was larger than that predicted in the analysis and the amount of ground surface settlement reached the control level III in the highway intersection part. The estimated causes are as follows: the ground of the construction section concerned has a distribution of unconsolidated sandy gravel layer which is thicker than we predicted; the earth bearing capacity of the upper-half root foot part is insufficient; and the rigidity of support is insufficient. Accordingly, to minimize the ground surface settlement in the construction for the highway intersection part, we have decided to implement additional measures (Figure-2) such as reinforcing of legs, connecting of front and back supports, and shortening of cycle until the primary cross-section closure.

We have observed weakly consolidated silty sand on the whole surface of the cutting face of the highway intersection part; however, the ground surface settlement was restrained to within the control level I (Figure-3) even in the place with the largest settlement. Until the completion of lining work of highway intersection part in July 2023, progress of displacement has not been observed. We will continue to execute the remaining work safely with attention given to the surrounding environment.

Fig. 1 Location plan of Kunnui Tunnel

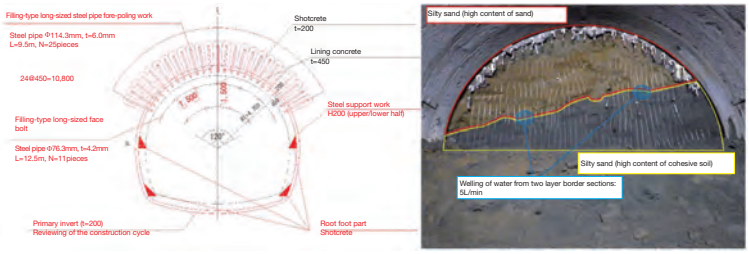

Fig. 2 Support conditions in the highway intersection part

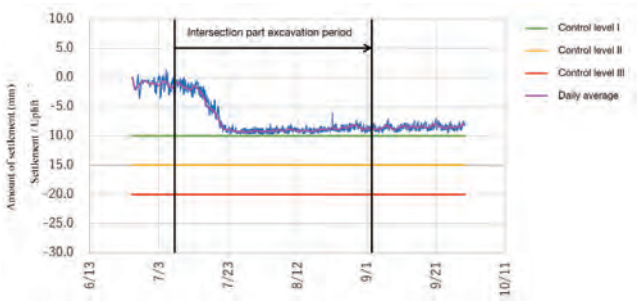

Fig. 3 Results of measurement of point with the largest ground surface settlement