Square Element Propulsion Method Applicable to Large-Section Horseshoe Tunnels in Trenchless Areas of Stations

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Introduction

The Sotetsu-Tokyu Direct Line is a 10km long line that connects Sagami Railway, which operates mainly in Kanagawa Prefecture, and Tokyu Railway, which operates in southwestern Tokyo, and is under construction for completion in the second half of FY 2022. The Shin-tsunashima Station (tentative) to be built in Yokohama City will be an underground station with an island platform at a depth of about 35 meters, based on four levels. The majority of the station will be constructed using open-cut construction methods, but the 34.5-meter-long Tokyo side of the station, which is 240 meters long, will be constructed using trenchless methods because of the presence of solid buildings such as a hospital above ground (Fig. 1). This paper focuses on the trenchless method for the large section horseshoe tunnel.

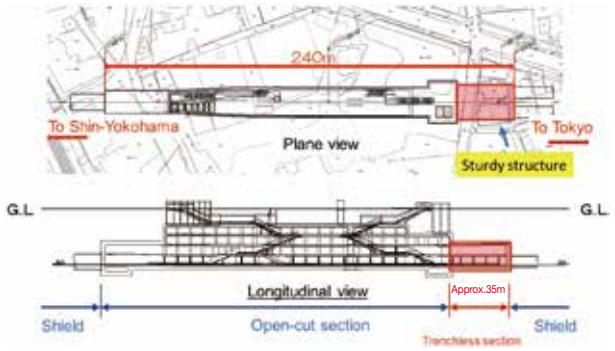

Fig. 1 Shin-tsunashima Station and Trenchless Segment Overview

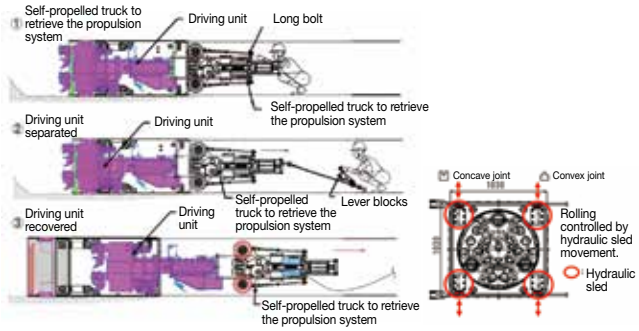

Fig. 2 self-propelled cart (left) and hydraulic correction jack (right)

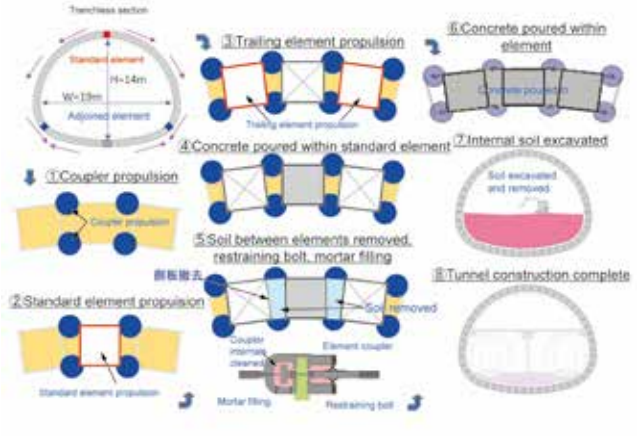

Fig. 3 Square element construction sequence

1. Construction Plan for the Trenchless Section of the Station

To construct the trenchless section of the station, we adopted an advanced construction method for the outer shell in consideration of the geology and the impact above ground. Shafts in Japanese rail stations are set up on the departure and arrival sides, and the propulsion machines used to build the outer shell are recovered and reused in the shafts on the arrival side. However, in this construction area, it was impossible to install a shaft at the arrival side due to the condition of the ground, so the recovery of the propulsion system presented an issue. To address this issue, we developed a self-propelled truck to retrieve the propulsion system, which enabled us to reuse the propulsion system without a shaft (Fig. 2).
In addition, the square element propulsion method, which is a new technology, was adopted in order to achieve a horseshoe cross-section with a longer construction length and larger cross-section than the conventional method. A square element is a box-shaped cross-section (1000 mm x 1000 mm) of steel plates welded together to form a single element, with concave and convex joints connected. The construction sequence is shown in Fig. 3.

2. Longer distances and horseshoe-shaped cross section

In the construction of a square element, the propulsion machine is driven into the ground by extending the pressing jacks in the launching shaft, and the subsequent elements are connected one after another. For rectangular element propulsions, the position of the propulsion machine becomes the position of the main structure, so strict excavation accuracy is required. In this construction section, the excavation length was long, and each element had a different angle in a horseshoe shape, so it was important to ensure the excavation accuracy. Therefore, in order to secure the digging accuracy, a new hydraulic correction jack (Fig. 2) was added to the propulsion system to control and manage not only the vertical and horizontal displacement, but also the rolling.

3. Construction results

As a result of the above measures, the 42 square elements were constructed within the control values. Internal excavation after the construction of the elements was also completed, but there was little leakage into the interior and the impact on the ground surface was minimal. We believe that this will help expand the applicability of the trenchless method in the construction of large cross-sectional underground spaces.