Construction of an Underground Passage with a Rectangular Shaped Muddy Soil Pressure Balanced Shield Machine — Public Facility Construction for the First-type City Redevelopment Project, Toranomon 1-chome District —

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Introduction

A large-scale redevelopment is underway in the Toranomon area of Tokyo in preparation for the Tokyo 2020 Olympic and Paralympic Games. To improve the traffic connection in the surrounding area, a pedestrian underpass connecting the stations of two subway lines is being developed.
The underground passage of about 370 meters in length is to be constructed by three methods; closed-face shield TBM, pipe jacking, and cut and cover. For the section of about 218 meters out of the total length, muddy soil pressure balanced shield TBM method with rectangular cross section (external diameter: W = 7.92 m, H = 5.02 m) was applied.

1. Characteristics of This Project

The earth covering above the shield tunnel is from 3.0 meters to 5.6 meters, and the target excavation ground is soft alluvial viscous soil with N-value of about 0 to 2. Right above the tunnel are several important underground utilities and close to the sides are many low-rise buildings. The shield vertical alignment changes from an upward 0.28% slope to an 4.46% slope (Vertical Curve R = 500 m).

2. Challenges and Solutions

The challenges in this project are: I. Suppression of ground deformation and suppression of influence on underground utilities and surrounding buildings, and II. Attitude control of the shield machine. For the task I, to suppress the influence of shield drilling on underground installations and low-rise buildings, the ground improvement by the high pressure jet stirring method was carried out in the upper and side portions of the tunnel. In order to suppress the ground deformation, controlling the earth pressure and the amount of discharged soil is crucial and thus to check the validity of the set earth pressure, stratified settlement gauges were installed at 10 meters and 30 meters from the launching shaft, and the excavation was carried out while confirming the underground displacement in real time. For the muck discharge, a pumping system was adopted, and the discharge amount was controlled with a flow meter and a density meter installed in the pumping pipe. In addition, a simultaneous grouting device was installed on the upper part of the shield machine, and backfill grouting was carried out immediately whenever tail voids were generated.
For the task II, to deal with the vertical curve, the shield machine was equipped with an articulation unit (with angles 1.0° up and down). In addition, the rolling of the shield machine was controlled by adjusting the amount of overcut by the extensible cutter built in the spokes, selecting appropriate shield jacks, injecting the filler from the lower body of the shield machine and using the articulation unit. With these methods, successful construction under the special condition — soft ground covered with small earth covering and the use of rectangular shield — was achieved, resulting in the high accuracy of "ground surface subsidence: within 10 mm (negotiated control value), finished shape of the tunnel: within ± 50 mm (upper, lower, left and right tolerances)."

Photo 1 Rectangular shaped muddy soil pressure balanced shield machine

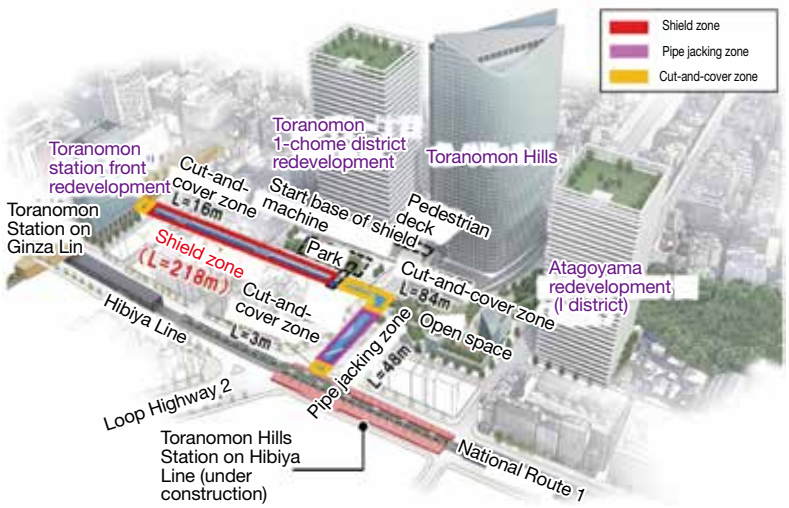

Fig. 1 Construction location map