Construction of an entrance/exit for an underground expressway on Tokyo Metropolitan Expressway by the open-cut tunnel construction method

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ABSTRACT

For the construction of the Central Circular Shinjuku Route the shield-tunneling method was adopted for approximately 70% of the route to mitigate the impact of construction on the neighboring environment and traffic flow. The turnoffs and entrances/exits were constructed using an innovative method. After completion of the shield tunnels for the main roads, the cut and cover method was used to construct the concrete bodies of the turnoffs and entrances/exits. These concrete bodies were connected to the shield tunnels by cutting through the steel segments. This method was employed after sufficient consideration. Some of the geotechnical issues are shown in this paper.

Keywords: shield tunnel, entrance/exit, cut and cover, earth retaining wall, stability of tunnel

1 INTRODUCTION

The Metropolitan Expressway Central Circular Route is a 47km road that surrounds central Tokyo. Of the Central Circular Route, the Shinjuku Route is the western 11km section. The shield-tunneling method was adopted for approximately 70% of the main roads. After completion of the shield tunnels, the cut and cover method was used to construct the concrete bodies of entrances/exits and junctions. This open-cut tunnel construction method is optimal as a method that can minimize earth excavation for construction work as well as the effect on environment such as street traffic and underground installations.

2 TOMIGAYA ENTRANCE/EXIT

The outline figures of Tomigaya entrance/exit are shown from Fig.2 to Fig.5. It is typical of it that the two shield tunnels are asymmetrically arranged and the room for emergency stairs is located below the roadway floor at 3BL. The site has the following geological layers, starting from the top: refilled layer (B), loamy layer (Lm, Lc), Tokyo layer (Tos, Toc, Tog), Kazusa layer (Ks, Kc). As Tokyo layer is diluvial layer, the shield tunnels lies in relatively stiff layers.

3 CONSTRUCTION METHOD

Fig.6 shows the procedure for the construction. Earth retaining walls by the Soil Mixing Wall Method and

Fig. 2. Overview of Tomigaya entrance/exit
Impervious walls are constructed before the shield tunnel reaches them (STEP1). After the passage of shield machine, the shield tunnel is internally reinforced and the wells are installed (STEP2). The ground between the earth retaining walls and both tunnels is excavated (STEP3). The skin plates of shield tunnels are removed and concrete bodies are constructed with the main girders of shield tunnels embedded in concrete (STEP4 to 5). The main girders of shield tunnels which project into the open space are removed and then back-filled (STEP6).
4 MAIN ISSUES OF CONSTRUCTION

Fig. 7 shows the main issues concerning geotechnical design and construction. Various approaches were considered, and the following measures were selected.

4.1 Stability of the earth retaining wall without embedment

The ground between the earth retaining walls was totally excavated before the excavation between both tunnels, because the bottom of the retaining walls were located above the shield tunnels. As shown in Fig.8, the preceding underground strut by jet grouting was applied at the bottom of retaining walls. Struts were installed just above the soil improvement before the excavation of soil improvement. By these measures, the arm length of cantilever of retaining walls while removed embedment was minimized and the retaining walls were remained stable during excavation. Then the struts at the bottom of retaining walls were installed for the further excavation between both tunnels.

4.2 Preventing water leakage through discontinuities in the earth retaining wall

Water leakage was a concern, as the earth retaining walls and tunnels were discontinuous and the portions of discontinuity were located under the ground water level. Grouting was used to form impervious walls to enclose the entire structures and the inner ground water level was lowered by using the wells. Despite these measures, water might still leak along paths created by the deformation of tunnels during excavation. As shown in Fig.9, water stop structure and the use of jet grouting to improve the soil behind the earth retaining wall were employed to eliminate leakage. Elastic material was used as the filling to follow the deformation of tunnels and eliminate the gap.

4.3 Stability of the shield tunnels during excavation

In the stage of excavation between both tunnels, the entire tunnel might be destabilized by the unbalance of the load acting on the tunnels. As shown in Fig.10, the struts between both shield tunnels were applied based on the sequential excavation analysis. As the relative position between both tunnels and the struts changed along the tunnel axis, every connection plate had different shape.

Furthermore, for the portion that the elevation of each tunnel was significantly different (B-B section on Fig.5), the preceding underground strut by jet grouting between both tunnels below the excavated area was employed to stabilize the tunnels as the result of a comparative study. Also the concrete anchor blocks were constructed so that they transmitted the compressive force of underground struts surely to the shield tunnels.

![Fig. 6. Construction phases](image-url)
Fig. 7. Main issues of construction

Fig. 8. Retaining wall without embedment

Fig. 9. Water stop structure

Fig. 10. Struts between the tunnels

Fig. 11. Excavation between both tunnels

Fig. 12. Before the cut-off of main girders of shield tunnels

5 CONSTRUCTION STATES

Fig. 11 shows the state of excavation between both tunnels. Fig. 12 shows the state when the construction of concrete bodies were finished and the main girders of shield tunnels were waiting to be removed.

6 CONCLUSIONS

With the measures mentioned above, the construction work of Tomigaya entrance/exit was completed successfully. Now, all of The Metropolitan Expressway Central Circular Route has been in service. It is expected that the severe traffic congestion is relieved and the amount of exhaust gas is reduced. We hope that this paper will serve as a useful reference for the future construction work.

REFERENCES