Construction of a road tunnel of the world's largest class directly beneath a railway station using the R&C Method

—Underpass construction project on the Tokyo Outer Ring Road—

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1. Project overview

This project will construct a double-layer four-section box culvert under Sugano Station where the Tokyo Outer Ring Road crosses the Keisei Main Line. The R&C Method was used in construction.
The R&C Method is a method for construction of underground structures by replacing a rectangular section box-type roof beneath the ground installed as a shield to protect the railway tracks with a box culvert built at the starting shaft. The box culvert in this project is composed of steel segments and has the following dimensions: height 18.4 m, width 43.8 m, and total length 37.4 m (9.35 m per box multiplied by four boxes). The cross-section size of the culvert is the largest class in the history of application of the R&C method.

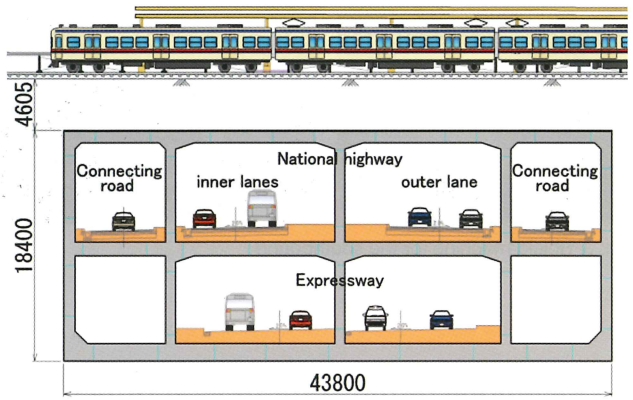

Fig. 1 Cross section view of the box culvert

2. Face stabilization measures

The R&C method is an open-face shield method. Normally, the height of most box culverts built using this method is less than 10 m, and usually the face has one stage. In this project, because of the size, there were various issues to be taken into consideration including measures to deal with deformation of the railway tracks and maintaining stability of the face. To solve these issues, a pipe roof was installed horizontally in the mid-section, and a structure with a two-stage face was adopted (Fig. 2). Furthermore, measures to reinforce the ground by chemical grouting and to boost the rigidity of the box roof were combined, and as a result the deformation of the railway tracks was reduced and the safety of construction was improved.

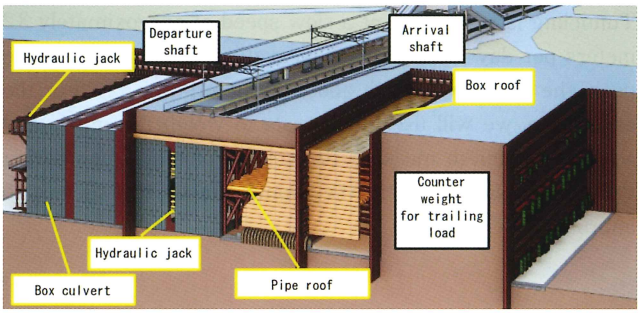

Fig. 2 Box culvert traction status diagram

3. Measurement of stress intensity inside the box culvert and guaranteeing precision of traction

In this project, steel segments were utilized in the box culvert with the objective of shortening processes and reducing labor for on-site operations. Consequently, this required more risk assessment than for the traditional R&C Method, which has a longer history of usage. That is why three-dimensional FEM analysis was used in advance to clarify the out-of-plane load caused by jack thrust, and the relative displacement allowance of the box culvert was determined based on the stress intensity that occurred in the segments and bolts. In the execution of box culvert traction, the shield jacks were controlled based on the measurement values obtained from strain gauges installed inside the box culvert and laser distance meters that monitor the location and position of the box culvert. Also, intensive computerized control was utilized for some of the jacks in the culvert traction.

4. Track measurement

The scope of impact of this project on the railway tracks extended approximately 120 m. Control values were set for all facilities within the tracks, and measured automatically using an automatic tracking total station. The railway track was checked regularly and at suitable intervals throughout all stages of the construction process, ensuring safe operation of the tracks open for traffic.

5. Conclusion

The face was excavated during the day, while box culvert traction was generally conducted at night when the tracks were closed for traffic and one-time traction was set at about 20 cm.
The box culvert traction had no significant impact on the tracks, and both internal stress within the box culvert and traction force were maintained within the projected scope until successful completion of construction (Fig. 3)

Fig. 3 Completion of the box culvert traction