Direct excavation of RC structures with a shield machine and construction of a sharply curved alignment

Atsushi TANAKA ► Chief, Underground Regulating Reservoir Beneath Ring Road No.7 Construction Office, TAISEI CORPORATION

Introduction

The Tokyo Metropolitan Government is planning to construct an underground wide-area, tunnel type reservoir for flood control, along Ring Road No. 7 to temporarily hold floodwaters during typhoons and localized rainstorms.

This construction section is 5.4 kilometers in total linking the two regulating reservoirs in service, Kanda River-Ring Road No. 7 underground reservoir and Shirako River underground reservoir. The tunnel is 13.2 meters in outer diameter and 12.5 meters in inner diameter, which will be built using a slurry shield method, along a trunk road at depths of 32 meters to 40 meters.

The shield machine is currently being manufactured and will be launched for the project in July 2019.

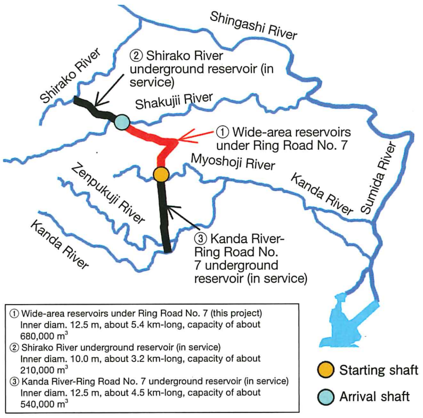

Fig. 1 Overview of the wide-area reservoirs

(1) Cutting RC structures underground on site directly with a shield machine

The shield machine, after being set in the starting shaft, will directly commence cutting the lateral walls (RC structure, thickness 1.7 m) of the starting shaft, and RC wall diaphragms (1.2 m thick). When the shield machine directly cuts materials in the starting shaft, the structural materials encountered are normally not steel, but carbon fibers and FFU components (Fiber Reinforced Foamed Urethane) because they can be cut with ease. But this project does not use such materials. In the past, there were cases where RC structures such as embedded ducts and piles were cut directly, but cutting RC structures directly in a full-face excavation as seen in this project has no precedent.

The cutter head is a conical shape which, on the entire surface, is provided with carbide bits suitable for a full-face excavation that are ultra hard, approximately 48 times harder than conventional preceding bits used generally for soil and sand stratum. After the process of direct cutting, the shield machine, thanks to the use of bits with greater endurance that are highly resistant to wear and impact, will be able to excavate a tunnel length of 5.4 km without changing the bits.

When cutting the existing structures underground, the rotation speed of the cutter will be approximately doubled (to 0.84 rpm) and the shield machine with continue boring at a low rate of 1-2 mm/min in a manner to thinly peel the structure surface off.

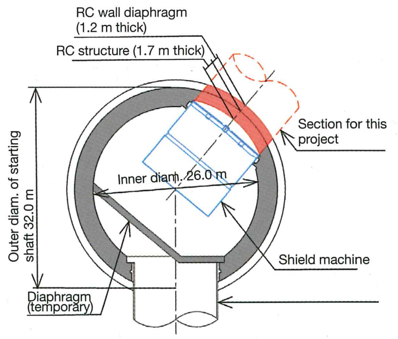

Fig. 2 Starting shaft for the shield machine

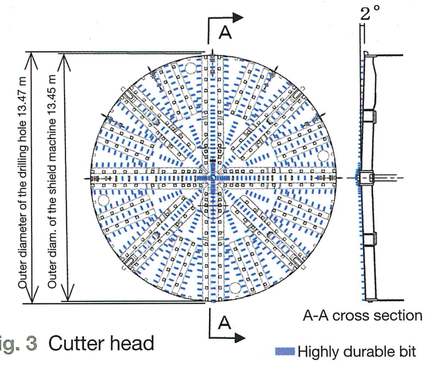

Fig. 3 Cutter head

(2) Boring a sharp curve

The minimum curve radius is 100 m in horizontal alignment for the tunnel. Given 13.45 m as an outer diameter of the shield machine, R=100 m is one of the sharpest curves attempted for large section tunnels. To keep the horizontal alignment optimal, the articulation angle of the shield machine is set to 4.3 degrees max. The segment portion at a sharp curve excavation is composed of rings tapered to form the shape of a curved cornice along its total length (Fig. 4).

Since generally, the section at a sharp curve tends to be over-broken, highly cohesive plastic filler will be injected into the ground from the side barrel of the shield machine to prevent the porous ground from collapsing, and by doing so, will minimize excavation impact on the ground surface.

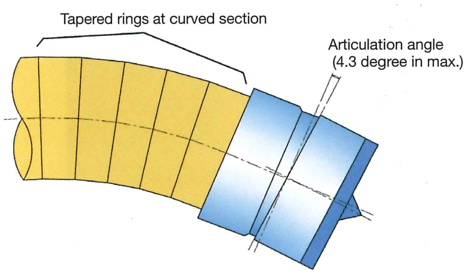

Fig. 4 Construction of a sharply curved section