Widening of an extremely large underground cavity from small aqueducts

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This is a new project for construction of a 659-m long irrigation and discharge tunnel with the main objective of maintaining the flow discharge from the Koishiwaragawa Dam (under construction by the Japan Water Agency in Fukuoka Prefecture) and reaching the amount of discharge necessary for supply of water for the waterworks system. One of the characteristics of the construction is the specific location of the discharge equipment chamber, which has an extremely large cross-section (250 m^2), where valves are installed to control the discharge volume. The zone is sandwiched between zones with smaller cross-sections (29 m^2) of the upstream aqueduct and the downstream aqueduct.

1. Overview of the geological conditions

The geology of the tunnel is composed of hornfels from psammitic schist of the Sangun metamorphic belt dating back to the end of the Paleozoic Era through the early Mesozoic Era. It is relatively hard with uniaxial compressive strength of about 80 N/mm^2. The lithology of the discharge equipment chamber features sound rocks overall, but there is intercalation of clay in the joint faces.

i)Issues pertaining to the excavation method and solutions

Issues

- Initially, the plan envisioned a tunnel constructed as a three-turn slanted structure extending upwards from the downstream side. The excavation of the crown section raised concerns of collapse of natural ground due to the proximity of construction to the already completed upper section of the drift and delays of the construction process due to the complexity of the excavation.
- Since the discharge equipment chamber was a zone with extremely large cross-section sandwiched between zones with smaller cross-sections, the environment aggravated retention of dust.
- In the excavation equipment for the small sections, the equipment arm could not reach the excavation location, so it was impossible to excavate the full face of the arch section without replacing the equipment.

ii)Solutions

- Excavation was launched from the upstream side with due consideration of the 5% longitudinal slope. The number of turns was changed from three to one, and the slope of the drift was planned at 23% of the grade ability of the equipment.
- As a solution to the issue of retention of dust inside the extra-large sections, a ventilating hole was installed to connect the upstream portion with the downstream. Also, a silent fan was used to supplement the effect of the ventilating hole, and the necessary ventilation volume was maintained at over 937 m^3/min.
- The cross section of the tunnel heading was built by dividing it into right and left half sections. In order to maintain the stability of the supports in the half sections, the steel supports were fixed by installing temporary anchors (D25, L=2.0 m) (two anchors per support).

Figure 2 shows the steps in the excavation process.

2. Summary

The reduction of the number of turns of the tunnel structure during excavation served to simplify the construction methods, and resulted in improved safety and shorter construction period. Also, the utilization of the ventilating hole for water supply and drainage as well as electricity supply during the excavation for the turn structure not only improved the work environment but also boosted operational efficiency.

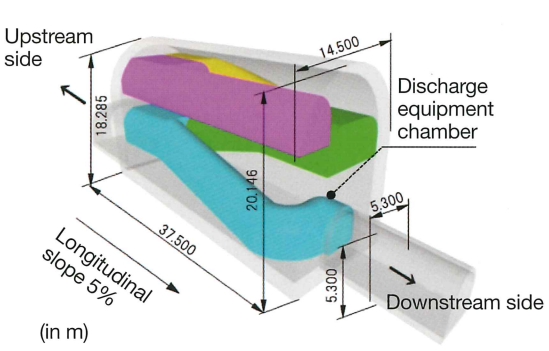

Fig. 1 Initial excavation plan diagram

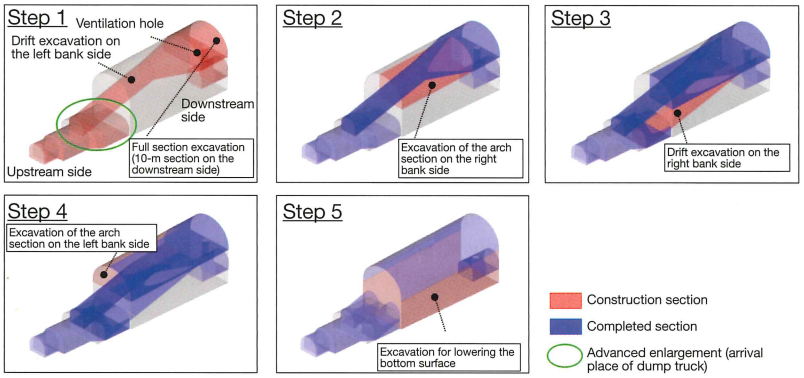

Fig. 2 Steps in the excavation proces