Construction of a shaft and a water-tight pressure tunnel with a large cross-section in a lake

- Project for construction of a new spillway at the Kano River Dam Tunnel

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This project is concerned with the construction of a tunnel spillway 11.5 m in inner diameter in the ground on the right side of an operating dam. The structural elements to be provided from upstream were an influent channel, an intake shaft, a tunnel, an outfall and an energy dissipator (Photo 1.)

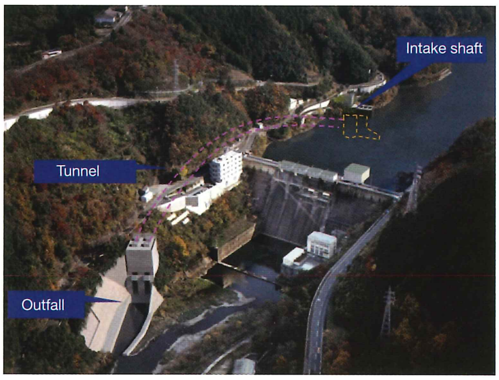

Photo 1 Construction map

1. Pressure tunnel with a large cross section

This tunnel is a pressure tunnel in which water pressure is extremely high, with external water pressure up to 0.9 MPa and an internal water pressure up to 0.4MPa. Of a total length of 457 meters, 323 meters were constructed with standard structures of reinforced concrete, and the remainder composed of steel pipes such as effluent pipes, transition pipes. The boring cross-section of the tunnel was 142 m^2 for standard structure, and 322 m^2 (width 19.1 x max. height 19.2) for a steel pipe section, which boasts the world's largest size as a pressure tunnel. The section of reinforced concrete did not depend on water sealing grouting for water tightness, which is normally used for pressure tunnels, but on a system of applying water-tight sheets to the total circumference. In order to lower the risk of water leakage, we contrived a new approach for finishing the wall surface. The tunnel walls were made smooth with shotcreting prior to application of water-tight sheets to reduce the number of times sheets had to be welding by changing the sheet width from 2 meters to 3 meters.

As reinforcement material, we introduced prefabricated mesh reinforcement in units, which are designed for lower risk of damage and for saving labor (Photo 2.)
The lining concrete that was used was the type with medium fluidity which is able to completely fill the cavity.

2. Excavation of a shaft at great depths

The intake shaft was built in the lake, in the shape of a cylinder by driving 34 steel pipe sheet piles of 1500 mm in diameter (L=44.0 m), which was temporarily water-proofed. Inside of the shaft, excavation was made from the top of sheet piles to a depth of 41 m by installing ring-shaped supports (H-300 in two stages, H-400 in four stages and H-800 in four stages.) Then, concrete was placed underneath to build the bottom slab before being temporality back-filled. After cutting the steel pile sheets, the shaft was linked through penetration with the tunnel which had been bored from the outfall side. During the excavation of the shaft, there was a risk that the steel sheet piles might deform to create bleeding channels, leading to significant groundwater inflow. Measurement instruments were placed on the steel pipe sheet piles and supports for around-the-clock monitoring.
(3) Excavation for the penetration of an intake
The excavation for the penetration of the intake has the following features: 1) 14 of the steel pipe sheet piles at the intake shaft were cut; 2) The outer circumference of the steel pipe sheet piles, after being back-filled with single-sized crushed stone, was water-proofed by injecting underwater inseparable cement milk; 3) The tunnel to which the intake was to be connected had a large cross-section with a boring surface of about 270 m^2 (17 m wide x 17.9 m high.) Prior to cutting of steel pipe sheet piles, a hole was bored for monitoring to confirm there was no water inflow from behind steel pipe sheet piles. The face was divided into four benches, by cutting steel pipes with a grind-stone cutter and Sharp Lance. During the whole process to the moment of breakthrough, the project was completed safely, with neither abnormal deformations in the shaft and tunnel, nor inflows from the connected sections (Photo 3.)

Photo 2 Completion of the reinforcement

Photo 3 Full view of the connection in the outfall