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Construction of a gas pipeline using small cross-section shield tunneling for rocks under high water pressure

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The Toyama line, a 102 km-long natural gas pipeline, was constructed from Itoigawa City, Niigata Prefecture to Toyama City, Toyama Prefecture for the purpose of expanded use and stable supply of natural gas. This project laid a gas pipeline under high pressure in Construction Segment A-1 which is nearest to the starting point (on Niigata side). A tunneling segment of about 2 kilometers out of the total length was designed to pass through the mountain area, considering that severe traffic congestion could potentially be caused by large vehicles used for muck hauling as well dust, noise and vibration that would occur during excavation.

Ground condition and construction plan

This tunneling segment is mainly composed of collapsing and crushable brecciated slate and Holocene sandy soil with an earth covering of 10.5 to 117.5 meters, with an assumed maximum groundwater pressure of 1.2 MPa. When establishing this tunnel plan, the crucial requirement was that the construction process should be managed so as to put the Toyama line in operation as soon as possible, and to achieve this goal, two tunnels were excavated from opposite directions at the same time, and docked with each other at the mid-point for breakthrough.

Of the tunneling course, the segment beginning from the starting portal up to about 200 meters included highly permeable sandy ground. Considering that a NATM method, if employed, may be less efficient and economical because it is necessary to use various auxiliary methods such as water sealing injection and long forepiling, we adopted a muddy soil pressure balanced shield method, which proved to be effective for both rock ground and sandy soil (850 m long, shield outer diameter 2280 mm, segment's outer diameter 2150 mm).

Pressurized excavation in the sandy section and open excavation of the rock section

The 200 m section from the point where the shield machine started excavation, being composed mainly of gravel-mixed sand, was bored under pressure with the use of bentonite muddy water and air bubbles, but during the excavation, observing that the soil became gravel-like, and the screw was frequently clogged with gravel 40 mm in diameter, it was feared that the excavation might be impossible.

Therefore, we judged that the status in the chamber could not be stabilized, and decided that the chamber should not be filled with muck, but that the face should be excavated with an open-type shield method. At places where water flow was estimated to be relatively small, drainage was omitted. By doing so, excavation proceeded by discharging water inflow with additives from the screw conveyor. At places with large amounts of water inflow, the excavation was controlled by draining water from the shield and segments so it did not exceed the pressure resistance of the shield machine. At a drainage level of 2000 L/min at the final stage, excavation was able to be completed successfully by preventing the clogging of the screw and chamber. The longitudinal alignment of the tunnel was designed at 0.3% in advance; the water inflow in the tunnel was made to flow naturally under gravity.

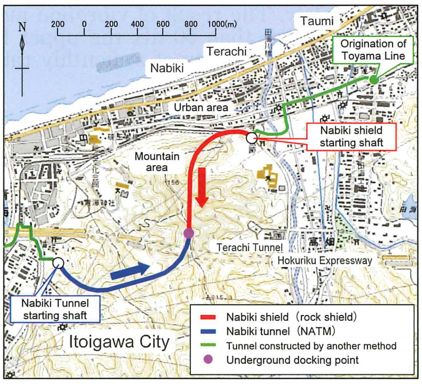

Fig. 1 Tunnel plan view

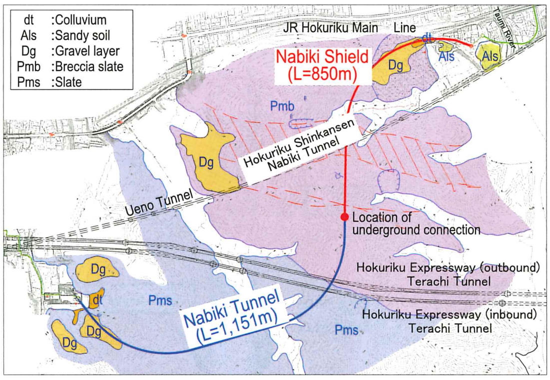

Fig. 2 Plan view of geology and tunnel alignment

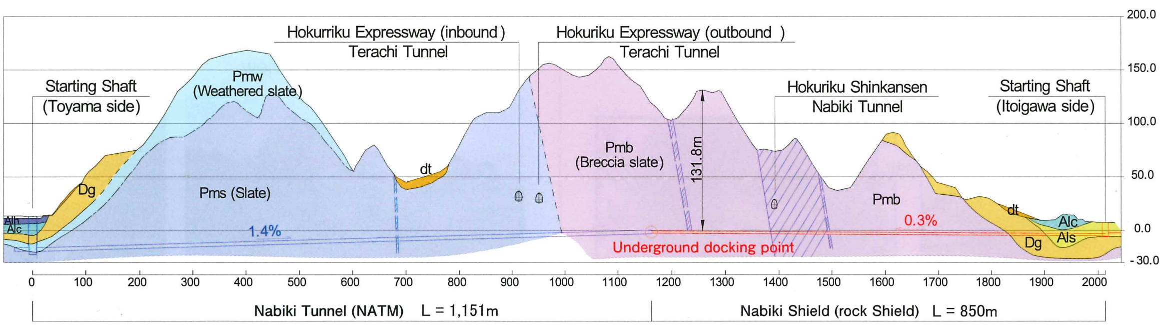

Fig. 3 Tunnel longitudinal profile