Breaking Through the Complex Geological Formations along the Median Tectonic Line with 3D Computerized Construction

— San-Ennanshin Expressway, Aokuzuretoge Pilot Tunnel, Ikejima Construction Area —

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Overview

The Ikejima section of the Aokuzuretoge pilot tunnel on the San-Ennanshin Expressway is a tunnel with a standard excavation cross section of 5.7m in diameter, a section length of 1,168m (total length: 5,014m), and a maximum overburden of 625m. The location of the tunnel is close to the Median Tectonic Line, which is one of the world's largest faults and runs through Japan for about 1,000 km from eastern Kyushu to the Kanto region (with a separation of about 500 m) (Fig. 1), and has a geology that is complex and difficult to predict in advance. In addition, the tunnel is subject to deformation due to the fragile geology consisting mainly of gouge (fault clay) and fault gravel caused by the intense fault movement of the Median Tectonic Line and the large overburden. In response to these geological conditions, a three-dimensional numerical analysis was performed based on geological information such as the location and size of fault fracture zones and the strength of the ground collected three-dimensionally by a cutting face exploration. Furthermore, a support structure was studied in advance, with early closure and double support construction adopted to ensure tunnel stability.

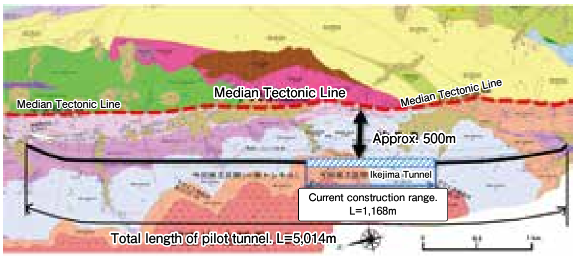

Fig. 1 Geological plane view

1. 3D Computerized Construction

In order to collect three-dimensional information, three types of three-dimensional frontal surveys, namely seismic prospecting reflection survey, electromagnetic resistivity survey, and borehole logging, were carried out in addition to conducting advanced boring surveys on all lines to understand the location of the fault zone in front of the face, geological structure and water retention. Based on the results of these investigations, 3D FEM analysis was carried out to investigate the support structure.

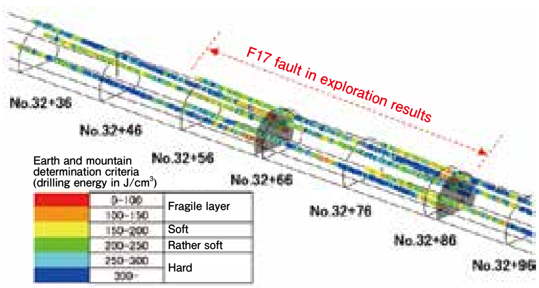

Fig. 2 3D forward survey results

2. Construction of the large overburden fault crush zone

From the results of the three-dimensional frontal survey, it was estimated that there was a fault crush zone where the ground strength was further reduced in the section with the maximum overburden (Fig. 2). Therefore, it was feared that the designed support structure would not ensure the stability of the tunnel, and it was decided to consider the use of a double support structure (Fig. 3) as an even stronger support structure. A 3D FEM analysis was carried out to reflect the detailed three-dimensional geological data obtained from the forward exploration results, the early closure, and the construction steps. As a result, the effect of the double support structure was confirmed to be more than 50% reduction in both the displacement of shotcrete and the stress generated in the main support structure (Fig. 4), and the double support structure was constructed after the test construction.

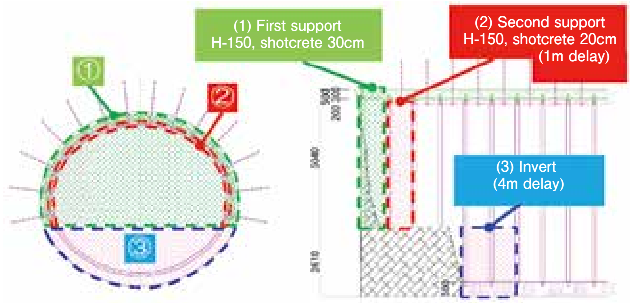

Fig. 3 Structure and construction steps of double support

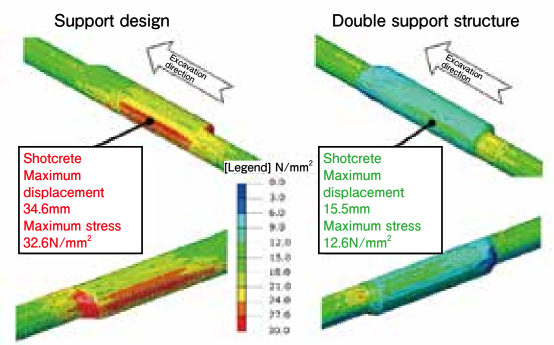

Fig. 4 3D FEM analysis results

The geological conditions along the Median Tectonic Line are far more complex and fragile than assumed at the time of design. For such rapidly changing and difficult-to-predict ground conditions, 3D computerized construction, in which the state and distribution of fault crush zones and fragile layers are grasped by multiple 3D frontal surveys and the support structure is studied by three-dimensional numerical analysis, was an effective means of advanced preparation. We were able to excavate the crush zone section with the maximum overburden without any deformation or excess displacement of the support structure.

Photo Survey point No.37+82 Heavily folded cutting face