1. Introduction

The Hokuriku Shinkansen is a 690 km-long line that starts in Tokyo and ends in Osaka City via Nagano, Toyama, and Obama. The Okunono section of the New Hokuriku Tunnel is a 4,880-meter-long middle section of a 20 km-long mountain tunnel located in Fukui prefecture. Construction was done using a working pit (inclined shaft). The cross-section of the excavation was approximately 70 m², using the full-sectional method with an auxiliary bench. Digging was done by blasting method, with continuous belt conveyor method used for shedding. Eleven faults were expected in the construction area (shown in Fig. 1), with widths ranging from a couple of meters to maximum 80 m. The natural ground was expected to be fragile with many fractures developed along the faults, with concerns of sudden water inflow especially in the area of chert.

2. Overview of Exploration Methods

As shown in Table 1, three types of forward exploration were carried out to understand the geological conditions in front of the cutting face.

3. Prediction of Natural Ground using Forward Exploration Results and Actual Digging Results

Conditions of the natural ground 150 m ahead were predicted by combining result from the non-core exploration drillings and in-pit elastic wave survey described above. The results showed multiple sections of fragile terrain including fault fracture zones, fracture concentration zones, and stratigraphic boundaries, as well as sections with high risk of sudden and heavy water inflow. Among the potentially bad sections, the following two (Fig. 1) were unique in the way they clearly showed the characteristics from the forward exploration results.

- Section 1: 453km185 ~ 215m

This section raised concern of sudden water inflow. The water inflow rapidly increased to 1,000 L/min, during logging. Additional measurements of the inflow rate and inflow pressure were done. Judging from the results, due to the predominantly fractured chert soil, there was a very high possibility that a large amount of water inflow would occur when the tunnel face was reached.

4. Conclusion

Bad ground conditions were predicted in advance with a high degree of accuracy by evaluating the ground using a combination of various types of frontal surveys. The excavation was conducted safely without any delays by considering appropriate support patterns and auxiliary construction methods beforehand as well.