Results and Evaluation of Measurements at the Seikan Tunnel after 35 Years of Operation

Yuichi KOBARA ▶ Chief, Maintenance Division, Construction Coordination Department, Hokkaido Shinkansen Construction Bureau, Japan Railway Construction, Transport and Technology Agency (JRTT)

1. Introduction

The Seikan Tunnel is a railroad tunnel connecting Aomori Prefecture and Hokkaido, Japan (Figure-1), and is the world's longest railroad tunnel with an undersea section. The tunnel was put into service in March 1988 as the Tsugaru Kaikyo Line (conventional line), followed by the Hokkaido Shinkansen Line in March 2016. Using a dual gauge that is rarely seen in the world, it has been in service as an important main artery for passenger and cargo logistics between Honshu and Hokkaido. The Seikan Tunnel consists of a main tunnel where trains run, a working tunnel for maintenance, drainage, and ventilation, and a pilot tunnel. The main tunnel is 53.85 km long, of which 23.30 km is below the seafloor, reaching 240 m below sea level at its deepest point (Figure 2). The Seikan Tunnel is in a special environment where high water pressure and an inexhaustible seawater must be taken into account. Therefore, ever since the opening of Tsugaru Kaikyo Line, surveys and measurements have been conducted continually for the section under the seafloor through "Seikan Tunnel Disaster Prevention System" and "regular measurements." The following is an overview of the application of obtained data.

2. Utilization of Monitoring Data in the Seikan Tunnel Disaster Prevention System

The Seikan Tunnel Disaster Prevention System is in place to ensure the safe operation of trains in the Seikan Tunnel (Photo-1). The system displays real-time data from seismographs, strain meter, and water inflow meter, and those data are used to support train operations and to evaluate tunnel health.

2-1 Seismographs and Strain meters

Seismographs and lining strain gauges are installed in the Seikan Tunnel at the following four locations which were associated with difficulties in tunnel construction: the Izumi Fault (16K), the volcaniclastic dike (21K), section with unconformity in strata (30K), and the F10 fault (33K). The dynamic behavior of the tunnel lining at the time of earthquakes is monitored to determine if there is any damage to the tunnel, and at the same time, the longitudinal and transverse displacement of the tunnel is monitored during normal conditions.

2-2 Water Inflow Meter

The amount of water inflow is the most important item to be monitored in order to maintain the function of the Seikan Tunnel, which is under the seafloor. The water inflow meters are installed at 27 locations along the drainage channels of the main, working, and pilot tunnels, and are used not only to determine the effects of earthquakes, but also to analyze the variation of water inflow amount under normal conditions to verify the sealing performance of the grouting in the tunnel area. The water inflow has been slightly decreasing since the start of the measurement, but the trend is similar to that of other undersea tunnels in Japan, such as the Kanmon Tunnel.

3. Utilization of Periodic Measurement Data of Maintenance Management Items

In the Seikan Tunnel, various measurements are periodically taken to evaluate the structural integrity and to obtain maintenance management indicators such as the need for countermeasures. The following sections introduce the inflow water pressure meter and inner space displacement meter.

3-1 Inflow Water Pressure Meter

Water inflow pressure meters are installed at five locations in the working shafts which are associated with difficulties in construction and areas with geological difficulties. They are used for seepage flow analysis (Figure 3) together with water inflow data to verify the effectiveness of water sealing around the tunnel.

3-2 Measurement of Inner Space Displacement

The internal displacement of tunnel cross-sections is measured using a 3D light wave measuring device, and measuring points are at 77 cross-sections of the main tunnel and a total of 202 cross-sections of the working and pilot tunnel. The displacement data was analyzed using the finite difference method (Figure 4) and a ground degradation model to determine/implement necessary countermeasures for the structural stability. Note that the accumulated displacement of the main tunnel is 6mm at the maximum, which is lower than the level of taking countermeasures, but the frequency of measurements is being reviewed based on the displacement estimations and the damage status.

Fig. 1 Seikan Tunnel Location Map

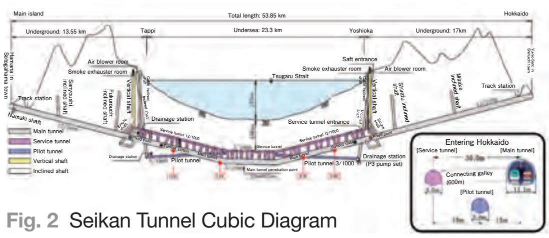

Fig. 2 Seikan Tunnel Cubic Diagram

Photo 1 Seikan Tunnel Disaster Prevention System

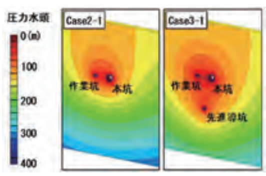

Fig. 3 Seepage Flow Analysis Diagram

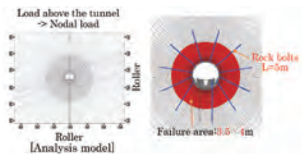

Fig. 4 Finite Difference Method Analysis Diagram