Construction of a Mountain Tunnel under Obstacle-Spotted Areas on Sandy Ground with Overburden

— Shin Meishin Yokkaichi Tunnel —

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1. Introduction

The Shin-Meishin Expressway Yokkaichi Tunnel is a 1,353m long expressway tunnel (inbound and outbound). The geology of this tunnel consists mainly of soft layers and unconsolidated ground, such as consolidated silt, sand and gravel, and fan deposits. The minimum soil cover is only 9m, and the ground surface is dotted with obstructions such as golf courses, roads, and rivers.

Therefore, surface subsidence measurements and displacement measurements were taken at various locations to monitor the impact on the obstacles.

Photo 1 Aerial view

2. Evaluating Face Stability by Measuring Preceding Settlement

Since the tunnel was mainly composed of unconsolidated ground and the soil cover was small, there was concern from the beginning that the face would become unstable. Therefore, it was necessary to understand the behavior of the surrounding ground due to tunnel excavation. To evaluate and monitor the stability of the ground in front of the face from inside the tunnel, a top-end leading subsidence meter was adopted, as shown in Figure 1. The relationship between the settled amount u calculated by this measurement and the position of the face is shown in Figure-2, using the displacement ratio R, which is calculated by dividing the settled amount u by the total displacement

As a result, the displacement ratio Ruf until the upper half passage is 10% to 20%. This result is small compared to the percentage of prior displacement, which is generally considered to be 30 to 50% of the total displacement. Thus, by measuring the leading displacement, which is not captured by the standard A-measurement, it is possible to measure the total displacement occurring in the ground. By actually measuring the total displacement, it was possible to evaluate the strain in the ground and more precisely determine the plasticization of the surrounding ground.

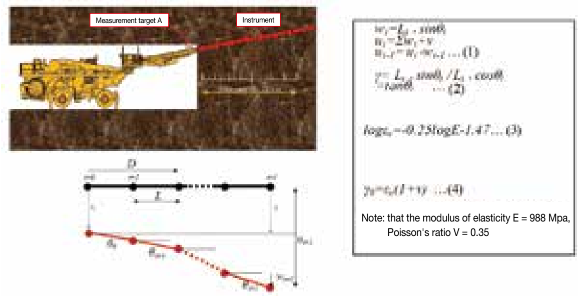

Fig. 1 Principle of the crown leading settlement measurement

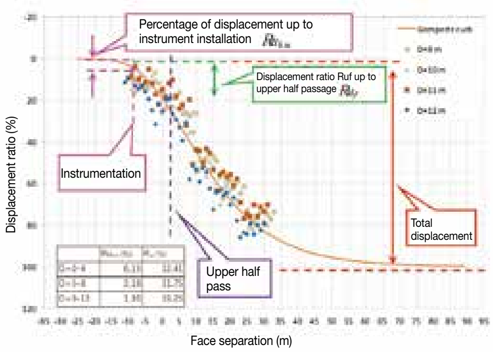

Fig. 2 Percentage of prior settlement (%)

3. Measurement of ground surface settlement of city streets

On the surface, the amount of settlement of the road surface was measured by live monitoring using a total station. The measurement results are shown in Figure 3. The maximum settlement was 22mm, and levels were kept at control level I without causing deformation such as sinking.

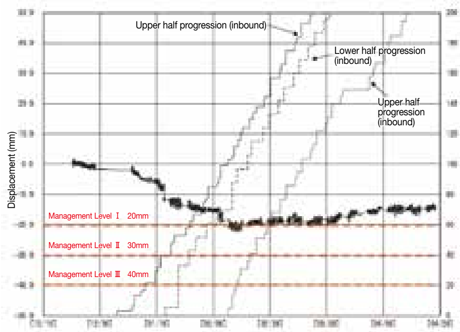

Fig. 3 Amount of subsidence of the ground surface directly under the municipal roadway Change over time

4. Measuring pipeline settlement

A ϕ 1500 mm hume pipe in service existed across the top of the tunnel, which was used for agricultural purposes, water supplies, and industrial water. Therefore, a settlement plate was installed at the top of the pipe before passing through the tunnel, and settlement measurements were taken to monitor the impact on the pipe. The measurement results are shown in Figure 4. The amount of settlement was kept to about 22mm by various measures to stabilize the face and to prevent water inflow. The maximum amount of settlement in the section parallel to the downstream tunnel was about 16 mm. This allowed construction to be carried out without damaging the function of the tunnel.

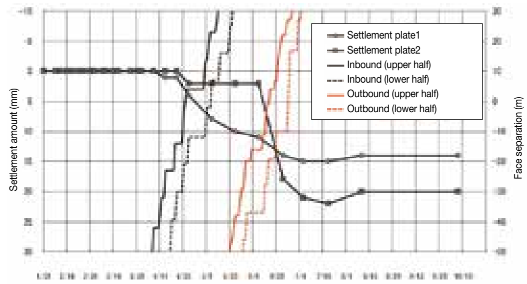

Fig. 4 Settlement plate measurement results