

Double Support Structure Overcomes Load of 610m Earth Pressure

Aokuzure Pass Tunnel - Nagano Construction Site

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1. Project Overview

Construction of the San-en Nanshin Expressway, a high-standard road approximately 100km long is underway from Iida City, Nagano Prefecture to Hamamatsu City, Shizuoka Prefecture. Once opened, it will become an important route that will connect the Chuo Expressway and the Shin-Tomei Expressway and contribute to strengthening regional cooperation and the development of the Mikawa, Enshu, and Minami-Shinshu regions.

This tunnel is located approximately in the middle of the San-en Nanshin Expressway, approximately 500m west of the Median Tectonic Line. It is located in a mountainous area with steep terrain formed by fault activity and river erosion, and the maximum earth cover was 610 m. The main geology was porphyry mylonite, a fault rock that underwent plastic flow due to thermal degeneration and dynamic metamorphism caused by high temperatures and pressures.

2. The Biggest Challenge in Tunnel Construction

Empirically, it is assumed that a large load from the ground acts on the tunnel when the earth cover exceeds 500m. In the Nagano section of this tunnel (L = 2,854m), the tunnel was constructed with a standard support structure from the beginning of excavation to around 2,730m. However, although the compressive strength of the bedrock is relatively high at 1,000 to 3,500 MPa, buckling of the steel arch supports, cracks in the sprayed concrete, and fractures of rock bolts were confirmed, forcing the support structure to be modified (Photo 1).

3. Countermeasures to Solve the Problem

When constructing a tunnel with a large cover, it is recommended to increase the rigidity of the support such as using double supports to resist the load from the ground, or to release stress from the ground by using compressible support members.

For this tunnel, a double support structure using high-strength sprayed concrete with a design standard strength of 36N/mm² was applied, based on the experience in the Shizuoka construction area, where the support structure had to be changed due to the load from the large overburden. In addition, for sections where the earth cover exceeds approximately 600m, it was decided to apply ultra-high strength sprayed concrete with a design standard strength of 54N/mm² (Fig.1 and Photo 2). By applying a double support structure using high-strength sprayed concrete and ultra-high-strength sprayed concrete, it was possible to continue the tunnel excavation without causing damage to the tunnel support members.

The amount of displacement and deformation of the tunnel after excavation was approximately 100 mm for the crown settlement and 25 mm for the convergence at the stage of the single support construction, but by constructing the double support, subsequent displacement and deformation were reduced. It was confirmed that crown settlement and

convergence after the construction of the secondary support structure were reduced to 10mm for each. The breakthrough of this tunnel was achieved in May 2023. Construction of the concrete lining is currently underway, with the goal of completion by Fall of 2024.



Photo 1 Damage of support members at large earth pressure area

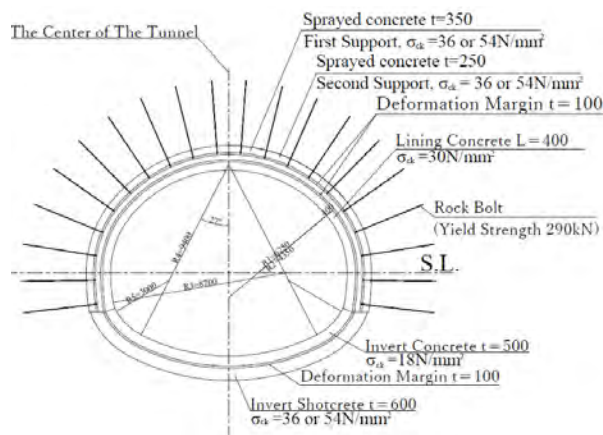


Fig. 1 Construction support pattern of Countermeasure work

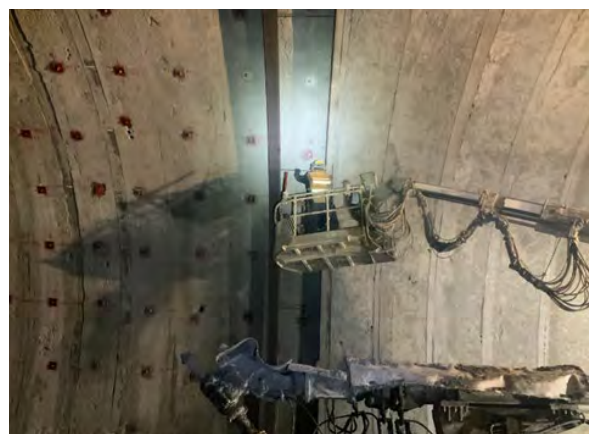


Photo 2 Construction status of the double support structure