Construction of an Underground Power Plant by Remodeling an Existing Plant

— Project for remodeling the Bunsui Power Plant No.1 at Shikoku Electric Power Co., Inc.

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In recent years, the weather pattern has dramatically changed, and there are frequent torrential downpours. Because of these conditions, this project was aimed at demolishing a hydropower plant on the ground whose equipment was at a risk of deterioration and damage in the event of a landslide. To avert this danger, a new underground hydropower plant was planned for the relocation of the old one. The project started in April 2013, and the new plant was completed in April 2017, ready to start operation. In September of the same year, all related work including removal of the old power plant was completed.

1. Layout

The underground hydropower plant was located at a considerable distance from the landslide block, more than twice the height of the cavity for the plant to be free from impact by excavation of the underground cavity or a landslide. For a new plant layout, making the best use of the existing water intake and penstock, a new penstock was provided, along approximately the 190 meters to connect the existing penstock and the new underground hydropower plant, as well as a new diversion channel about 200 m long between the underground power plant and the existing discharge port, respectively in the shortest distance.

2. Design of the underground cavity

The underground plant was constructed under a slope producing localized pressure, and the geology to be excavated was composed of pelitic schist (black schist) with a strong anisotropy, involving developments of schistosity. The behavior at the time of excavation was considered to be dominated by anisotrophy and fissility; for such geology, the use of conventional isotropic model was considered to be difficult to simulate the rock behavior accurately. By deeming the formation of schistosity as a discontinuous surface, we used a multiple yield model (MYM) belonging to the equivalent continuum analysis method for the analysis of cavity excavation. Based upon analysis results, the supports of the cavity were designed.

3. Blasting excavation in the vicinity of an existing power plant in operation

The cavity and penstocks for the underground power plant were planned to be excavated in the vicinity of an in-service power plant and landslide block, so we were required to excavate without any impact on such facilities, while the power plant was kept in operation.

To cope with the problem, actual measurements of the landslide were used to verify a relationship between blasting vibrations and landslide volumes to derive a new vibration management level based on our study. Blasting was done methodically adjusting the amount of explosives and their configuration, while measuring vibrations. As a result, the existing plant has been kept in operation during a blasting excavation period of as long as 17 months. Power generation was suspended only three months out of the 54 months required for connection between new and old penstocks.

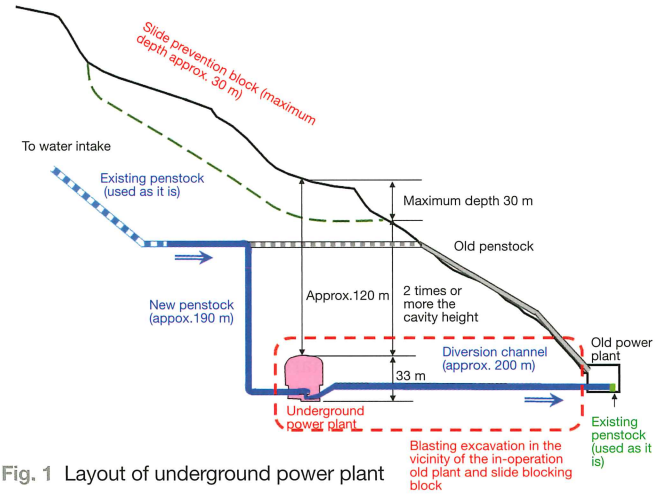


Fig. 1 Layout of underground power plant

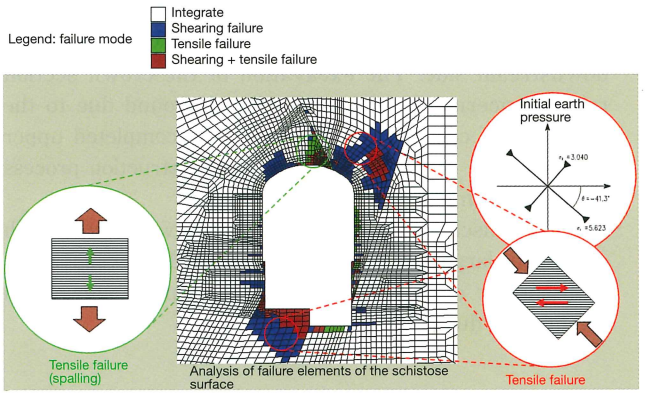
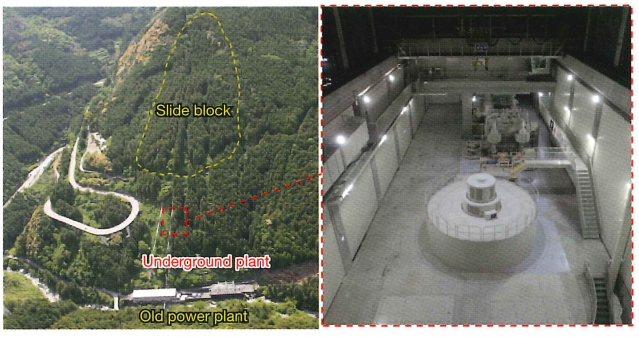


Fig. 2 Results of cavity excavation analysis by MYM



Location of the underground plant View of plant interior

Fig. 3 Location of the underground plant and view of interior