Deformation Behaviour of a Large Underground Cavern

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Summary

The Imaichi underground power station, with a cross sectional area of 1420 m², which is now under construction by Tokyo Electric Power Co., Inc., is one of the largest underground caverns in the world. Due to the considerable depth of the overburden of 400 m, the horseshoe-shaped section was adopted for the first time in Japan to minimize excessive stress concentration on the surrounding bedrock and keep loosened zones to a minimum.

The bedrock consists of sandstone, slate, siliceous sandstone and breccia. The rock is generally hard and compact, with few fractured zones which may have an adverse influence on the excavation of the cavern.

The supporting system of the cavern consists of prestressed rock anchors, rock bolts and shotcrete.

Approximately 800 instruments, mainly multiple stage extensometers, were used to monitor behaviour of the surrounding rock during excavation of the cavern. With the exception of some cracks which occurred in a portion of the shotcrete when about half the height of the cavern had been excavated, excavation work was completed without any major trouble. In spite of the symmetrical shape of the cavern, the deformation behaviour of the surrounding rock during excavation was remarkably asymmetric. The reason for this was concluded to be the peculiar deformation behaviour exhibited by Breccia during stress relief, as shown by in-situ rock tests, etc., and analysis of deformation data after completion of the excavation work.

1. Introduction

The Imaichi Hydroelectric Power Plant, which is presently under construction, is situated about 130 km north of central Tokyo, near Nikko, and will be a pure pumped storage power plant with a maximum output of 1050 MW. Since the transformer is located in the same cavern as the generators, the dimensions of the power house cavern — 33.5 m in width, 51 m in height (cross sectional area of 1420 m²) and 160 m in length — rank it among the largest in the world.

A horseshoe-shaped section has been adopted (Fig. 1) for the first time in Japan for cavern stability and rationalization of construction.
Construction was commenced in October 1979, with the excavating of the cavern and concrete work for the floor and walls being almost completed. The installation of the turbine generator is scheduled to start in April 1986.

In this paper, the authors describe the site investigation, design and construction of the Imaichi underground power plant cavern, and the behaviour of the surrounding rock during excavation, with particular emphasis on details of deformation behaviour.

2. Geology and Rock Properties

2.1 Geology

The cavern is located about 400 m below the ground surface, and the horizontal distance from the lower reservoir is about 600 m.

The geology of the area surrounding the cavern is composed of three rock types, (1) alternation of sandstone and slate strata (hereafter called alternation zone), (2) siliceous sandstone and (3) breccia (Fig. 2).