Study on an In-Situ stress measurement that can consider orthotropic and nonlinear elasticity of rock with stress release method

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Abstract

Since ancient times, the underground has been variously developed for resources such as minerals and groundwater, and for the construction of tunnels and pipelines for gas, oil, and water. And in recent year, new possibilities for underground applications have been proposed, such as geological disposal of high-level radioactive waste, underground storage of carbon dioxide (CCS), and construction of accelerators. The common problems are large scale and depth. In general, the construction of underground cavities should be designed so that the direction of the maximum principal stress is not perpendicular to the long axis of the cavity, and in cases where the initial stress is high, the cavity should be designed to reduce stress concentration. Therefore, accurate evaluation of In-Situ stress state is important technique to construct large-scale cavities or tunnels underground.

The subject of this study is conical wall hole technique, which is a type of the stress release methods and under development. The purpose of this study is making the conical wall hole technique practical, by establishing a theory for measurement in orthotropic rocks and establishing evaluation procedures for each combination of rock with and without orthotropy and nonlinearity.

The measurement theory of the conical wall hole technique corresponding to orthotropic rocks was established with reference to the Compact Conical-ended Borehole Overcoring technique, which is also a type of stress release method. In addition to the coordinate systems used in the usual theory of measurement, Global coordinate system and Borehole coordinate system, Orthotropic coordinate system was defined as the principal axis of orthotropy. The most probable value of stress was calculated using the least-squares method.

Another property of real rock is nonlinearity which makes it impossible to uniquely determine the Young's modulus of the rock. It was suggested to reduce the measurement error by previous studies that dividing the stress-strain curve into several sections and using the slope at the section of estimated stress as Young's modulus. That this stress is generally consistent with the overburden pressure is indicated by studies of stress measurements at various locations in Japan. Therefore, the overburden pressure was used as the standard for stress evaluation.

The methods adapted to the orthotropy and nonlinearity of the conical wall hole technique were integrated as a stress evaluation procedure by defining the procedures for rock classification and measurement.