Proposal of analysis methods for test results of the new in-situ rock mass test

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1. Introduction

For conventional testing methods on in-situ rock masses, it is necessary to conduct several tests to investigate strength and stiffness anisotropy. Therefore the in-situ torsion shear test for rock masses was proposed. This test could examine the anisotropy of mechanical properties of rock masses in only one test.

Strength and stiffness anisotropy are often dominant in clastic sedimentary rock masses. In this report, the analytical method of test results is shown based on transversely isotropic body.

2. In-situ torsion shear test for rock masses

Figure-1 shows the concept of in-situ rock mass torsion shear test for rock masses. The cylindrical specimen is prepared at an outcrop or at a bottom of drill hole. Then internal pressure p_{in} and external pressure p_{out} acting on the side of the specimen and torsional load T and direct load Q are loaded.

Mechanical properties of rock masses can be back analysed from comparing the distribution of normal and shear stresses on the top of specimen by separate load cells with the analysis solution of FEM.

3. FEM analysis

In the FEM analysis, the three-dimensional model of transversely isotropic elastic body was assumed for tests on sedimentary rock masses. Figure-2 shows the test in transversely isotropic elastic body where stiffnesses differ between $E_X=E_y$ within the plane of isotropy (Xy plane) and E_z normal direction (z axis). ξ is dip angle between the isotropic plane and the direction of slope (y axis). $\alpha = (E_x/E_z)^{0.5}$ is anisotropy parameter.[1] Figure-3 shows an analysis area of FEM. The elements for FEM model are solid elements of transversely isotropic elasticity. The load is applied in two steps; in isotropic consolidation process, $\sigma_Z = Q / A_s$= 1MPa (A_s= $(D^2_{out}-D^2_{in})\pi/4$: area of specimen) and

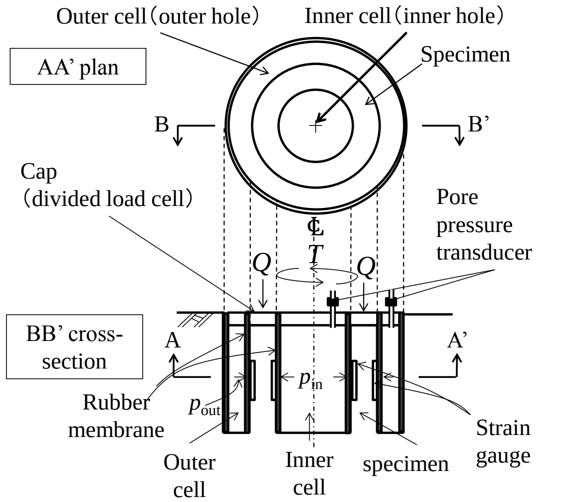

Figure-1 In-situ rock torsion shear test for rock masses

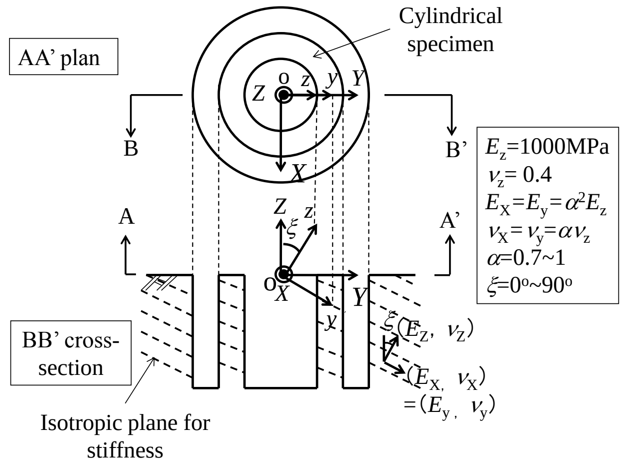

Figure-2 Transversely isotropic elastic boby

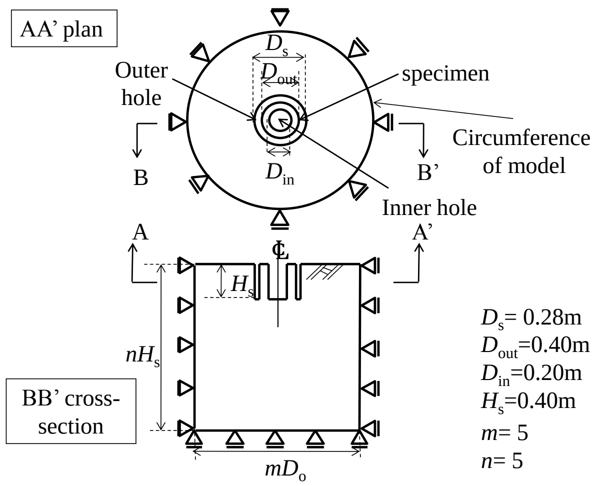

Figure-3 FEM model

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$p_o = p_{in} = p_{out}$ = 1MPa, and in the torsion shear process $\tau_{\theta Z} = 3T/(2\pi(D^2_{out}/4-D^2_{in}/4))$ act on the top of the specimen.[2)]

Figure-4 shows the distribution of stress increments on the upper of the specimen in the shear process. Δ is mean increment in torsion shear process from consolidation process. As α becomes larger, the value of ($\Delta\sigma_Z$, $\Delta\tau_{Z\theta}$) axis becomes larger, and the stress distribution changes periodically.

４．Analysis method for test results

Figure-5 shows a flow of the analysis of the test results. ξ can be determined by the circumferential location of the peak and the trough of the distribution of stress increments (θ_p, θ_t). Figure-6 shows the relationships between a peak position of $\Delta\sigma_Z$ of the shear process and ξ. From the distribution of stress, (θ_p, θ_t) is determined, then ξ is determined from like figure-6 and from observation of outcrops. If ξ is decided, next α is decided from the relationships between stress and α, like in figure-7.

５．Conclusions

The in-situ torsion shear test is proposed to investigate anisotropy of rock masses. A revise of finite element analysis assuming transversely isotropic elastic body is conducted.

As a result, the dip angle ξ and anisotropy parameter of rock mass α can be back analysed from test results.

６．Reference

1) Graham, J. and Houlsby, G. T. : Anisotropic elasticity of a natural clay, Geotechnique 33, No.2, pp165~180, 1983.

2) Japan Geotechnical Society. : Method for torsional shear test on hollow cylindrical specimens of soils. (JGS0551-2009)

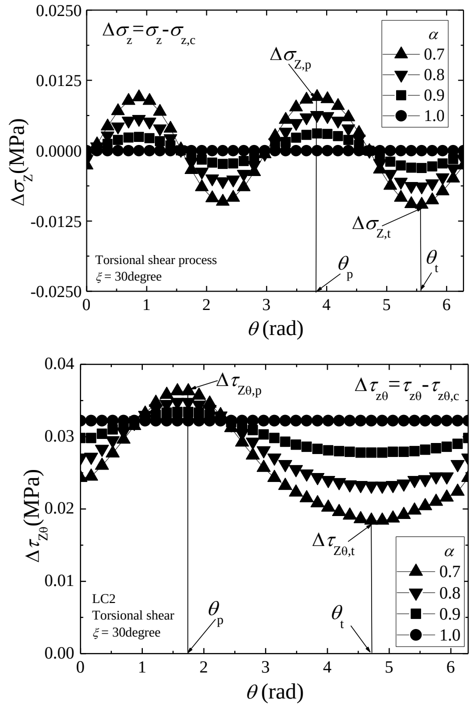

Figure-4 Distribution of stress increment in torsion shear process (top: normal stress increment, bottom: shear stress increment)

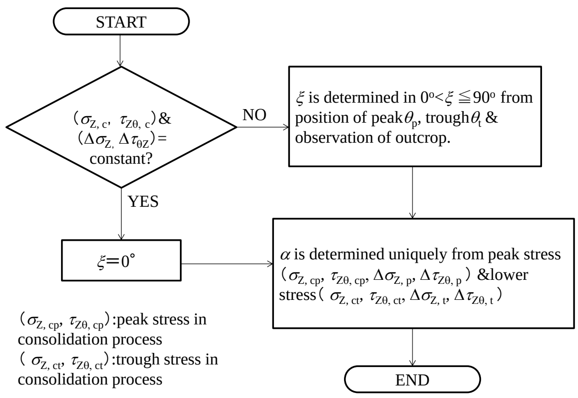

Figure-5 The flow for analysis of test results

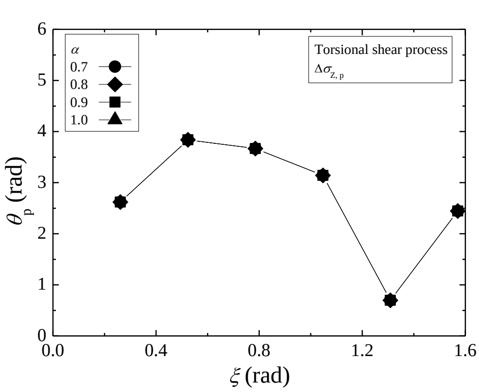

Figure-6 the relationships between a peak position of $\Delta\sigma_Z$ of the shear process and ξ

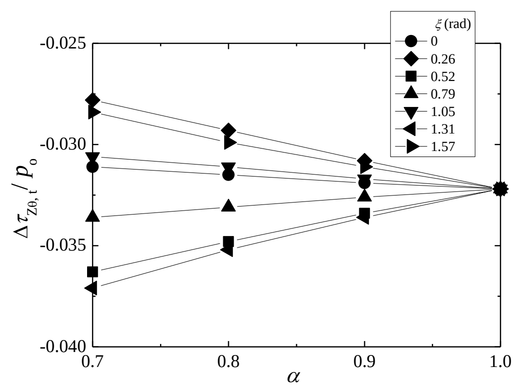

Figure-7 The relationships between peak stress and α