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Simulation of Triaxial Compression Tests on Soil Samples Obtained from Seabed Ground in Deep Sea by Elasto-viscoplastic Constitutive Equation

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ABSTRACT

The simulations and numerical analyses of triaxial compression tests on soil samples obtained from seabed ground in deep sea were performed by elasto-viscoplastic constitutive equation. From the results it is proved that simulation can express very well the experimental results. And from the results of three dimensional finite element analyses it is found that the shear strain and volumetric strain are distributed nonuniformly in the test specimen.

KEY WORDS: Methane hydrate; constitutive equation; triaxial compression test; finite element method; seabed ground

INTRODUCTION

Methane hydrate is currently being eagerly examined as a next-generation energy resource in Japan to replace oil and natural gas. The Research Consortium for Methane Hydrate Resources in Japan was established to undertake research in accordance with "Japan's Methane Hydrate Exploitation Program" prepared by the Ministry of Economy, Trade and Industry. In this Consortium the Engineering Advancement Association of Japan is doing research on Environment Impact. In the Research Group for Environment Impact we are investigating if the deformation of seabed ground occurs in production of methane gas from methane hydrate.
We performed triaxial compression tests on soil samples obtained from seabed ground in deep sea at Nankai Trough which is expected as one of the fields of natural resources of methane hydrate. In this study simulations and numerical analyses of these triaxial compression tests were performed by elasto-viscoplastic constitutive equation proposed by Kimoto and Oka et al. (2004; 2005) and compared with experimental results.

OUTLINE OF TRIAXIAL COMPRESSION TESTS

The digging of wells was carried out in deep sea at Nankai Trough which is expected as one of the fields of natural resources of methane hydrate. We performed triaxial compression tests on core samples obtained from this Nankai Trough Well (Nishio, Ogisako, Abe, Denda, Akagawa and Hirakawa, 2006). The triaxial compression tests were carried out in K_0 consolidation undrained condition. The depth of core samples used in tests is 739.70-955.00 m where the depth of seabed surface is 730 m.

SIMULATION OF TRIAXIAL COMPRESSION TESTS

Conditions for simulation The simulations of these triaxial compression tests were performed by the elasto-viscoplastic constitutive equation proposed by Kimoto and Oka et al. The parameters used in simulation were determined from the test results. Some of them are shown in Table 1.

Results of simulation A parameter σ'_{mai} in Table 1 is an initial value of parameter σ'_{ma} which denotes a microstructural changes. Because this value is supposed to equal to a value of a consolidation yield stress σ'_{mbi} , it is assumed that $\sigma'_{mai}=\sigma'_{mbi}$. Fig. 1 shows the relationship between deviator stress and axial strain in an overconsolidated soil sample No. 6-1-4. In an experimental result shown as a dotted line

Table 1. Material parameters used in simulation

Sample No.	6-1-3	6-1-4
Axial strain rate $\dot{\varepsilon}_{11}$ (%/min)	0.050	0.050
Coefficient of earth pressure at rest K_0	0.473	0.626
Initial mean effective stress σ'_{m0} (kPa)	680	289
Structural parameter σ'_{mai} (kPa)	680	443
Structural parameter σ'_{maf} (kPa)	680	443
Structural parameter β	0	0
Initial void ratio e_0	0.945	0.897
Compression index λ	0.0937	0.0937
Swelling index κ	0.0135	0.0135
Stress ratio at maximum compression M_m^*	1.29	1.29
Viscoplastic parameter m'	10.0	9.3
Viscoplastic parameter C_0 (1/sec)	1.22×10^{-7}	1.37×10^{-9}
Elastic shear modulus G_0 (kPa)	128000	96000