Mechanical properties of methane hydrate bearing sediments from alternating layers of sand and clay in the Eastern Nankai Trough

Daisuke Katsuki[1]; Kiyofumi Suzuki[1]; Takao Ebinuma[1]; Hideo Narita[2]

[1] MHRL, AIST; [2] MHRL,AIST

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1. Introduction

The methane hydrate bearing sediments in the Eastern Nankai Trough are sand layers in the alternating layers of sand and clay. The methane hydrate crystals borne in the sandy sediments tend to fill the pore spaces. For natural gas production from the methane hydrate crystals in sandy sediments, depressurization of the pore pressure of methane hydrate bearing sediments is acknowledge as an valid procedure. An increase in effective stress acting on sediments and changes of the mechanical properties of methane hydrate bearing sediments due to dissociation of methane hydrate crystals will occur when the pore pressure is depressurized. Alternating layers surrounding production wells might be destabilized by deformations, which would occur depending on the degree of gap between production well and surrounding layers and on formation of the alternating layers, if natural gas production began without sufficient information about the mechanical properties of alternating layers. Thus, the mechanical properties of natural and artificial alternating layers have been studied by focusing attention on shear behavior in the interface between layers of sand and clay with triaxial compression test and box shear test.

2. Mechanical Properties of Alternating Layers of Sand and Clay

For the triaxial compression test, the natural samples of sand and clay of the alternating layers in the Eastern Nankai Trough have been obtained by trimming the basic offshore test boring cores picked into the cylindrical shape 50 mm in diameter and 100 mm in height. The sand and clay samples have been consolidated in a zero lateral strain condition and subsequently sheared respectively in drained and undrained conditions. It is revealed that the sand and clay layers possess 0.24 MPa and 0.42 MPa in cohesion and 35 degrees and 26 degrees in internal friction angle, respectively.

The box shear test have been carried out on the natural samples of the test boring cores, the artificial samples of sandy sediments and of the artificially layered sand-clay sediments to observe shearing behavior in the interfaces between the layers of sand and clay. The artificially layered sand-clay samples have been prepared by sedimentation in liquid water with sorting process or by lapping a consolidated clay layer over a tapped sand layer. These sediments are trimmed into a cylindrical shape 30 mm in diameter and 20 mm in height. The artificial sandy sediments have been formed by tapping a quartz sand into a mold. The artificially layered sediments formed with sorting process have the gradation of grain size in the vertical direction between sandy and clayey layers, while those formed by lapping have the defined interface between them. These interfaces different in the gradation would imitate the topside and the downside interfaces of the sand layers of the alternating layers in the Eastern Nankai Trough, in which the alternating layers had been formed by turbidity current, respectively. The ranges of the values of porosity for the sand layers, the sand-clay interfaces formed with sorting process and the clay layers, which have been obtained from both the test boring cores and the artificial sediments, are 42%˜45%, 37%˜40% and 37˜40%, respectively. The testing conditions are as follows: displacement rate is 0.05 mm/min; temperature is 5 degrees Celsius; the vertical stresses are 0.5, 3.5 and 7.0 MPa. The pore water pressures for the sand samples and the sand layers of the layered samples are 0.5 MPa. The pore water pressure of 0.5 MPa has been applied to the clay layers of the layered samples, however the clayey layers would be sheared at an undrained condition. The results of the test indicate the difference of the shear behaviors between the upside and the downside interfaces of sand layer.