

Investigation of Deformation Mechanism for Methane Hydrate Sediment based upon Mechanical Properties in Unloading and Reloading Process under Triaxial Compression

Kuniyuki Miyazaki*, Akira Masui*, Tsutomu Yamaguchi**, Yasuhide Sakamoto*, Yuji Ogata* and Kazuo Aoki*

*Methane Hydrate Research Center, National Institute of Advanced Industrial Science and Technology (AIST)
Onogawa, Tsukuba-shi, Ibaraki, Japan

** Department of Environmental Science, Toho University
Miyama, Funabashi-shi, Chiba, Japan

ABSTRACT

In this study, unloading-reloading tests were conducted for artificial methane hydrate sediment samples under triaxial compression and the mechanical behaviors were discussed. In the early stage of axial loading, where consolidation of the sample would occur, the slope of unloading-reloading curve increased; in the following stage, where dilatancy behavior would be a dominant deformation mechanism, the slope decreased slightly. The findings may be of some help not only to understand the deformation mechanism but also to construct a mechanical model or a constitutive equation for methane hydrate sediment.

KEY WORDS: Methane hydrate; triaxial compression test; stress-strain curve; consolidation; dilatancy; unloading; reloading.

INTRODUCTION

Methane hydrate is anticipated to be a promising energy resource of natural gas, since a large amount of reservoir exists in marine sediments or in permafrost regions worldwide (Kvenvolden, 1988; Kvenvolden et al., 1993; Okuda, 1993). It is important to predict mechanical behaviors of methane hydrate reservoir for sustainable production of methane hydrate.

Deformation mechanism of methane hydrate sediment has a great significance not only on mechanical stability of methane hydrate reservoir in production but also on evaluation of gas productivity from methane hydrate reservoir. Although some previous studies have reported about mechanical properties of artificial methane hydrate sediment sample in triaxial compression test (Masui et al., 2005; Winters et al., 2005; Masui et al., 2008; Miyazaki et al., 2008), almost no information is available concerning the property in unloading and reloading process. Mechanical properties in unloading and reloading process during a triaxial compression test may be of some help to understand the deformation mechanism or construct a mechanical model for methane hydrate sediment.

In this study, unloading-reloading tests were conducted for artificial methane hydrate sediment samples under triaxial compression and the mechanical behaviors were discussed.

TESTING METHOD

Host Specimen

In this study, the method of triaxial compression test followed previous studies (for example, Masui et al., 2005).

A host specimen was produced by compacting water-saturated Toyoura sand densely in a mold on a vibration table. Fig. 1 shows the particle size distribution of Toyoura sand which is characterized by parameters of effective size $D_{10} = 0.12$ mm, mean size $D_{50} = 0.18$ mm and uniformity $U_c = 1.6$ (Masui et al., 2008). The initial water content, dominating methane hydrate saturation of the specimen, was adjusted by draining excess water with a syringe pump. The size of a host specimen was 50 mm in diameter and 100 mm in length. The porosity of a host specimen ranged from 36 % to 39 %.

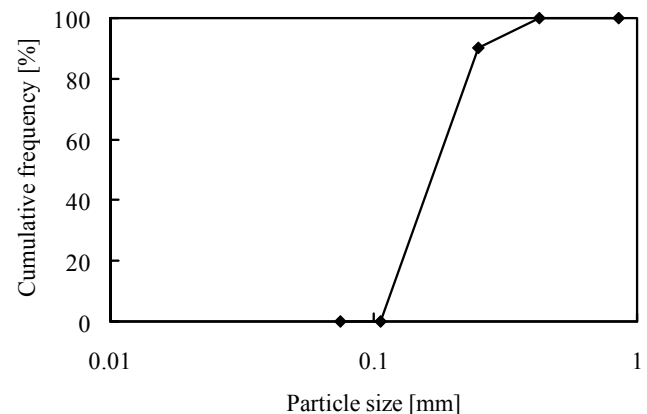


Fig. 1 Particle size distribution of Toyoura sand (Masui et al., 2008)

Experimental Apparatus

The experimental apparatus used for methane hydrate formation in a host specimen and a following triaxial compression test is illustrated in Fig. 2. The apparatus is a digital servo-controlled testing machine with a capacity of 200 kN for axial load, 20 MPa for confining pressure and 20 MPa for pore pressure. The temperature inside the triaxial vessel can