

Shear behaviour of methane hydrate-bearing sand

Masayuki Hyodo, Yukio Nakata, Norimasa Yoshimoto and Rolando Orense
Department of Civil and Environmental Engineering, Yamaguchi University
Ube, Yamaguchi, Japan

ABSTRACT

The possible existence of a vast amount of methane hydrate around islands has attracted attention as the largest potential hydrocarbon resource in Japan. At the same time, several production methods have been considered to extract the gas from the hydrate zone. Although it is known that the hydrates pose significant obstacles to drilling and production operations, there is at present only limited knowledge on the mechanical behavior of hydrate-rich zones, which is necessary to understand the stability around the site. In order to know the properties of methane hydrate and/or its sand mixtures, a series of tests was carried out on artificial methane hydrate produced in sand, using low temperature and a newly developed high confining pressure triaxial compression technique. The specimens used were prepared by producing an artificial methane hydrate in the pore of sand sediments. On the basis of the experimental results, the factors affecting mechanical properties of the hydrate produced in sand were discussed. It is highly required to collect still more data regarding the properties of methane hydrate in sedimentation (soil) to understand the stability of any attempt at methane hydrate production.

KEY WORDS: Methane hydrate; triaxial compression test; temperature; MH saturation; dissociation response; volumetric strain; effective confining pressure.

INTRODUCTION

A lot of attention has been paid to methane hydrate (hereinafter referred to as MH) as the main energy for the next generation. The existence of about 6 trillion m³ of MH has been estimated in seas adjacent to Japan, and the Research Consortium for Methane Hydrate Resources (MH21 Consortium) has been established in 2001 as a recent national project in Japan (Ichikawa, et al. 2003). MH is stable at high pressure and the low temperature, and exists in cemented condition with sand particles of sandy sediments beneath the deep ocean floor. Compared to heating method and decompression method of sampling MH, a more feasible method currently in used is by dissociating MH into its components and collecting methane gas. During digging and sampling of MH, concerns are raised regarding the possible exclusion of methane gas due to subsidence and deformation of seabed resulting from the loss in

cementing force as MH is dissociated (Collet and Dallmore, 2002). Therefore, it is necessary to examine the deformation characteristics of ground according to variation in temperature and pressure condition in order to produce MH properly (Hyodo, et al. 2005).

For this purpose, a low-temperature high-pressure triaxial test equipment was developed to reproduce the temperature and pressure condition of the seabed where MH exists. Then, MH was generated in the sand specimen set inside the triaxial cell for the purpose of examining its shear strength. Moreover, MH formation was replicated and MH was dissociated under different conditions of temperature and pressure in order to understand the resulting deformation behavior of the ground.

OUTLINE OF EXPERIMENTAL APPARATUS

The main feature of the experimental apparatus employed is as follows. Using the circulating-type high-temperature water tank set up outside the test apparatus, a side liquid with temperature adjusted within the range of -35~+50°C was circulated, and the temperature condition inside the triaxial cell was adjusted. Since tests were performed at low temperature, a side liquid with freezing point as low as -40°C, such as aurora brine, was employed. Either strain-controlled or stress-controlled load application was possible. For confinement, oil was used as pressure source, and by increasing the pressure, cell pressure as high as 30 MPa was possible. Back pressure was applied through the rotation of the pulse motor, and by changing the capacity of the upper control cylinder, back pressure as high as 20 MPa can be applied. With this device, it was possible to reproduce the high pore water pressure and high confining pressure at the seabed, as well as the state of MH and temperature change during formation.

MH FORMATION AND EXPERIMENTAL PROCEDURE

Specimen Preparation

To form MH in the experimental apparatus in this research, a distribution pipe was installed which was capable of carrying the methane gas pressure to the test specimen. The simplified piping distribution chart is shown in Fig. 1. Because MH is generated by the reaction of methane with water under constant pressure and