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Mechanical properties of Stratified hydrate-bearing sediments

Tingting Luo[a], Weiguo Liu[a]*, Yanghui Li[a], Yongchen Song[a], Qi Wu[a], Zhaoran Wu[a]

[a]*Key Laboratory of Ocean Energy Utilization and Energy Conservation of Ministry of Education, School of Energy and Power Engineering, Dalian University of Technology, Dalian 116024, P. R. China*

Abstract

Methane hydrate–bearing layers will be disturbed during the production of methane hydrates, which may induce the deformation or settlement of the layers, and the destruction of engineering structures, so it's important to study the mechanical properties of the hydrate-bearing sediments. In this paper, specimens were prepared in which the methane hydrates were in different location of the specimens by a special deposition method in which the methane hydrate was put in the mold separating with the kaolin, the volume of methane hydrate was 40% of the whole volume of the specimen. A series of triaxial shear tests were carried out under different confining pressures of 1.25 MPa, 2.5 MPa, 3.75 MPa and 5 MPa, conditions with temperature of -6 ºC and strain rate of 1 %/min. The results indicated that the maximum deviator stress of the sediments increased with the declining of the clay of hydrate and the failure strength achieved maximum when the hydrate clay was in the center of the sediments; the failure strength increased with the increasing of the confining pressure in the low confining pressure stage.

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Keywords: hydrate-bearing sediments; mechanical properties; stratified; failure strength; location.

1. Introduction

With the big amount of resource and high energy density, gas hydrate is a great development prospect of clean energy [1]. Natural gas hydrate distribute in a very wide range, mainly in the permafrost, and deep water sediments of the sea or the continental margin [4-6]. In the world many regions of gas hydrate deposits were found [2]. However, unlike conventional petroleum, natural gas and other resources, gas

* Corresponding author. Tel.: +86-13009489152; fax: +86-411-8470-8015.
E-mail address: liuwg@dlut.edu.cn.

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hydrate form in the reservoir supported by the cemented or skeletal form [3.4]. As a metastable substance, the rise of the temperature or the reduction of pore pressure possibly cause dissociation of hydrate [5.6]. Therefore, before the commercialization exploitation of gas hydrate resource, a comprehensive analysis about the stability of the gas hydrate deposits should be studied to fully grasp inherent mechanism of the reservoir, to avoid the damage of the climate caused by the dissociation of the gas hydrate. In recent years, the study on the mechanical properties of methane hydrate has been popular. Hyodo did a series of triaxial compression test on methane hydrate-bearing sediments and proved that the strength of gas hydrate deposits increased with the increasing of confining pressure [7]. Miyazaki did a series of triaxial compression tests for methane hydrate-bearing sediments and discovered that the effective confining pressure would limit the lateral deformation of sediments [8]. But the study on the stratified hydrate-bearing sediments was little. In this work, a series of triaxial shear tests were carried out under the different confining pressures to study the mechanics characteristics of stratified hydrate-bearing sediments. The triaxial test system was used to measure the mechanical properties of stratified hydrate specimens, and the test specimens were made of a certain mole fraction of methane hydrate containing ice and kaolin clay.

2. Experimental Methods

2.1. Specimen preparation

The brief process diagram of specimen preparation has been introduced in our previous work [9]. In this paper, ice powder particles with a particle size of about 250 μm was put into stainless steel reactors, and then methane gas of 10 MPa were rejected into the chamber with temperature kept at -10 ºC for more than 48 hours to generate the hydrate. Next, the prepared mold and pressure crystallization device were placed into a freezer (-10 ºC) to be cooled to prevent hydrate dissociation on mold-pressure process due to the higher temperature, then the hydrate containing ice and kaolin clay were put into the cold condition(-10 ºC). Most importantly the author used a special deposition way, the hydrates and kaolin were put separately in the mold under the load conditions (10 MPa) and be axially pressed into the desired size (50mm × 100mm). In the forming the sample in the refrigerator, the layer of hydrates and kaolin were separated.

2.2. Testing apparatus

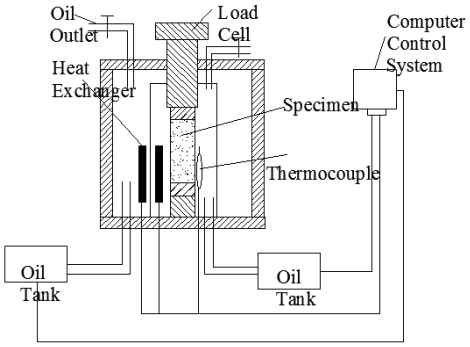

Fig.1. The schematic diagram of triaxial testing system