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Numerical Simulation of the Responses of the Seabed on the Dissociation of Gas Hydrate

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ABSTRACT

The development of the stresses and displacements in the seabed caused by the dissociation of gas hydrate were numerically simulated by using the software ABAQUS. The effects of the dissociation size and the sustaining strength of the gas hydrate sediment after dissociation on the responses of the sediment were mainly investigated. It is shown that the deformation and the stresses in the seabed increased with the expansion of the gas hydrate dissociation size. The sediment will subsequently lose the stability or even slide when the strength of the gas hydrate sediment decreases and the gas hydrate dissociation size increases to some extent.

KEY WORDS:
Gas hydrate, Slide, Dissociation, Stability of seabed

INTRODUCTION

Natural gas hydrate is a crystalline solid usually occurring in deep ocean and permafrost. It has been estimated being of two times as much as the carbon resources on the Earth and thought as a kind of new potential energy in the 21st century. The gas hydrate dissociation in the seabed, which is usually due to the increase of the temperature or the decrease of the pressure, can cause the seabed settle or even slide. Therefore, it is very important to investigate the responses of the dissociation of gas hydrate on the stability of seabed.

Some researchers thought that the Storegga slide in Norway (Locat et al, 2002; Hovland et al, 2001), Cape Fear slide in east coast of America and the landslide in the continental shelf of West Africa (Kayer et al, 1991; Sultan et al, 2004) and some other slides (Gilles et al, 1999) were all caused by gas hydrate dissociation. However, previous researches on this kind of landslides were almost based on geophysics and geochemistry investigation data (Paull et al, 2003; Bunz et al, 2003; Rao et al, 2002), but less researches were on the mechanism.

Generally, once the pressure or the temperature changes in the seabed, the gas hydrate in it begins to dissociate. The increase of the pore pressure caused by the released gas and the damage of the cementation among soil grains lead to the decrease of the strength meanwhile the stiffness of the seabed. So the seabed will deform and the stresses will redistribute. In some conditions, the seabed can even become instable and slide.

This paper investigates the responses of the seabed under different gas hydrate dissociation situations. The effected size and the distribution of deformation and stresses are mainly analyzed.

PROBLEM AND THE NUMERICAL MODEL

The sketch of sediment profile is shown in Fig. 1. The thicknesses of over layer and the gas hydrate sediment are 100m and 25m respectively. The water depth is 1000m and the slope angle of the seabed β is 3^0. The gas hydrate dissociation size R is defined as the horizontal distance from the center to the boundary of the dissociation zone.

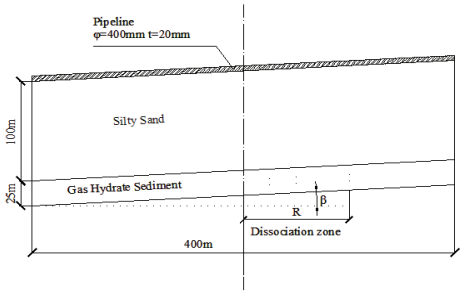

Fig. 1 The sketch of pipeline and sediment profile

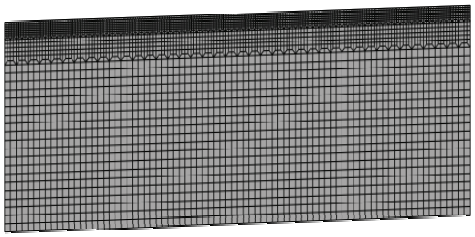

Fig. 2 The sketch of divided element mesh

ABAQUS (Version 6.7) was used to model the behavior of the seabed. The elements, shown in Fig. 2, were meshed as 5m×5m. The boundary conditions were as follows: the bottom was fixed in three directions, the horizontal displacements were fixed at the side boundaries, and the upper boundary was free.