ABSTRACT

Cracks may be created in clays after gas hydrate dissociates. More cracks can be created in clays with a high degree of gas saturation after dissociation and the degree of gas saturation is linked to peak undrained shear strength of the clays through experimental tests. A damage model is proposed in this study to characterize strength reduction of clays after cracks are developed. NGI ADP model and damage model are implemented to Plaxis software. A variable distribution of gas hydrate was revealed in Shenhu area, in northern continental slope of the South China Sea. Geotechnical models for two critical slopes are proposed based on seismic profiles. Submarine slope stability is evaluated for these slopes in this area if gas hydrate is dissociated. The finite element analysis showed that safety factor is reduced by 6% to 13% after gas hydrate dissociation.

KEY WORDS: Gas hydrate dissociation; clay, slope stability; damage model.

INTRODUCTION

Gas hydrate dissociation is often considered as a triggering factor for submarine slope failures occurring in relatively deep waters where the bulk of the gas hydrate is found in fine-grained sediments. Physical and mechanical properties of sediments with gas hydrate have been intensively studied in recent years (Soga, et al., 2006, Yun, 2007, Sultan and Garziglia, 2011, Zhang et al., 2017). It was concluded that strength of soil is increasing with increasing of hydrate saturation and confining pressure. However, there are relatively few studies that focus on the effect of gas hydrate dissociation on the geotechnical behavior of clays, and very few on how gas hydrate dissociation affects the undrained shear strength of clays with cracks caused by dissociation. Sample cracking due to gas hydrate dissociation was observed on the continental slope Keathley area, Gulf of Mexico (Fugro, 2006). Jin et al., (2015) studied crack extension induced by dissociation of fracture-hosted methane gas hydrate. Lee et al., (2010) reported volume change associated with formation and dissociation of hydrate in sediment using miscible TetraHydroFuran (THF) as a hydrate, and the result indicated that large axial strains were caused due to dissociation by heating. Yang et al. (2010 and 2015) illustrated the effects of hydrate dissociation in clays from laboratory tests. The tests were combined with visualization including very-high-resolution CT scanning using R11 as the hydrate forming fluid in both laponite and Onsøy clay. The results showed that gas hydrate melting in clay leads to formation of gas bubbles; with increasing volume bubble shape changes to disk shape and fractures develop; continued release of gas leads to connection of fractures from different locations and formation of gas migration pathways. The study developed a mechanistic understanding on how cracks developed in clays due to hydrate dissociation.

Results from both Triaxial compression tests (CAUC) and Direct simple shear tests (DSS) on Onsøy clay showed that undrained shear strength is decreasing due to cracks created after gas exsolution up to degree of gas saturation of $\eta = 20 \%$ and there is less decrease in effects on undrained shear strength for $\eta = 20$ to $67 \%$ (Yang et al., 2017 and 2018). In this study, the experimental results on clays due to gas coming out of solution are used to characterize strength of clays after cracks are developed. A damage model is proposed and a case study in south china sea (SCS) on slope stability after gas hydrate melting is carried out.

DAMAGE MODEL

Degradation of undrained shear strength of clays after gas hydrate dissociation may be due to the following reasons: a loss of sediment cementation, and this is similar to the melting of ice-laden sediment; a loss of strength because of increase in excess pore water pressure and a loss of strength because cracks are created (Fig.1).

![Damage model illustration](image_url)