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Post-cyclic Strength Degradation of Undisturbed and Remolded Marine Silty Clay

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ABSTRACT

A series of static and cyclic-static tri-axial compression tests under consolidated-undrained conditions are carried out to study the characteristics of post-cyclic strength of the undisturbed and the remolded samples of marine silty clay. It is found that the post-cyclic monotonic strength decreases if the cyclic strain or pore pressure is over a certain value. The maximum degradation is 10% for undisturbed samples while 70% for remolded ones. The relationship between normalized undrained shear strength and apparent overconsolidation ratio, which is determined by the excess pore pressure induced by cyclic loading, is also established. Static consolidated-undrained tests on overconsolidated remolded samples are also performed. It is proposed that the static consolidated-undrained tests may be substituted for the cyclic-static consolidated-undrained tests if the post-cyclic strength degradation of remolded silty clay is needed to be evaluated simply.

KEY WORDS: Pre-cyclic strength; post-cyclic strength; degradation; cyclic strain ratio; pore pressure ratio.

NOMENCLATURE

$s_{u,s}$ Pre-cyclic strength
$s_{u,c}$ Post-cyclic strength
$s_{u,c}/s_{u,s}$ Post-cyclic strength ratio
$\varepsilon_{f,s}$ Static failure strain
$u_{f,s}$ Static failure pore pressure
ε_{cy} Cyclic strain caused by cyclic loading
u_a Excess pore pressure caused by cyclic loading
$u_a/u_{f,s}$ Pore pressure ratio
$\varepsilon_{cy}/\varepsilon_{f,s}$ Cyclic strain ratio
σ_3 Confining pressure
σ_{30} The initial confining pressure
σ_d Cyclic stress
σ_d/σ_{30} Cyclic stress ratio
N Number of cycles
m Constant obtained from tests
OCR Overconsolidation ratio
AOCR Apparent overconsolidation ratio
NUSS Normalized undrained shear strength
$s_{u,c}/(\sigma_{30}-u_a)$ Normalized post-cyclic shear strength
$s_{u,s}/\sigma_{30}$ Normalized pre-cyclic shear strength

INTRODUCTION

The post-cyclic undrained shear strength is one of the most important parameters in design and stability analyses of structures on clay seabeds. The cyclic loading induced by ocean waves is significant and serious. It usually leads the increase of excess pore pressure in clay sediments and consequently the obvious decrease of the undrained shear strength (Hyde and Ward,1986). Some accidents of offshore structures due to the degradation of post-cyclic shear strength have been reported in the literature (Bea et al,1983). The post-cyclic undrained shear behaviour of clay or silty clay under cyclic loading has been the focus in recent years. Some considerable advances have been made (Matsui,1992; Yasuhara,1995; Moses,2003).

In the present research, cyclic tri-axial tests or simple shear tests on undisturbed or remolded samples are usually performed first. The characteristics of the stress–strain, pore water pressure and strength are then analyzed. It is shown that the post-cyclic undrained shear strength is often related to the pore pressure and cyclic strain caused by the cyclic loading. Some researchers, such as Thiers & Seed (1969) , Lee & Focht (1975), Hyde & Ward (1985), Anderson (1976) and Yasuhara et al (1994, 1997), suggested that the post-cyclic undrained shear strength of clay decreases 0~50% relative to the pre-cyclic undrained shear strength, especially when the excess pore pressure or the cyclic strain is greater than a critical value. Anderson (1976) indicated that the post-cyclic strength degradation of Dramman clay is smaller than 25% when the cyclic strain is smaller than 3%. Thiers & Seed (1969) indicated that the post-cyclic strength degradation of Anchorage silty clay is not greater than 50% when the cyclic strain is bigger than half of the static failure strain.

Yasuhara et al (1992) present a method to evaluate the post-cyclic strength by use of the excess pore pressure induced by cyclic loading. This method is very popular. Hyde et al (1986) give a good explanation for the post-cyclic strength degradation with the concept of apparent