UNDRAINED SHEAR BEHAVIOR OF ARIAKE CLAY

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1. INTRODUCTION

Understanding of the undrained behavior is a vital importance for engineering design. This behavior is brought out by the test result of Ariake clay. The Ariake clay was collected at Saga plain. The natural water content is about 138-152%. The liquid and plastic limits are 112% and 42%, respectively. The quasi pre-consolidation pressure is 20 kPa. The isotropically consolidated undrained triaxial compression tests were carried out on the undisturbed and remoulded clays.

2. STRESS~STRAIN BEHAVIOR: The stress~strain behavior of undisturbed and remoulded samples are examined and presented in Figure 1. The undisturbed samples exhibit the typical manner of naturally cemented clays. The strain softening behavior is recognized under effective confining pressures even far greater than the quasi pre-consolidation pressure with continued positive excess pore pressure (Nagendra Prasad et al., 1999). On the other hand, the remoulded (uncemented) samples would not show such this behavior. As a result, it is impossible to obtain a unique plot of q/p'_0 vs ε_s for naturally cemented (undisturbed) clays. The excess pore pressure and shear strain relation of both naturally cemented and uncemented clays is essentially the same. It leads to the conclusion that the cementation plays a great role on the deviator stress~shear strain behavior and insignificant role on the excess pore pressure~shear strain behavior, which is similar to the behavior of cement stabilized Ariake clay (Horpibulsuk et al., 2001). The residual strengths of uncemented clays are higher than those of cemented clays because water contents of uncemented clays are lower.

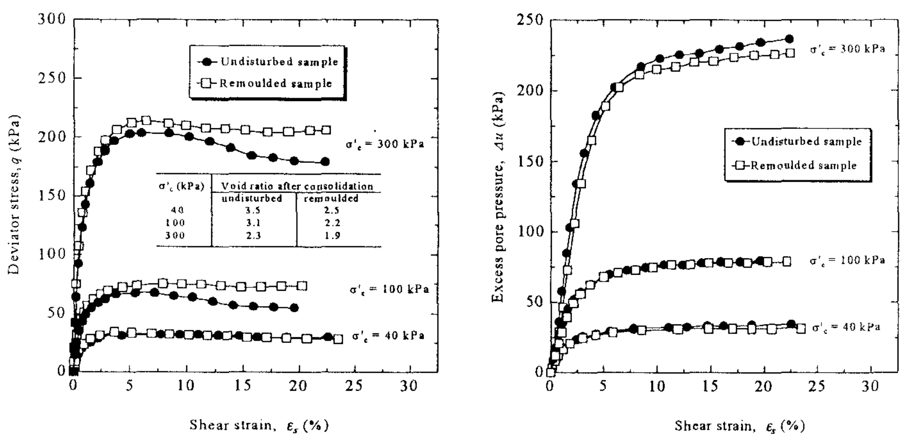

Figure 1. Deviator stress~shear strain and excess pore pressure~shear strain relationships of undisturbed and remoulded samples

3. NORMALIZED EXCESS PORE PRESSURE~STRESS RATIO ($\Delta u/p'_0$, η) RELATIONSHIP:

Handali (1986) demonstrated that the ($\Delta u/p'_0$, η) relationship for normally consolidated clay is linear for all stress levels even up to failure. He introduced a pore pressure parameter C which denoted the slope of the ($\Delta u/p'_0$, η) line as an alternative to Skempton's A-parameter. He emphasized that C can be considered as material properties depending on ϕ', while the A-value depends on the level of deviator stress. This parameter is successfully used for formulation of undrained stress path of normally consolidated Bangkok and Korea clays (Balasubrmaniam et al., 1989 and Lee et al., 1999). It is revealed that the parameters C are 0.52 and 0.67 for Bangkok and Korea clays, respectively.

Figure 2 shows the ($\Delta u/p'_0$, η) relationship of undisturbed Araike clay samples. It is found that the relationship is bi-linear which is different from the results of Bangkok and Korea clays. The first and second slopes (C_1 and C_2) are 0.51 and 0.28, respectively. The curve of the sample subjected to effective cell pressure, σ'_c of 300 kPa is slightly different from others due to the effect of secondary consolidation.

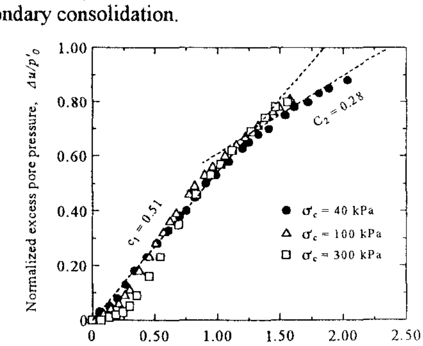

Figure 2. Normalized excess pore pressure and stress ratio relationship of Ariake clay

4. STRENGTH CHARACTERISTIC: The undrained stress paths are presented in Figure 3(a) along with the failure envelope corresponding to maximum deviator stress criterion. The effective stress parameters calculated from this failure envelope are $c' = 5.19$ kPa and $\phi' = 30°$. Appearance of the cohesion intercept is due to cementation bond. The friction angle of the Ariake clay is high comparing to that of Bangkok and Korea clays (about 25° for both). This might be because Japanese clays consist of a lot of diatom microfossils. This influence on the increase in effective stress parameters was presented by Shiwakoti et al., 2000.

5. PREDICTION OF EFFECTIVE STRESS PATH: The slope of $(\Delta u/p'_0, \eta)$ relationship in Figure 2 is used to formulate the equation of effective stress path as expressed in Eq. (1) and Eq. (2) (Balasubramaniam et al., 1989).

$$\left(\frac{p'}{p'_0}\right) = \frac{3(1-C\eta)}{3-\eta} \qquad (1)$$

$$dp' = \frac{3p'_0(1-3C)d\eta}{(3-\eta)^2} \qquad (2)$$

where p'_0 is the initial effective cell pressure, p' is the mean effective stress = $(\sigma'_1+\sigma'_3)/3$, C is the slope of the $(\Delta u/p'_0, \eta)$ relationship, η is the stress ratio = (q/p') and q is the deviator stress $(\sigma'_1-\sigma'_3)$. The σ'_1 and σ'_3 are the major and minor principal effective stresses, respectively.

From the two equations above, the undrained stress paths can be simply predicted by taking the C value as 0.51 for all effective cell pressures. The predicted and laboratory stress paths are compared and presented in Figure 3(b).

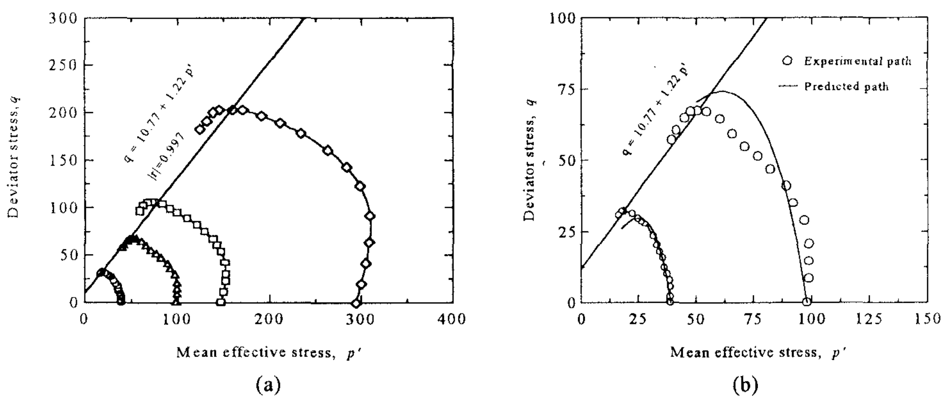

Figure 3. (a) Undrained stress paths (b) Predicted and experimental undrained stress paths

6. CONCLUSIONS

The undrained behavior of Ariake clay and a simple method to predict undrained stress paths are presented in this paper. Its behavior is in accordance with the behavior of cemented soils. The strain softening is observed under effective cell pressures even far higher than the quasi pre-consolidation pressures, associated with the continued positive excess pore pressure due to the cementation effect. However, this influence insignificantly affects the excess pore pressure~shear strain relationship. The normalization of excess pore pressure can be done using the method proposed by Handali (1986). Ariake clay shows the bi-linear relationship while the linear relationship is obtained for Bangkok and Korea clays. By using the normalization, the undrained stress paths can be simply predicted. The predicted undrained stress paths give good agreement to the experiment ones.

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