# PORE PRESSURE GENERATION OF SOFT SILTY CLAY SUBJECTED TO K-CONSOLIDATION IN CYCLIC TRIAXIAL TESTS

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## INTRODUCTION

A series of cyclic triaxial tests was conducted on undisturbed Ariake silty clay subjected to undrained cyclic loading. Testing was performed under various consolidation stress ratio $K=\sigma_{3o}'/\sigma_{1o}'$. Based on the experimental results, a method for evaluating the response of peak pore pressure generation is proposed. The evaluation is made by considering the variations of cyclic deviator stress ratio ($q_{cy}/p_c'$) and parameter K.

## TESTING PROCEDURE

The sample used in this investigation is undisturbed, Ariake silty clay, taken from the construction site of Saga Airport. Its index properties are $\omega_o$=87.5%, $\omega_L$=86.1%, $I_p$=47.9%, $G_s$=2.69.

To ensure a degree of saturation around 96%, all specimens were subjected to a back pressure of 2.0 kgf/cm$^2$ for 24 hours, with initial isotropic confining pressure of 0.13 kgf/cm$^2$. To reach the initial K-consolidation stress ratio, $K=\sigma_{3o}'/\sigma_{1o}'$, point A in Fig. 1, a vertical stress with an increment rate of 0.025 kgf/cm$^2$ per hour is applied. A consolidation was then performed under constant K-consolidation stress ratio K=1.00, 0.70, 0.56, and 0.50, by stress control with a vertical stress increment rate of 0.0135 kgf/cm$^2$ per hour.

A sinusoidal cyclic axial load was applied to a specimen under two-way stress-controlled conditions with a loading frequency of 0.1 Hz. After a certain number of loading cycle, reaching almost accumulated cyclic axial strain 10%, the load was interrupted. The conditions of cyclic triaxial tests are summarized in Table 1, only present a part of four series tests.

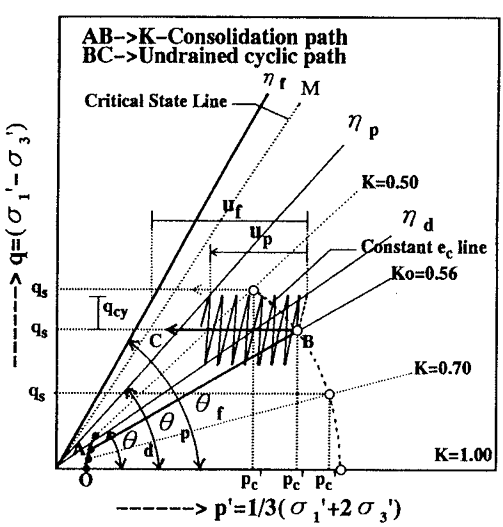


Fig. 1 Sketch for testing program and definition

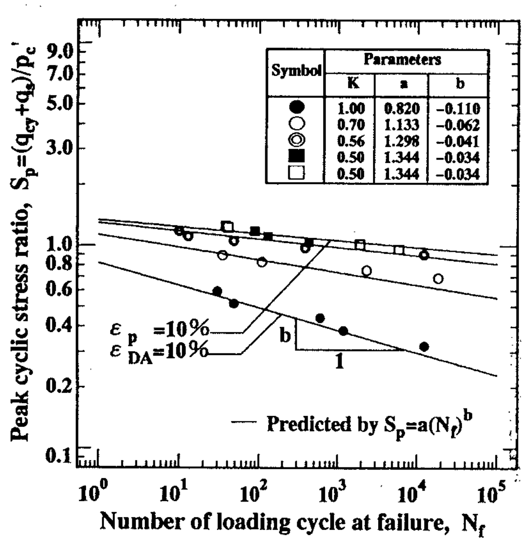


Fig. 2 Relation of $S_p=(q_{cy}+q_s)/p_c'$ versus $N_f$ for various $K=\sigma_{3o}'/\sigma_{1o}'$ at $\varepsilon_p$=10%

## EVALUATION AND DISCUSSIONS

The cyclic strength ratio of test results to cause the accumulated peak axial strain $\varepsilon_p$=10% is shown in Fig. 2, expressing as

$$S_p=a*(N_f)^b \quad (1)$$

Table 1. Conditions of cyclic triaxial tests

| Test Number | K Values | $e_c$ | $\omega_c$ (%) | $\sigma_{3o}'$ (Kgf/cm$^2$) | $q_{cy}/p_c'$ | N at $\varepsilon_p$=10% |
|---|---|---|---|---|---|---|
| K-1 | 1.00 | 2.506 | 96.1 | 0.755 | 0.517 | 43 |
| K-2 | 0.70 | 2.446 | 88.7 | 0.625 | 0.520 | 37 |
| K-3 | 0.70 | 2.301 | 82.9 | 0.625 | 0.382 | 2306 |
| K-4 | 0.56 | 2.429 | 88.7 | 0.500 | 0.557 | 10 |
| K-5 | 0.50 | 2.402 | 88.3 | 0.450 | 0.507 | 36 |

$\omega_c$ and $e_c$ are water content and void ratio prior to cyclic loading where $S_p=(q_{cy}+q_s)/p_c'$ is peak cyclic stress ratio. a is the value of $S_p$ at N=1, it is correlated to consolidation stress ratio $\eta_K=q_s/p_c'=3(1-K)/(1+2K)$ by $a=0.8(1+\eta_K)$. b is an experimental parameter, also various with parameter $\eta_K$.

Referring to Fig. 1, a relative angle stress ratio $R_\theta$ is introduced as

$$R_\theta=\frac{\tan(\theta_p-\theta_d)}{\tan(\theta_f-\theta_d)}=\left(\frac{\eta_f-\eta_d}{\eta_f-\eta_d}\right)\left(\frac{1+\eta_f*\eta_d}{1+\eta_p*\eta_d}\right) \qquad (2)$$

where $\theta_p$ and $\theta_d$ indicate the angles of stress ratio $\eta_p$ and $\eta_d$ to the axis p'. $\theta_f$ is an angle of cyclic stress ratio at failure $\eta_f$, defined at $\varepsilon_p=10\%$. The variation of $\eta_f$ with stress ratio parameter K is shown in Fig. 3 by a linear relation $\eta_f=2.2+0.8*K$.

The relation between the normalized peak pore pressure $(u_p/u_f)$ and parameter $R_\theta$ is shown in Fig. 4, expressing

$$R_\theta=\alpha_o*\ln(1+\alpha*N/N_f) \qquad (3)$$

where $\alpha_o$ and $\alpha$ are experimental parameters. Using the conditions in Fig. 4, $\alpha_o$ is obtained as $\alpha_o=1/\ln(1+\alpha)$. Prediction curves are made for $\alpha$=5, 10, 15, and 25 to show a good agreement with the test curves.

The dependence of peak pore pressure generation on the number of loading cycle is subsequently obtained from the eqs. (2) and (3) as

$$u/u_f=\frac{\eta_f}{\eta_p}\left(\frac{1+\eta_p*\eta_d}{1+\eta_f*\eta_d}\right)\left(\frac{\ln(1+\alpha N/N_f)}{\ln(1+\alpha)}\right) \qquad (4)$$

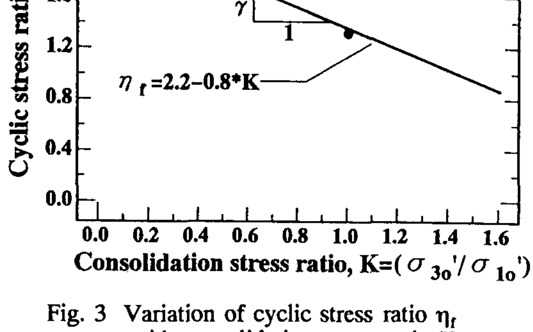


Fig. 3 Variation of cyclic stress ratio $\eta_f$ with consolidation stress ratio K

Using equation (4), the test results shown in Fig. 4 is quite accurately to represent by using parameters $\alpha$=10. The curves are shown in Fig. 5.

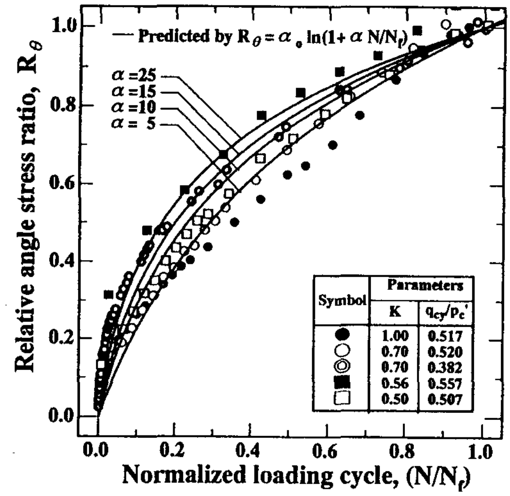


Fig. 4 Relation of the normalized pore pressure $(u_p/u_f)$ and the loading cycle $(N/N_f)$

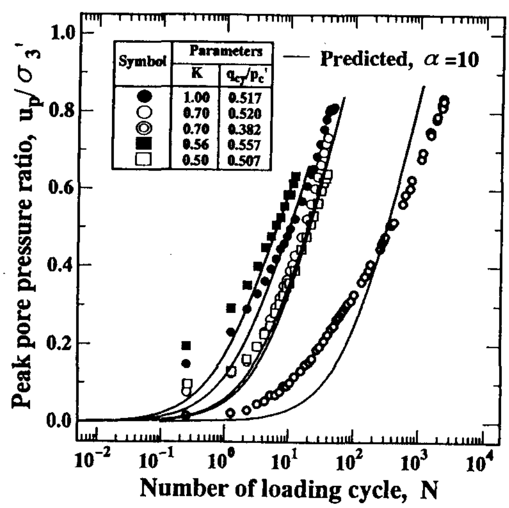


Fig. 5 Predicted and observed responses of peak pore pressure $u_p$ with loading cycle N.

## CONCLUSIONS

The peak pore pressure generation subjected to various consolidation stress ratio K is normalized to have a unique non-linear relation with their loading cycle at failure $N_f$. An evaluation is made to show the applicability of the proposed relation, the results show good agreement with experimental curves.

## REFERENCE

Samang, L. et al. (1994). Pore pressure generation and its post-dissipation in soft clay subjected to cyclic loading. Submitted for IS-HIROSHIMA '95