III - A 77 UNDRAINED AND PARTIALLY DRAINED BEHAVIOUR OF SILTY CLAY UNDER CYCLIC ONE WAY LOADING

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1. INTRODUCTION

Behaviour of low embankment of road or runway founded on soft ground such as Ariake deposit is greatly influenced by traffic-induced cyclic loading. This type of loading is associated with one-way loading without stress reversal. The deformation of subground under long term cyclic loading is generally in partially drained condition.

Aiming at the investigation of such phenomenon, this study describes the behaviour of undisturbed silty clay in undrained and partially drained cyclic triaxial tests. Testing was performed under consolidation stress ratio $K(=\sigma_{30}'/\sigma_{10}')=0.5$ for various cyclic deviator stress ratio (q_{cy}/p_{co}') and effective lateral pressure σ_{30}'.

2. TESTING PROGRAM

Undisturbed Ariake silty clay was used in this investigation, which was sampled from the construction site of Saga airport. The index properties of this soil are ω_0=70.8%, ω_L=62.9%, I_p=31.8%, ρ_s=2.62 g/cm^3.

Specimens with 5 cm diameter and 10 cm height were subjected to a back pressure of 2.0 kgf/cm^2 for 24 hours, B value was observed around 0.97, with isotropic confining pressure of 0.13 kgf/cm^2. To reach K=0.5, point A in Fig. 1, a vertical stress was applied with increment rate of 0.025 kgf/cm^2 per hour. K-consolidation, path AB in Fig. 1, was then made by stress control method, with the same rate of a vertical stress as above-stated.

In order to simulate phenomenon of traffic loading, sinusoidal cyclic load was applied to a specimen under one way stress-controlled condition with a frequency of 0.1 Hz. The measurements of excess pore pressure, both undrained and partially drained tests, were taken at the center of the top of the specimen through upper pedestal. The conditions of undrained and partially drained cyclic triaxial tests are summarized in Tables 1 and 2, respectively.

Table 1. Undrained cyclic one-way loading

Test number	σ_{10}' (kgf/cm^2)	σ_{30}' (kgf/cm^2)	e_c	ω_c (%)	q_{cy}/p_{co}'
AU1	1.00	0.50	1.66	63.4	0.796
AU2	1.00	0.50	1.66	69.8	0.734
AU3	1.00	0.50	1.61	68.9	0.610
AU4	1.00	0.50	1.72	73.5	0.341
BU1	1.50	0.75	1.62	59.2	0.534
BU2	1.50	0.75	1.55	54.0	0.445
BU3	1.50	0.75	1.63	57.4	0.343
CU1	2.00	1.00	1.42	52.8	0.505
CU2	2.00	1.00	1.45	53.8	0.317
CU3	2.00	1.00	1.65	56.9	0.227

Table 2. Partially-drained cyclic one-way loading

Test number	σ_{10}(kgf/cm^2)	σ_{30}' (kgf/cm^2)	e_c	ω_c (%)	q_{cy}/p_{co}'
AP1	1.00	0.50	1.76	67.1	0.729
AP2	1.00	0.50	1.69	63.8	0.623
AP3	1.00	0.50	1.59	58.9	0.523
BP1	1.50	0.75	1.51	54.7	0.534
BP2	1.50	0.75	1.53	56.7	0.460
BP3	1.50	0.75	1.55	60.3	0.354
CP1	2.00	1.00	1.23	43.1	0.517
CP2	2.00	1.00	1.37	49.1	0.320
CP3	2.00	1.00	1.35	49.4	0.230

e_c and ω_c are void ratio and water content after consolidation.

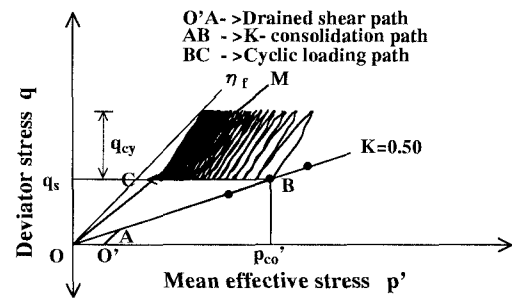

Fig. 1 Schematic diagram for testing

3. UNDRAINED CYCLIC SHEAR STRENGTH

In this study, the peak axial strain ε_{pa}=10% is considered as failure definition for evaluating undrained cyclic shear strength. Using this criterion, the relation between the number of loading cycle at failure N_f and the cyclic deviator stress ratio (q_{cy}/p_{co}') is shown in Fig. 2.

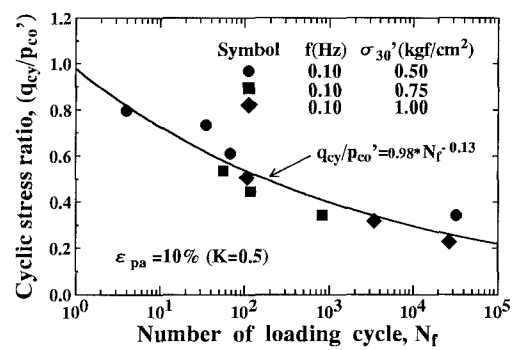

Fig.2 Relation of q_{cy}/p_{co}' and N_f at ε_{pa}=10%

This figure shows that the values of q_{cy}/p_{co}' for σ_{30}'=0.5 kgf/cm^2 are obtained slightly higher than those for σ_{30}'=0.75 and 1.0 kgf/cm^2. However, the relatioship is charactrerized to be independent of effective lateral pressure σ_{30}'.

4. UNDRAINED AND PARTIALLY DRAINED CYCLIC BEHAVIOUR

Hyodo et al. (1988) proposed a method for evaluating a long term cyclic behaviour of clay on the basis of undrained and partially drained cylic triaxial test results under isotropic condition (K=1.0), as a boundary value problem. This study investigates long term cyclic behaviour under anisotropic condition (K=0.5) .Drained cyclic triaxial tests were performed by allowing drainage through radial path during the loading, and this is regarded as partially drained cyclic conditions.

The experimental facts indicate that the excess pore pressure within a clay specimen is not uniformly distributed during drained cyclic test and the generation and dissipation of excess pore pressure occur simultaneously. Its magnitude depends on the distance from the drainage boundary. This situation implies that clay specimen can not be regarded as an element as the one for undrained cyclic tests.

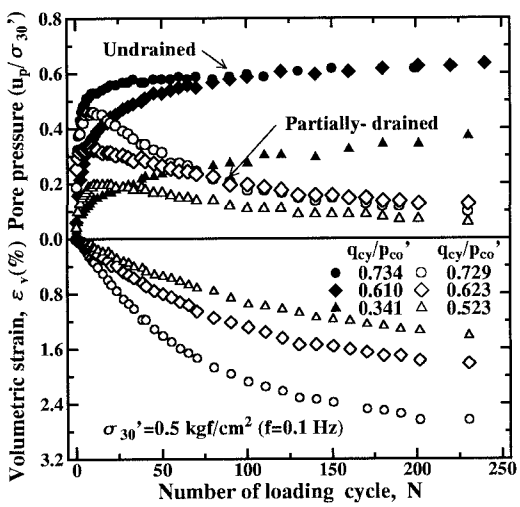

Fig. 3 Time dependent variations of u_p/σ_{30}' and ε_v for σ_{30}'=0.5 kgf/cm²

Fig. 3 shows the time dependent variations of excess pore pressure ratio (u_p/σ_{30}') and volumetric strain (ε_v) for various cyclic deviator stress ratio (q_{cy}/p_{co}'). u_p is excess pore pressure at the peak deviator stress (center of specimen), it is assumed to be maximum one in the specimen during the loading. It can be seen that the excess pore pressure generates very rapidly in the first few cycles, partially drained cyclic tests have peak at almost 10 cycles and after that the dissipation takes place gradually to reach small value of u_p/σ_{30}' at N>200 cycles. As q_{cy}/p_{co}' increases, partially drained condition, u_p/σ_{30}' and ε_v also tend to increase with the loading cycle N.

Using the peak values of u_p/σ_{30}' for partially drained tests with σ_{30}'=0.5, 0.75, and 1.0 kgf/cm² and the values of ε_v at N=200 cycles, the variations of $(u_p/\sigma_{30}')_{peak}$ and $(\varepsilon_v)_{N=200}$ with stress ratio q_{cy}/p_{co}' are shown in Fig. 4. The magnitudes of $(u_p/\sigma_{30}')_{peak}$ and $(\varepsilon_v)_{N=200}$ increase with the increasing of stress ratio q_{cy}/p_{co}'. From this figure, it is also clarified that the effects of effective lateral pressure on the generation and dissipation of excess pore pressure as well as cyclic volumetric change are significant.

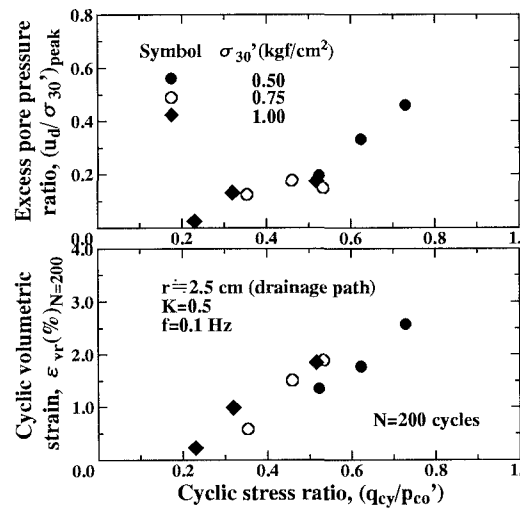

Fig. 4 Relation between $(u_p/\sigma_{30}')_{peak}$ and $(\varepsilon_v)_{N=200}$ with stress ratio q_{cy}/p_{co}'

5. CONCLUSIONS

Undrained cyclic ,one way loading with K=0.5, shear strength is characterized to be independent of effective lateral pressure σ_{30}'. The generation and dissipation of excess pore pressure and volumetric change during partially drained cyclic tests increase with cyclic stress ratio depending on the magnitude of effective lateral pressure σ_{30}'. Finally, the obtained test results in this study can provide a useful interpretation for evaluating the time dependent response of soft subgrade layers as partially drained behaviour due to traffic loading.

REFERENCE

Hyodo. M., Yasuhara. K., Murata. H., and Hirao. K. (1988). Prediction of pore pressure and deformation in soft clay under long term cyclic shear conditions. Proceeding of JSCE. No. 400, III-10, pp. 151-160.