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POST CYCLIC RECOMPRESSION VOLUMETRIC STRAIN OF NATURAL NC UNDISTURBED CLAYS

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SUMMARY The post cyclic recompression volumetric strain ,ε_{vr}, and residual pore water pressure ,u_r, during the subsequent consolidation after cyclic loading for a natural NC undisturbed clay are presented and discussed based on one dimensional consolidation settlement approach.

PROPERTIES OF TESTED CLAY AND EXPERIMENTAL WORK

A natural NC saturated marine clay samples taken from the shallow alluvial clay deposits in Osaka Basin at Fukushima are selected for the present analysis. The physical properties of the natural clay layer indicate that the clay samples are NC clays contains 41% of clay particles. Its basic index properties are: Liquid Limit of 67 %, Plastic Limit of 44.5% and 22.5 of Plasticity Index.

Fig.1 shows a schematic diagram of (e)-(logσ') plane. In the experimental work, specimens at point (A) are isotropically consolidated for about 24 hours, and then subjected to cyclic loading up to point (B) in undrained condition for different numbers of cycles and different cyclic axial strains ,ε_c, using an instrumented and servo controlled electro-hydraulic triaxial apparatus[1]. After one hour curing under zero shear stress, the specimens are consolidated by allowing drainage from the bottom end until they reach the effective stress before cyclic loading at point (D).

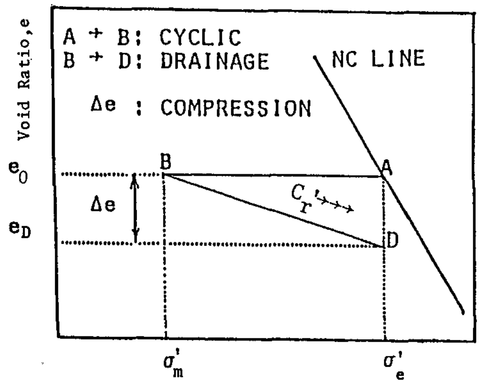

FIG. 1

TEST RESULTS AND DISCUSSIONS

Post Cyclic Recompression Volumetric Strain

Fig.2 illustrates the variation of specimen compressibility described by ε_{vr} with time. From this figure it can be noticed that the specimen compressibility after cyclic loading increases with increasing the cyclic loading effect, in which the increasing rate with logarithmic of time increases as ε_c increases. A moderate rate is observed up to 1.0% of ε_c, while a larger rate is sighted for the specimen subjected to larger ε_c. On the average, the rate tends to reach equilibrium level after about 90 minutes for ε_c up to about 1.5%, and the time increases slightly for larger ε_c.

Post Cyclic Residual Pore Water Pressure

Fig.3 shows the distribution of the residual pore water pressure with time for the same specimens in Fig.2. In this figure u_r is normalized by the equivalent consolidation stress, σ'_e, at the beginning of the test. As a consequence of the increasing ε_{vr} with time, u_r decreases with time, and also increases with increasing of ε_c.

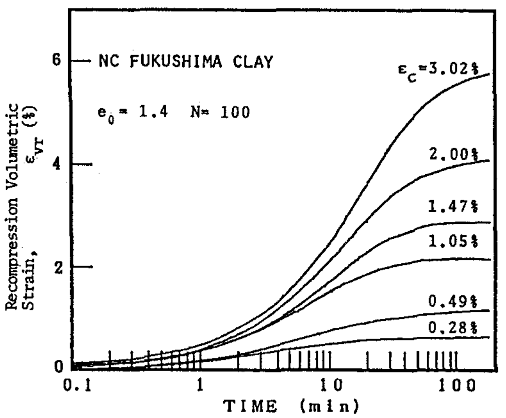

FIG. 2

Estimation of Post Cyclic Recompression Volumetric Strain

Fig.4 shows the relationship between ε_{vr} and u_r/σ'_e at 1, 10 and 100 numbers of cycles. It can be noticed that ε_{vr}

increases with increasing of u_r/σ'_e. Also all test data points at different numbers of cycles are located within a certain narrow band, indicating for little significant effect by increasing the numbers of cycles. Based on the settlement-void ratio relation, ε_{vr} can be expressed by Eq.(1)[2&3].

$$\varepsilon_{vr} = \frac{C_r}{1 + e_0} \log \frac{1}{1 - (\Delta u/\sigma'_e)} \quad \text{.............(1)}$$

in which C_r is the recompression index on the path (BD) in Fig.1, and e_0 is the initial void ratio.

To correlate the behavior of the tested NC clay with the basic ordinary consolidation test in Oedometer, ε_{vr} is estimated using Eq.(1) and an available C_r value measured in Oedometer device equal to 0.064, and the result is shown by the dotted curve in Fig.4. As can be seen in Fig.4 the predicted relation shows a remarkable disagreement with the experimental results. This difference may be regarded to the cyclic loading effect.

Yasuhara and Andersen[2] suggested an experimental constant α to reflect the effect of cyclic loading on Drammen clay specimens tested in DSS apparatus. Their constant α is an average value of C'_r measured in in both DSS apparatus and conventional Oedometer for different cyclic loading levels. A verification of this concept is extended for the present results. Fig.5 shows the C'_r/C_r versus u_r/σ'_e relationship for NC Fukushima clay. The average data points is determined as 1.538 and the value of C'_r is calculated as 0.099. Afterwards, using this value in Eq.(1) ε_{vr} is predicted as shown by the broken-dotted curve in Fig.4. Inspection of the obtained relation with the experimental results indicates that the predicted relation is still under estimation with increasing of u_r/σ'_e. Inspection of the data points variation in Fig.5 shows a tendency of linear variation , indicating that it may be possible to fit by the straight solid line in Fig. 5. Therefore it can be expressed by,

$$C'_r/C_r = \alpha_r \, (u_r/\sigma'_e) + 1 \quad \text{................(2)}$$

in which α_r is constant and is found as 1.144 for NC Fukushima clay. By estimating C'_r based on Eq.(2), the recompression volumetric strain in Fig.4 is predicted as shown by the solid curve in Fig.4 and a reliable fitting result is confirmed through the test data points.

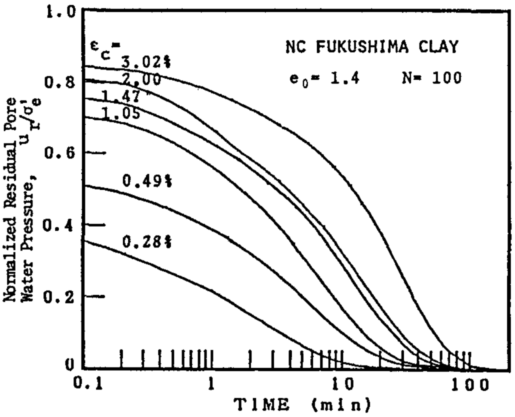

FIG.3

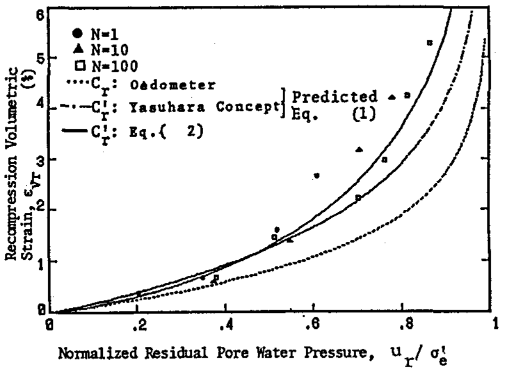

FIG.4

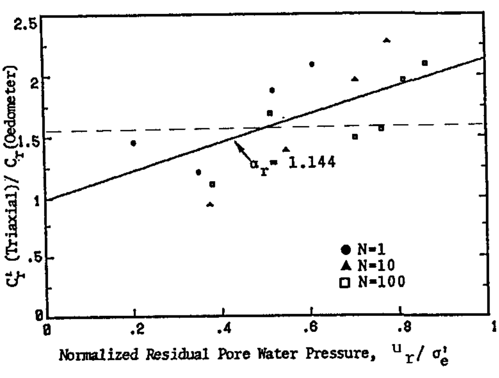

FIG.5

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1. Matsui, T., N. Abe, and M.A. Bahr, (1991), Proc. 2nd Int. Conf. on Soil Dynamics, St Louis, Missouri, USA, V(1), 1.18, 41-46.
2. Yasuhara, K., and K. Andersen, (1989), Proc. Soil Dynamics and Liquefaction Publication, V (1), 159-167.
3. Matsui, T., M.A. Bahr, and T. Hayashi (1990), Symposium on Ground Deformation , Tokyo, V(1), 75-80.(in Japanese)