III-245 THE INFLUENCE OF ANISOTROPIC CONSOLIDATION ON THE STIFFNESS OF NORMALLY CONSOLIDATED KAOLIN

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INTRODUCTION

Even though in general, the stress condition in the field is anisotropic i.e. the axial and radial effective stresses are not equal ($\sigma_a' \neq \sigma_r'$) for routine laboratory testing, the isotropic stress condition ($\sigma_a'=\sigma_r'$) is usually used during consolidation. Since, the subsequent behaviour of soils is greatly influenced by the initial stress condition, isotropically consolidated specimens are a poor simulation of the field behaviour of soils. The effect of anisotropic consolidation on the subsequent behaviour of soils has been extensively investigated, however, almost all the research has focused only on the most common in-situ anisotropic stress condition -the K_0-condition. But this is only one of in-situ anisotropic stress conditions. This paper reports on the effect of various anisotropic consolidation conditions on the stiffness of normally consolidated kaolin in triaxial compression.

TESTING

The kaolin used has a liquid limit of 67.6%, a plasticity index of 30.8, a specific gravity of 2.67 and a clay fraction of 49%. Bulk samples were prepared from a slurry one-dimensionally consolidated under a vertical effective consolidation stress of 1.0 kgf/cm². From this bulk sample, 10 cm high and 5 cm diameter specimens were trimmed and set in the triaxial apparatus with filter paper side drains. The specimen was then saturated by a combination of vacuum, time-lag and back-pressurization and then reconsolidated in an automated triaxial system at an axial strain rate of 0.01%/min along the specified constant stress-ratio path. The details of the saturation procedure and a description of the automated triaxial system have been reported by Ampadu and Tatsuoka, (1988). The specimen was then sheared undrained at a strain rate of 0.06%/min.

TEST RESULTS

The results of the tests are summarized in Table 1. The stresses are reported in terms of $q=\sigma_a'-\sigma_r'$ and $p'=(\sigma_a'+2\sigma_r')/3$, where the subscripts a and r denote the axial and radial directions respectively. The stress ratio is given by $\eta=q/p'$ and the degree of anisotropic consolidation is given by $\eta_0=q/p_0'$. The secant modulus E_s at any stress ratio $\eta*$ is defined as $E_s=\Delta q/(\Delta\varepsilon_a . p_0*')$ where $\Delta q=q-q_0*$ and $\Delta\varepsilon_a=\varepsilon_a-\varepsilon_{a0}*$. The symbol * on a parameter indicates the parameter value at the point from which E_s is measured.

Table 1.

TEST NO.	η_0	p_0'	w_f	ε_a^M
I73-2	0.00	2.98(1)	52.1	18.0
I622-2	0.00	2.20	53.2	20.0
ICU403	0.00	2.92	55.5	18.0
ICU402	0.00	2.00	57.2	19.0
A813-2	0.27	2.46	54.5	10.0
A803-3	0.64	2.27	52.5	1.4
A803-2	0.66	2.28	54.0	1.2
A843-1	0.77	2.17	54.0	0.5
A833-1	0.84	2.00	53.4	0.3
A823-1	0.95	1.91	54.6	0.1

(1):Lightly overconsolidated
p_0':mean effective stress at the end of consolidation (kgf/cm²)
w_f:final water content (%)
ε_a^M:axial strain at maximum q (%)

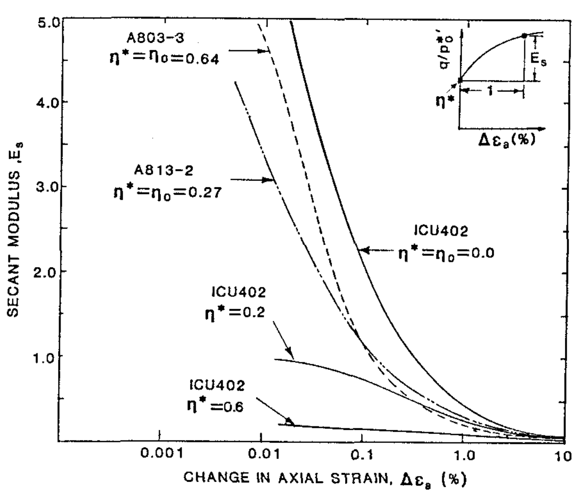

Fig. 1 Variation of E_s with $\Delta\varepsilon_a$

The variation of E_s measured from η^* values of 0, 0.2 and 0.6 for a representative isotropically consolidated (I-) specimen (ICU402) and anisotropically consolidated (A-) specimens of comparable η^* values (A813-1, $\eta^*=\eta_0=0.27$ and A803-3, $\eta^*=\eta_0=0.64$) are shown in Fig. 1. From this figure it can be seen that for the I-specimen, the curve for larger values of η^* are located below those for smaller values and for the same η^* value the curve for the A-specimen lies above that for the I-specimen.

This trend is shown quantitatively in Fig. 2 where the E_s values at $\Delta\varepsilon_a=0.1\%$ on a logarithmic scale are plotted against η^*. It can be seen from this figure that the initial E_s values (i.e. $\eta^*=\eta_0$) decreases gradually as the η_0 value increases. However, for the same value of $\eta^*$the E_s value for the equivalent A-specimen is much larger than that for the I-specimen and the difference increases as the value of η^* increases. A similar trend is observed for specimenI73-2 which has undergone a small degree of mechanical overconsolidation (OCR=1.22).

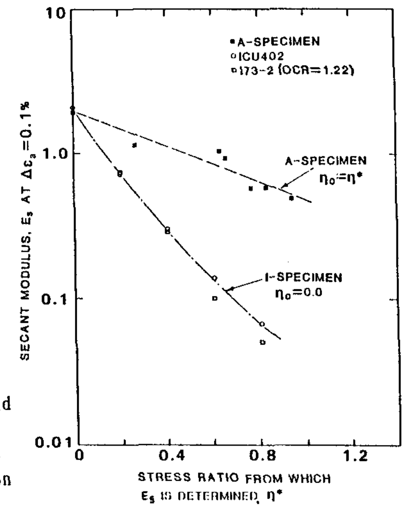

Fig. 2 Variation of E_s at $\Delta\varepsilon_a=0.1\%$ with η^*

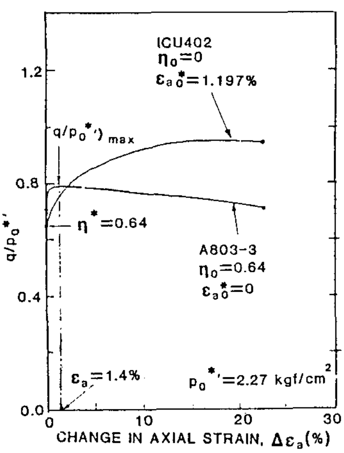

Fig. 3 Stress-Strain characteristics

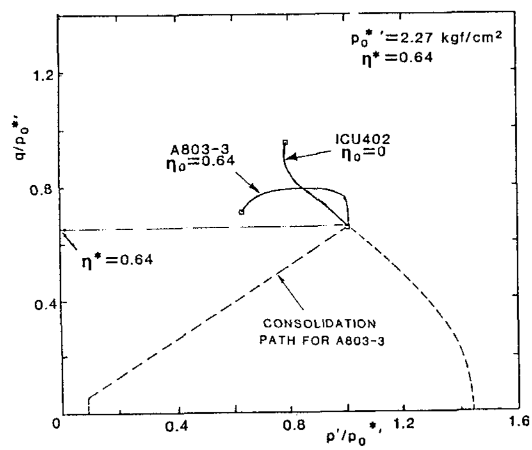

Fig. 4 Stress Paths for ICU402 and A803-3

This difference in behaviour is illustrated in the typical stress-strain characteristics shown in Fig. 3, where q normalized by the p' value at $\eta=0.64$ is plotted against the $\Delta\varepsilon_a$ measured from $\eta=0.64$. The stress paths for ICU402 and A803-3 are shown in Fig. 4. In this figure the portions of the stress path for which $\eta<0.64$ are shown dotted while that for $\eta>0.64$ are shown in full. In preparing Fig 4, it was assumed that for a given η_0, the stress paths for different values of p_0'are similar in shape. The stress path for ICU402 has therefore been enlarged to coincide with that for A803-3 at $\eta=0.64$.

CONCLUSION

It can be concluded from these discussions that, for this kaolin, the initial secant modulus of an isotropically consolidated specimen is higher than that for the anisotropically consolidated specimen. However, when measured from the same stress ratio, the secant modulus of an isotropically consolidated specimen is much smaller than that of the anisotropically consolidated specimen and the difference between the two increases as the degree of anisotropic consolidation increases.

REFERENCE:

Ampadu, S.I.K. and Tatsuoka, F.(1988):"The Influence of Initial Shear on Undrained Behaviour of Normally Consolidated Kaolin"; The 23rd Annual SMFE Symp. The Japanese Society of SMFE, Miyazaki