is another cause for the remaining part of this reduction?

Concerning Fig. 9, the logarithmic scale is used for the horizontal axis. The relation is not very much linear in this figure. Will another type of relation emerge when the arithmetic scale is used for the horizontal axis?

In conclusion, this paper presents an interesting contribution to the subject and is very useful. When possible, the cross-checking with the results obtained by the cyclic triaxial tests may be useful.

STUDY ON THE SETTLEMENT OF SATURATED CLAY LAYER INDUCED BY CYCLIC SHEAR[i]

Discussion by KAZUYA YASUHARA[ii] and KNUT H. ANDERSEN[iii]

The authors' research on post-cyclic recompression behaviour of clay has proceeded along the same line as a recent research by the writers (Yasuhara and Andersen, 1987 a, b; 1989). In both cases the research has been based on cyclic direct-simple shear testing of clay.

In evaluating the post-cyclic recompression settlements of foundations on clay, it is important to establish a parameter which is suitable to express the relationship between stress and compressibility of clay undergoing cyclic loading. The authors proposed the "dynamic compression index", C_{dyn}, in the following relation:

$$\varepsilon_{vr}=\frac{C_{dyn}}{1+e_0}\log\left(\frac{1}{1-\Delta u/\sigma_{v0}'}\right) \qquad (11)$$

The authors did not, however, present a simple practical way to determine this "dynamic compression index", C_{dyn}.

The writers (Yasuhara and Andersen, 1987 a, b; 1989) have in their research noticed that

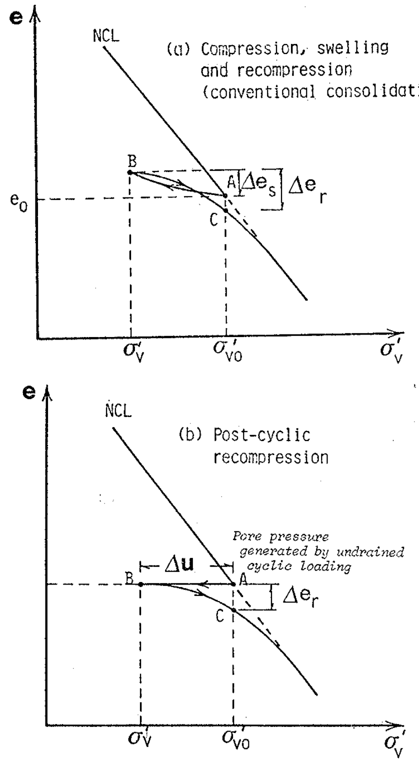

Fig. 17. Illustration of e-log σ_v' relations in (a) oedometer tests and (b) cyclic DSS tests followed by drainage

the post-cyclic recompression has similarities with the recompression in conventional oedometer tests subjected to compression, swelling and recompression (Fig. 17). The writers have therefore tried to predict the post-cyclic recompression in cyclic DSS tests by using the recompression index, C_r, determined from conventional oedometer tests. This corresponds to Eq. (11) being rewritten as:

$$\varepsilon_{vr}=\frac{C_r}{1+e_0'}\log\left(\frac{1}{1-\Delta u/\sigma_{v0}'}\right) \qquad (12)$$

where e_0': void ratio at the start of recompression.

The recompression volumetric strains measured in cyclic DSS tests on Drammen clay are in Fig. 18 compared to the recompression strains calculated using recompression indices from oedometer tests on the same clay. From this comparison the writers have concluded

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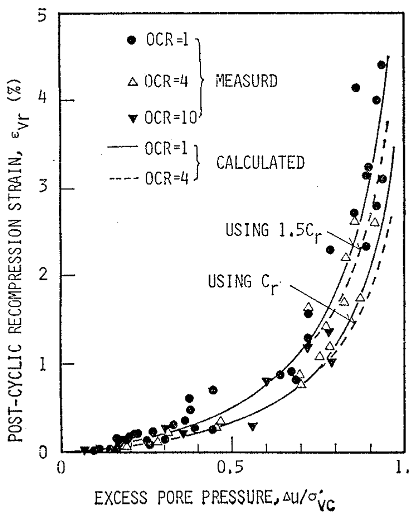

Fig. 18. Post-cyclic recompression volumetric strain versus normalized pore pressure of Drammen clay in undrained cyclic direct-simple shear tests

that C_r from oedometer tests should be multiplied by 1.5 to give a reasonable estimate of the recompression settlements of Drammen clay due to dissipation of cyclic-strain-induced excess pore pressure. The reason why the compression in the cyclic tests is higher than in the oedometer may be because cyclic loading not only generates an excess pore pressure, but also disturbes the clay structure.

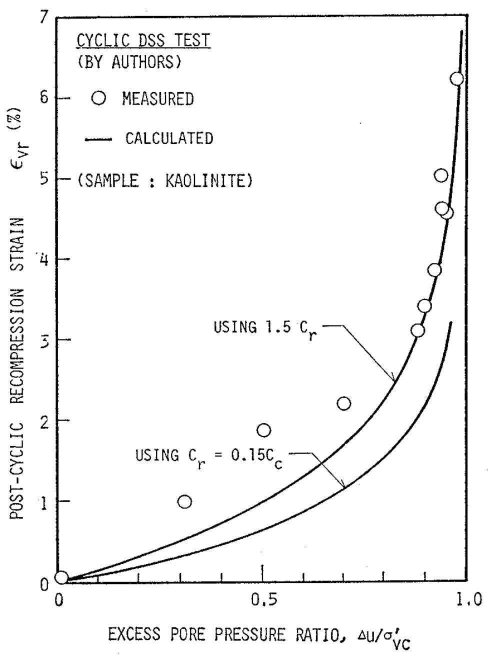

Fig. 19. Post-cyclic recompression volumetric strain versus normalized pore pressure of Kaolinite clay in undrained cyclic direct simple shear tests followed by drainage carried out by the authors

The procedure used for Drammen clay is also applied to calculate the recompression volumetric strains measured by the authors in their cyclic DSS tests on Kaolinite (Fig. 19). The authors have presented values of compression and swelling indices, but not the recompression index which is believed to be most relevant for calculation of the volumetric strains due to cyclic loading (Fig. 17). The writers have therefore assumed $C_r = 0.15 \cdot C_c$ for the calculations in Fig. 19. However, this assumption is uncertain and needs verification. Information that the authors may have about C_r for the Kaolinite clay would therefore be welcome.

Secondly, the authors concluded from Fig. 9 and Fig. 10 that the post-cyclic recompression settlements depend on the overconsolidation ratio. The writers have combined the data in the two figures and obtained Fig. 20. Even if one theoretically may expect an effect of the overconsolidation ratio, Fig. 20 indicates that this effect is small and within the scatter of the data points. The results from the cyclic DSS tests on Drammen clay carried out by the writers are plotted in the same way in Fig. 21. This plot seems to indicate an effect of overconsolidation ratio which is more significant

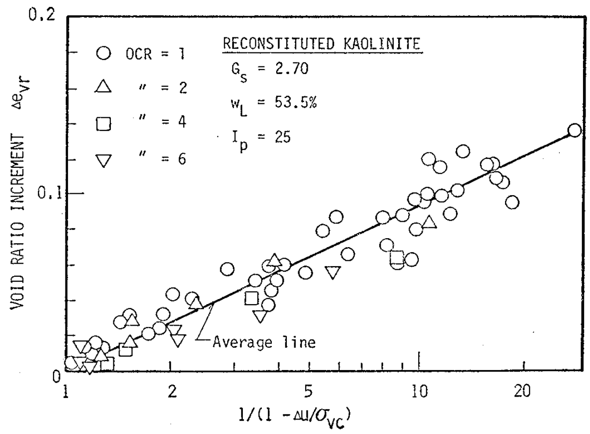

Fig. 20. Relation between void ratio change and normalized cyclically induced pore pressure in cyclic simple shear tests on Kaolinite clay followed by drainage carried out by the authors

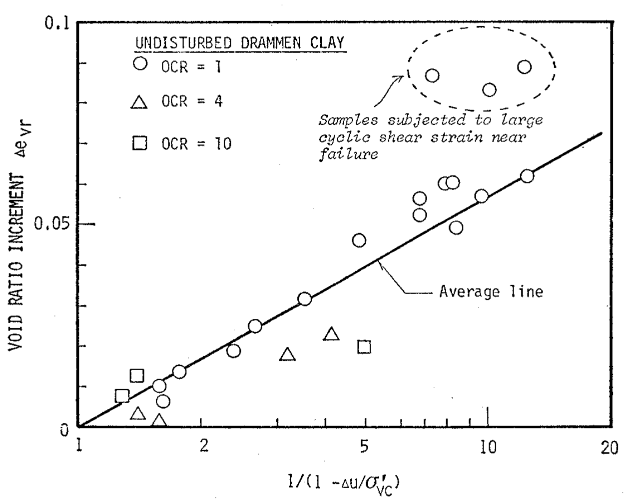

Fig. 21. Relation between void ratio change and normalized cyclic-induced pore pressure in cyclic direct-simple shear tests followed by drainage on Drammen clay carried out by the writers

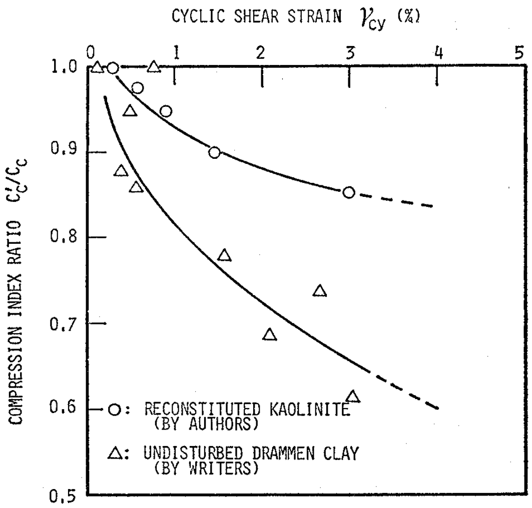

Fig. 22. Compression index ratio of undisturbed Drammen clay and reconstituted Kaolinite clay after cyclic loading followed by drainage in direct simple shear tests

than found for Kaolinite by the authors.

The writers agree with the authors in that cyclic loading will influence the compressibility of a clay under consolidation past the initial consolidation pressure. This is illustrated in Fig. 22 which shows the ratio C_c'/C_c as a function of the cyclic shear strain both for the Drammen clay and the Kaolinite clay. C_c is the compression index in the case of no cyclic loading, and C_c' is the compression index for loading past the initial consolidation stress after cyclic loading (Fig. 17). While both clays have a plasticity index of about 27, the cyclic loading has been stress-controlled for the Drammen clay and strain-controlled for the Kaolinite clay. Therefore, the numerical values are not directly comparable when plotted against cyclic shear strain. The results in Fig. 22 do show, however, that cyclic loading causes a reduction in the compression index for both clays.

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STUDY ON THE SETTLEMENT OF SATURATED CLAY LAYER INDUCED BY CYCLIC SHEAR[i]

Closure by SUKEO O-HARA[ii] and HIROSHI MATSUDA[iii]

The writers are very much grateful to Dr. A. R. Rodriguez, Dr. K. Yasuhara and Dr.

i) Vol. 28, No. 3, September 1988, pp. 103-113. (Previous discussions by A. R. Rodriguez, Vol. 30, No. 2, June 1990, pp. 138-139; and by K. Yasuhara and K. H. Anderson, Vol. 30, No. 2, June 1990, pp. 139-141).
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