DETERMINATION OF IN-SITU UNDRAINED STRENGTH OF SOFT CLAY DEPOSITS*

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In-situ undrained strength, S_{uf} of N.C. aged clay and O.C. young clay is given by Eqs. (13-1) and (13-2), respectively, as demonstrated in this paper.

$$S_{uf}=\alpha\times OCR\times p_0 \text{ or } \alpha\times p_c \quad (13\text{-}1)$$

$$=\alpha\times n\times OCR\times p_0 \text{ or } \alpha\times n\times p_c \quad (13\text{-}2)$$

where α=undrained strength ratio in the N.C. young state, and n=coefficient for strength decrease due to rebound.

The value of n, which is uniquely related to OCR (Nakase et al., 1971), is 1.0 at OCR=1.0 and decreases with increasing OCR. The difference in S_{uf} obtained from Eq. (13-1) (the authors method) and Eq. (13-2) (the SHANSEP method) will be negligible from a practical point of view when OCR is relatively small. The discusser pointed out using Fig. 21 that S_u for the normally consolidated aged clay at stress p_1 is very similar to the strength of overconsolidated clay at stress p_1 and having $p_c'=p_2$. This is another expression of the above mention. It is evident, however, that the difference in S_{uf} obtained from the two methods becomes more significant with increasing OCR. Since the value of n of overconsolidated clay is less than 1.0, the shear strength obtained from the SHANSEP method always gives a conservative value for aged clay.

The discusser suggested that desiccation is a stress history phenomenon potentially resulting in conventional overconsolidated material. The authors disagree with this opinion and consider that the structure developed by desiccation is different from that of conventional overconsolidated material and should remain unchanged with time. This suggestion is supported by Fig. 5 which indicates that OCR values obtained from oedometer test ($OCR=p_c/p_0$) and in-situ vane test ($OCR=S_{uf(v)}/S_{un(v)}$) showed good agreement for an N.C. aged clay (Khor Al-Zubair clay) of which upper 5 m has been subjected to desiccation stress. As pointed out in this paper, good agreement of OCR values from the two methods also supports the validity of Eq. (13-1). Fig. 22 presents stress-strain curves of a desiccated clay (Khor Al-Zubair clay) obtained from K_0-consolidated triaxial

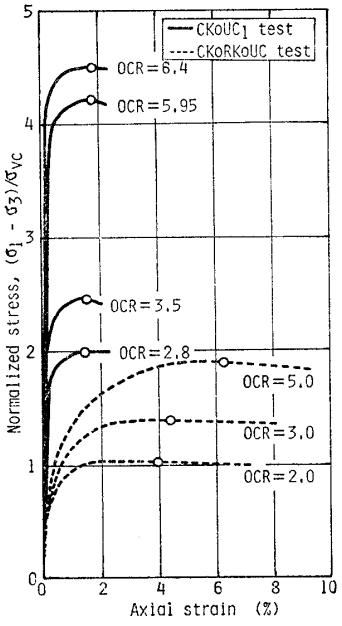

Fig. 22. Comparison of stress-strain curves of a desiccated clay obtained from K_0-consolidated triaxial tests by the authours' method (CK_0UC_1 test) and the SHANSEP method (CK_0RK_0UC test)

* Vol. 22, No. 2, June 1982, pp. 1-14. (Previous discussion by R. Foott, Vol. 22, No. 4, pp. 138-140.)

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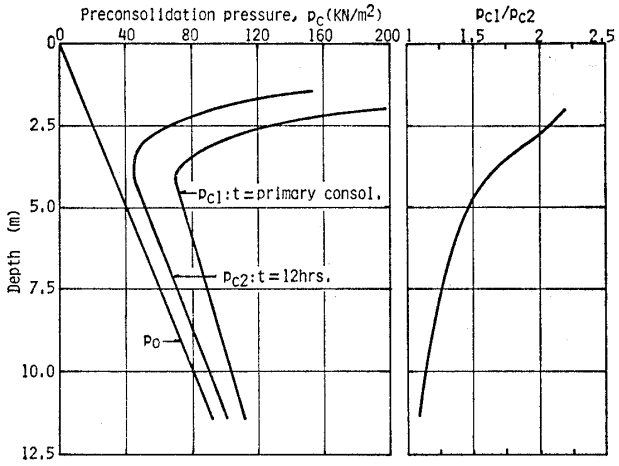

Fig. 23. Effect of loading time on the values of p_c (replotted from Ladd and Foott, 1974)

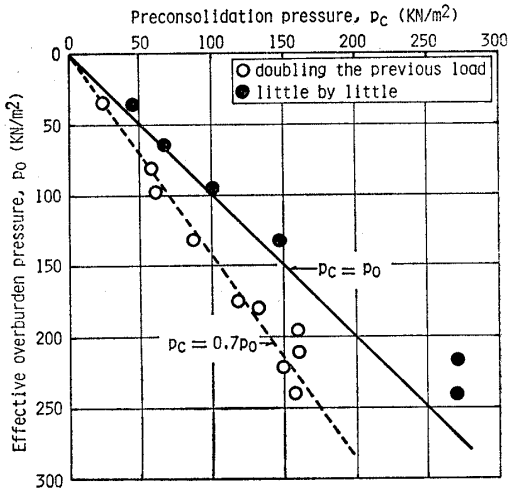

Fig. 24. Effect of load incremental ratio on the values of p_c of Fao clay found in the Arabian Gulf (after Hanzawa, 1977)

compression tests by the authors' method (CK_0UC_1 test) and the SHANSEP method (CK_0RK_0UC test). Considerable differences can be observed in strength-deformation properties obtained from the two methods.

It is questionable that p_c is appropriately determined by oedometer test alone even if high-quality undisturbed sample is obtained because p_c from oedometer test is significantly affected by loading time and load incremental ratio. Fig. 23 compares p_c values obtained from two kinds of oedometer tests performed under different loading time reported by the discusser (Ladd and Foott, 1974). The figure was replotted from the original figure. The ratio between p_{c1} (loading time=primary consolidation) and p_{c2} (loading time=12 hours) varies from 1.2 to 2.2. Hanzawa (1977) reported that p_c of a clay found in the Arabian Gulf was drastically changed with a change in load incremental ratio as presented in Fig. 24. As shown in these figures, the authors have doubts whether proper p_c can be evaluated from the oedometer test alone.

It should be pointed out here that there is a significant difference in stress-strain behavior between N.C. aged clay and O.C. young clay even if the difference in shear strength is relatively small. Strain value at failure in strength tests increases with increasing OCR for O.C. young clay, which indicates almost a constant value irrespective of OCR for N.C. aged clay (Hanzawa and Kishida, 1981). This difference should result from the difference in structure of both types of overconsolidated clays and strongly demonstrates the importance to understand the *real stress history* of a clay in-situ.