than that attained during subsequent strain softening. When this soil is sheared in the horizontal direction, substantial strains and excess pore pressures develop due to the large increment in shear stress required to produce failure. Thus $c_u(H)$ is only about one half of $c_u(V)$ even though ϕ' at failure may be 5 to 10° larger than for vertical loading. The same general trends are observed with the plastic insensitive clay, but to a much less degree: $c_u(H)/c_u(V)$ is larger, less strain softening occurs, and ϕ' may be little altered.

2.2.3 Effect of Stress History on Undrained Behavior

Since the importance of stress history on the undrained stress-strain-strength properties of cohesive soils is generally well recognized, only some of the more significant behavioral trends are summarized using normalized methods of presentation.

The increase in the undrained strength ratio (c_u/σ'_{vc}) with OCR ($=\sigma'_{vm}/\sigma'_{vc}$) from CK_oU direct simple shear tests on six clays is plotted in Fig. 25. These data were obtained by consolidating the samples beyond the in situ σ'_{vm} and then unloaded to different OCR values. A marked similarity in the shape of the curves exists in spite of major differences in the soil types. This is demonstrated in Fig. 26 where the same data are replotted in terms of the overconsolidated c_u/σ'_{vc} divided by the normally consolidated value for each soil. The first five clays fall within a very narrow band that is reasonably well-defined by the expression

$$\frac{(c_u/\sigma'_{vc})\,(OC)}{(c_u/\sigma'_{vc})\,(NC)} = OCR^m \qquad \text{(Eq. 2.3)}$$

with $m = 0.8$, though a better fit is obtained if m is decreased from 0.85 to 0.75 with increasing OCR. Limited data from CK_oU plane strain and triaxial tests on some of the same soils suggest that the relative increase in c_u/σ'_{vc} with OCR, compared to the curves in Fig. 26, is the same or somewhat less for vertical loading and is slightly greater for horizontal loading.

Overconsolidation also increases the effective stress envelope and decreases the pore pressure parameter A_f. The rapid decrease in A_f with OCR, as illustrated by the data in Fig. 27, is primarily responsible for the increase in the undrained strength ratio of overconsolidated clays. This figure also

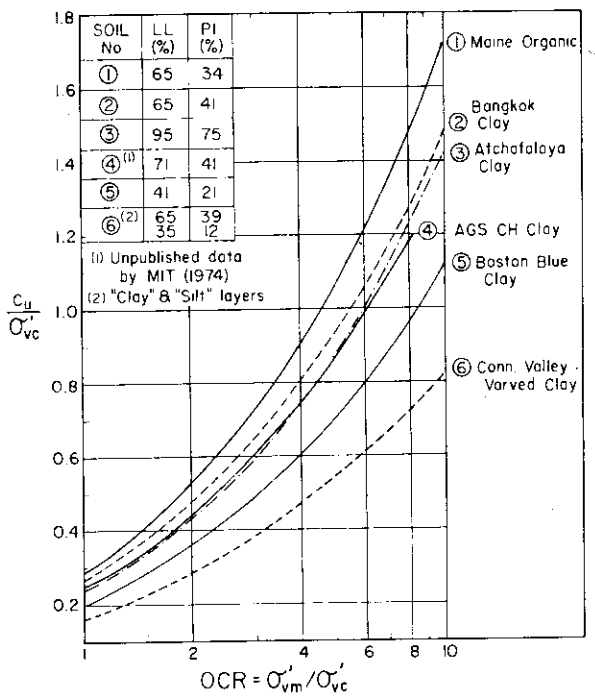

Fig. 25 Undrained strength ratio vs OCR from CK_oU direct simple shear tests on six clays (Ladd and Edgers, 1972).

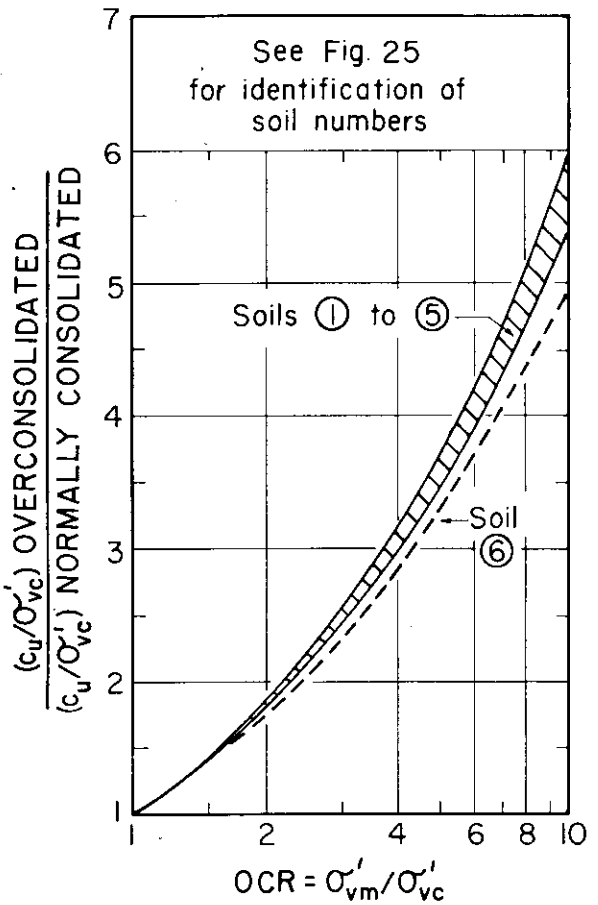

Fig. 26 Relative increase in undrained strength ratio with OCR from CK_oU direct simple shear tests (replot of data in Fig. 25).