CORRESPONDENCE

The Secretary,
The Institution of Civil Engineers.

DEAR SIR,

In their Paper "Fundamental shear-strength properties of the Lilla Edet clay" (*Géotechnique*, 10 : 3 : 101–109), Dr Bjerrum and Professor Tien-Hsing Wu concluded from a study of the geological history of the clay that the preconsolidation load determined from consolidation tests is not due to overconsolidation but rather to bonds of a chemical nature between particles. From experience with clays in New Zealand, we are of the opinion that such apparent consolidation loads are at least as common as preconsolidation loads caused by genuine overconsolidation. We have presented fairly convincing evidence of this phenomenon for two clays, namely Waterview and Whangamarino (Newland and Allely, 1956). We postulated that these clays had undergone changes with the passage of time since deposition by virtue of one or more aging processes, namely: (i) that their undisturbed strengths had increased due to thixotropic or chemical hardening, and (ii) that their liquid limits had decreased (in the present instances due to processes other than the leaching out of salt). The first process served to account for the existence of preconsolidation loads in excess of probable maximum past pressures, while the second served to account for the sensitivity of the clays, which for the Whangamarino clay was greater than 200. It is of interest to note that the Lilla Edet clay also has a sensitivity of 30–70.

We concluded with a note of caution regarding the evaluation of the fundamental shear strength parameters for such clays. We would like now to elaborate on this in view of the measurements made by Bjerrum and Tien-Hsing Wu. Particularly in the case of rigid chemical bonds (favoured by the Authors in preference to thixotropic hardening) considerable doubt exists as to the value of the intergranular pressure which is effective in mobilizing frictional resistance within the clay. In the first instance this will depend upon the amount of consolidation which has occurred before the onset of chemical bonding. In the accompanying Table, the various water contents at corresponding depths have been determined as nearly

Table compiled from data in Authors' Fig. 3

Depth: metres	W_P	W_L	W	LI
1·3	28	61	72	1·35
3·2	24	47	58	1·5
4·5	28	57	61	1·15
5·1	26	55	67	1·4
6·2	27	56	71	1·5
7·2	20	40	48	1·4
8·8	28	62	72	1·3
10·1	28	67	81	1·35
11·9	28	58	72	1·45
16·3	32	59	72	1·5
17·5	26	59	72	1·4

as possible in the circumstances from the results presented by the Authors in their Fig. 3. It will be seen that the liquidity index calculated from these is almost constant with depth. This raises the possibility that the clay is only partially, if at all, consolidated under the existing overburden pressure, the excess pressure then being carried by the chemical bond. Constant bond strength with depth is not inconceivable and this would then lead to constant in-situ shear strength with depth as is recorded in Boring 3. This would hold down to the depth at which the overburden pressure equalled the apparent preconsolidation pressure, whereas beyond it there would be an increase in strength with depth. The Massena clay (Casagrande, 1944) and the Grangemouth clay (Skempton, 1948) are possible examples of such a phenomenon.

Next, in the undrained triaxial test it is possible by measuring the pore-water pressures to ascertain the effective stress carried by the soil skeleton, but how this is shared between the rigid chemical bond and the interparticle surfaces will depend on relative rigidities and on how complete is the breakdown of bonds at the lower water contents. The Authors have in effect assumed that all the effective stress mobilizes frictional resistance which implies either that the rigidity of the bond is negligible by comparison with the rigidity of the clay particles or that frictional resistance is mobilized in the bond. The former conflicts with the idea of rigid bonds whereas if the latter holds, it would be coincidental if the ϕ for the bond was the same as that for the clay particles. Thus the value of ϕ would be likely to change as breakdown proceeded. If it is assumed that the bond is non-frictional but that it shares some of the applied stresses, then it is probable that lower frictional effective stresses than those used by the Authors should be employed in the present instance. This would lead to higher values of C_e being obtained.

The Authors claim that the sudden reduction in C_e in the range of natural water content is an indication of the breakdown in the rigid bonds between particles. However, we do not consider this to be a necessary condition of such breakdown. As we have suggested elsewhere (Newland and Allely, 1957), it is the cohesion component of strength at a given water content which supplies the resistance to consolidation thereby enabling the clay to support a given consolidation pressure. When the critical pressure is exceeded by, say, a small amount, breakdown of some of the bonds is induced and an abrupt change in the slope of the consolidation curve occurs, which is particularly evident in extra-sensitive clays. The clay eventually reaches equilibrium under the new pressure at a lower water content such that the true cohesion (now, however, arising from a different source) has a somewhat higher value. Ideally, then, in a given undisturbed bonded sample, the cohesion component would remain constant up to the critical pressure after which it would steadily increase as the water content decreased. Sample disturbance would of course alter this picture. Some suggestion of this in the Authors' results is shown by the fact that triaxial strengths are considerably higher than in-situ strengths, and by the fact that the slope of the consolidation curve up to the apparent preconsolidation pressure is relatively steep.

Yours faithfully,
P. L. Newland; B. H. Allely

Soil Mechanics Laboratory,
Auckland, N.Z.
10 January, 1961.

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