SOME LOADING TESTS ON LONG PIPE PILES

(McCammon, N. R. & Golder, H. Q. (1970). *Géotechnique* **20**, No. 2, 171–184)

M. J. Tomlinson, George Wimpey & Co. Ltd, Hayes, Middlesex

As pointed out by the Authors the values of skin friction observed by them both for the pile in a granular soil and in a cohesive soil are exceptionally low when compared with other observed values, or when calculated by current design methods. It is noted that a bentonite slurry was used under high pressure to assist the removal of soil from the interior of both piles before the various stages of testing. Is it possible that the slurry had penetrated the space between the exterior of the pile and the soil so reducing the skin friction?

Research (Hutchinson and Jensen, 1968; Tomlinson, 1971) has shown that thin coatings of soft material on the pile surface, either applied before pile driving, or picked up by the pile during driving through soft layers, can cause a marked reduction in skin friction. In addition to the possibility of the bentonite forming a soft coating on the pile shaft, the borehole record at test pile 1 shows layers of clay and silt within the granular soil formation which might have been carried down by the pile.

In the case of test pile 2 the soft clay overlying the stiff clay is unlikely to have accounted for the whole of the reduction in shear strength, but this layer in conjunction with the introduction of bentonite at the lower levels may well account for the observed low adhesion factors.

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Tomlinson, M. J. (1971). Some effects of pile driving on skin friction. *Behaviour of piles.* London: Institution of Civil Engineers.

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N. R. McCammon and H. Q. Golder

The Authors do not agree that the values of skin friction measured for the piles in granular soil and in cohesive soil are 'exceptionally low when compared with other observed values, or when calculated by current design methods'. Certainly they do not point this out as suggested by the Writer.

For the granular soil the measured value of 184 tons is low when compared with Meyerhof static (435 tons) but high compared with Meyerhof N values (100 tons), and 400–500 lb/sq. ft is a commonly used value for skin friction on caissons in sand.

For the cohesive soil the measured values of 181 tons and 226 tons are less than the value of Woodward *et al.* (1961) of 250 tons, and 304 tons is lower than their 416 tons but not exceptionally so.

The Writer asks if it is possible that the slurry had penetrated the space between the exterior of the pile and the soil so reducing the skin friction. The piles were flush on the outside (see p. 172) so that the only space was the water-filled voids in the soil. The Writer's suggestion is interesting but the Authors do not know whether the bentonite slurry penetrated these voids; however, it is considered unlikely.

Hutchinson and Jensen (1968) refer to bituminous coatings placed on piles before driving and mention possible stripping of these layers during driving, which surely is the opposite of the phenomenon of smear referred to by the Writer. It was for this reason that at Port Mann Bridge, B.C., piles coated with bitumen to reduce negative skin friction were placed in prebored holes filled with bentonite slurry which was then displaced by a clay-cement grout (Golder and Willeumier, 1964).

At test pile 2 the top 20 ft of soft clay was ignored in all computations (see p. 183).

The important thing about the method of constructing the test piles is that this is the same method as will be used in due course to construct the piles for the bridge. Whether the skin friction values have been reduced by artesian pressure in the ground water as the Authors mention, or by penetration of bentonite slurry around the tube as the Writer suggests, below the value which might have been obtained had these factors been absent, is not known. However, the values obtained from the tests are those which should be used in design at this site.

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STRESS-PROBE EXPERIMENTS ON SATURATED NORMALLY CONSOLIDATED CLAY

(LEWIN, P. I. & BURLAND, J. B. (1970). *Géotechnique* **20**, No. 1, 38–56)

R. H. G. Parry, University of Cambridge

It is important in studying the stress–strain properties of clays to be able to separate the elastic and inelastic volume changes. The systematic series of stress probes on remoulded, anisotropically consolidated slate dust described by the Authors has done much to clarify these volumetric strains. In particular they have confirmed the concept of an elastic wall put forward by Roscoe and Schofield (1963). This concept maintains that during unloading the change in voids ratio is elastic and depends solely on the change in mean principal effective stress $p = \frac{1}{3}(\sigma'_1 + \sigma'_2 + \sigma'_3)$. In effect, the elastic modulus at any time is assumed to be directly proportional to the mean principal effective stress, i.e.

$$\delta v^e = \frac{\kappa}{1+e}\frac{\delta p}{p} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where δv^e is the unit elastic volume change and κ is the initial slope of the swelling lines on an e–log p plot.

In earlier work (Parry, 1956, 1957, 1962), the following equation was used to separate elastic volume change from total volume change in triaxial tests on saturated remoulded Weald clay

$$\delta v^e = \frac{(1-2\nu)e}{k}\frac{\delta p}{p} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The parameter k and Poisson's ratio ν were taken to be constant and the term $(1-2\nu)/k$ was evaluated from the initial slope of the swelling curves on an e–p plot. As the variation of e is negligible compared with the variation of p, equations (1) and (2) are almost identical.

Equation (2) was used to predict pore pressures developed at failure in undrained triaxial tests from volumetric parameters obtained in drained tests.

In addition, it was suggested by the Writer that in triaxial compression and extension tests carried out under constant p conditions δv^e should be zero. A number of tests of this type were carried out and the observed volumetric strains confirmed this.

It was also suggested by the Writer that under cyclic shear stressing the inelastic component of volumetric strain should rapidly disappear and the observed volumetric strains