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DISCUSSIONS

Experimental study of axial behaviour of tapered piles: Discussion[1]

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The authors present test data and analysis from testing tapered piles in a 1.5 m high and 1.5 m diameter cylindrical test chamber lined with an "air bladder" enabling the lateral stress to be increased. No similar arrangement is used to increase also the vertical stress. This creates a soil that is highly overconsolidated.

The authors state that the test arrangement does not represent the state of stress along a prototype pile. The discussers agree. However, the authors also state that the purpose of the device (the testing chamber) "is to model the state of lateral stress [against the pile] along different "segments" of the pile...". If this means claiming that the state of lateral stress against the model pile would be similar to the state of stress against a real (prototype) pile, the discussers disagree.

Inflating the lining bladder compresses the soil and increases the stress acting against the pile (placed in the centre of the device). The authors appear to assume that the distribution of the so imposed stress is lateral and uniform. However, the soil will not move uniformly and it will not only move horizontally. There will also be an upward component near the pile head and a downward component near the pile toe. These movements will both cause stress rotation in the soil adjacent to the pile and impose load (residual load) in the pile. The stress against the pile will therefore vary along the pile. Moreover, the resulting increase of density cannot be uniform.

When testing, the authors first installed and secured a model pile in the test chamber and then poured sand around the pile. As Hanna and Tan (1973) have shown in their experiments with instrumented model piles, the placing of the sand has a pronounced effect on the state of stress in the sand *and* in the pile. The authors' arrangement will have had the effect of introducing additional load, i.e., residual load, in the pile. For information on residual load, see Nordlund (1963), Hunter and Davisson (1969), Altaee et al. (1993), and Fellenius and Altaee (1994).

The authors report that all strain gauges were zeroed before the start of each test, but they do not explain why. However, zeroing the gauges does not remove the residual load in the pile; the pile and the measurements will remain under the influence of the residual load. If the gauges had been zeroed immediately on placing the test pile in the chamber and before the sand was poured around the pile, that is, when the load in the pile truly was zero, then the load in the test pile at the start of the test (the residual load) could have been accounted for.

The authors do not recognize that in a zone of several pile diameters above the pile toe, the load in the pile and the unit shaft resistance are affected by the conditions at the pile toe (for reference, see Altaee et al. 1993). The height of this zone can be about three to five pile diameters. The diameter of the model piles ranges from 152 mm to 203 mm. At best, therefore, only about one-third or one-quarter of the length of the model piles near the midpoint can be assumed to be somewhat independent of end effects.

Reaction to the applied push load was obtained from pulling on the rim of the central hole of the 19 mm thick plate covering the surface of the sand. This plate has an outer diameter of 1.5 m and a central access hole 0.397 m in diameter. The maximum test load was about 45 kN. The discussers disagree with the authors' statement that the plate would be rigid. The authors have not recognized that as the load is applied, the plate bends upward, which allows the sand near the pile head to dilate and to release some of the imposed confining stress (release occurs already at very small movement). When the bladder-imposed lateral stress increases, the overall pile resistance increases, requiring a larger load to move the pile. As the test progresses, each load increment increases the upward bending of the plate, which progressively releases more of the lateral stress near the pile head. This is why the measurements show that the shaft resistance along the upper portion of the pile is smaller for the tests at larger confining stress than for those at smaller confining stress.

The loading tests produced load–movement relations that fannned out in a series of slightly curved lines. No indication of ultimate resistance is apparent in any one of the tests. To obtain one, the authors applied the limit load criterion proposed by Davisson (1972) (the authors mistakenly make reference to Davisson 1970). The authors do not say why this criterion and not some other, say 10% of the pile toe diameter, would be the pile capacity to apply in the authors' comparisons of the test results. Also, the shape of the load–movement curve of the straight-shaft pile is devoid of a sign of "failure," showing instead a continuous increase of resistance throughout the test (Fig. 5b).

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This indicates that toe resistance is an appreciable portion of the mobilized resistance. The measured values, however, show only a small toe resistance of the straight-shaft pile. This is entirely consistent with the presence of residual load, causing the measurements to purport a larger than actual shaft resistance and smaller than actual toe resistance.

Considering the undetermined influence of nonuniform density, residual load, end effects, and bending of the cover plate, the circuitous distribution of unit shaft resistance (the authors call it "unit load transfer") shown in Figs. 8–11 is not a surprise.

Even if the authors had been able to consider the influencing factors mentioned, the analysis of the results of the subject tests can only be correctly performed with due consideration to steady-state principles, where the dilation and contraction of the highly overconsolidated sand are discussed in relation to the distance to the steady-state line (see, for example, Altaee and Fellenius 1994).

In discussing the test results, the authors suggest that (1) "arching" occurred in the soil around the tapered piles but not around the straight-shaft piles, and (2) "at high confining pressures... crushing [of sand grains] becomes the unique mechanism of failure...".

The authors' conclusions include the unmerited and irrelevant recommendation that the tapered length of real piles should be restricted to an upper length of 20 pile diameters (the model piles had a length of 10 pile diameters) and the erroneous notion that the test results indicate the existence of critical depth.

The conclusion of the discussers is that the test results are affected by various controlling factors that are not accounted for and therefore the authors' discussion and conclusions are not persuasive.

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