The consolidation of soils exhibiting creep under constant effective stress

GARLANGER, J. E. (1972). *Géotechnique* **22**, No. 1, 71–78.

Discussion by Šuklje (1972). *Géotechnique* **22**, No. 4, 670–673

Author's reply to discussion by Šuklje (1972). *Géotechnique* **22**, No. 4, 673–674.

Discussion by Šuklje (1973). *Géotechnique* **23**, No. 2, 283–284

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Garlanger calculates the delayed strain rate by differentiating with respect to time the conventional log time equation for secondary settlement. This log time equation is widely used to describe the stress–strain–time behaviour of the soil skeleton (under certain conditions), and time is measured from the moment of application of the increment of load. At the moment of application of an increment of load, elements of soil which are remote from drainage faces experience only a rise in pore-pressure. In particular, effective stresses and void ratios are unaffected—at that moment.

The assumption that the stress–strain properties of a soil skeleton are independent of (or at most only weakly dependent on) the magnitude of the excess pore-pressure has withstood many decades of soil mechanics research testing—particularly in the use of back pressures to improve saturation. The assumption that the stress–strain–time behaviour of each element of the soil skeleton can be described by an equation which is based entirely on a moment when the element experienced a change in pore-pressure is therefore, in my opinion, illogical.

I have developed a theory which avoids this assumption (Hawley, 1970, 1971; Hawley and Borin 1973). In this theory the behaviour of each element of the soil skeleton at every moment in time is determined by the conditions (void ratio, effective stress, strain rate) being experienced by the element at that moment. I consider this to be a more logical procedure. The need to establish any origin for the measurement of time is avoided in that models for primary and secondary stages (and equally the instant and delayed components) are developed without postulating that the *soil skeleton* can register and remember origins for time measurement. I consider that only if effects such as time hardening (and other such physico-chemical effects) were to be incorporated, would the establishment of origins of time be appropriate.

Any decay phenomenon is liable to appear more nearly linear when plotted against the logarithm of time rather than against time. The fact that linear settlement against log time relationships have been found useful both in laboratory tests and in the study of geological sediments has given a misleading appearance of universal validity to the relationships. In both of these situations the settlements being considered are occurring at times which are one or more orders of magnitude greater than the high strain rate periods which preceded them. Under such conditions the linearity of the settlement against log time plot becomes insensitive to the choice of origin for time measurement. What linearity is observed is an inevitable result of the broad type (decay) of phenomenon being observed, and should not in my opinion be accepted as a stress–strain law of the soil skeleton. In particular it is not sufficiently precise, or indeed sufficiently logical (as already indicated) to be used in a unified approach to either the primary and secondary stages or the instant and delayed components of soil consolidation.

REFERENCES

- Hawley, J. G. (1970). *A unified theory for the one-dimensional consolidation of saturated clays*. PhD thesis, Cambridge University.
- Hawley, J. G. (1971). The primary–secondary transition during the consolidation of clay. *Proc. 1st Australia-New Zealand Conf. Geomech.*, Melbourne **1**, 127–131.
- Hawley, J. G. & Borin, D. L. (1973). A unified theory for the consolidation of clays. *Proc. 8th Int. Conf. Soil Mech. Fdn Engng, Moscow* **1.3**, 107–119.

The preface to the research document is by Professor Dr Ing. E. Schultze and it is stated that the investigation was undertaken to generalize the earlier research work by Schultze which related angles of shearing resistance to relative densities for particular non-cohesive soils.

Statistical methods were used to evaluate the significant volume of test data obtained from various sources but apparently the test procedures employed by the various laboratories introduced considerable uncertainties in the statistical methods of evaluation.

The following surprising conclusions were deduced from the research work. The influence of particle size on the angle of shearing resistance is not significant. The statistical equations indicate that the angle of shearing resistance decreases with increasing particle size. Well graded sands have smaller angles of shearing resistance than uniformly graded sand in the same initial state.

The research work includes a study of the critical depth of embedment of the penetrometer as introduced by De Beer (1963) and also presents a simplified energy equation to permit the test results from different penetrometers to be converted for the purposes of comparison.

It would be of considerable interest if research workers specializing in this subject would prepare a critique on the report.

S.T.

Corrigendum

Creep of a clay during shear and its rheological model. *Géotechnique* **25**, No. 2, 299–320. Page 319, latter part of eqn(40) should read

$$(t_i^2 - t_{i-1}^2)$$

Pages 302 and 303, symbols for vectors in vectorial sums should be in bold type.

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