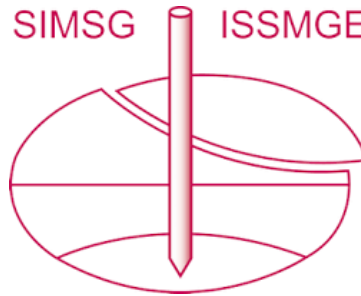


INTERNATIONAL SOCIETY FOR SOIL MECHANICS AND GEOTECHNICAL ENGINEERING



This paper was downloaded from the Online Library of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE). The library is available here:

<https://www.issmge.org/publications/online-library>

This is an open-access database that archives thousands of papers published under the Auspices of the ISSMGE and maintained by the Innovation and Development Committee of ISSMGE.

Prediction of Time for Consolidation from Sounding

Prédiction de la Durée de Consolidation des Matériaux Provenant de Sondages

G. A. JONES Soil Engineering, National Institute for Transport and Road Research, South Africa

SYNOPSIS For road embankments over alluvial deposits the time taken for settlement is often of greater significance than the magnitude of settlement. A method of estimating the time, based on deep sounding, is proposed in which the test is carried out at a constant stress. In order to demonstrate the feasibility of the proposal, a series of laboratory tests was carried out comparing consolidation characteristics measured by constant stress penetration, with those measured by conventional consolidometer tests.

INTRODUCTION

The planning of routes for highways requires preliminary geotechnical investigations. Estimates of the amount of settlement of embankments and, equally important, the period of settlement are often required. For such investigations an indication of the order of magnitude i.e. 0, 1, or 10 years may well be sufficient.

In South Africa, quasi static penetrometer testing (deep sounding) is used almost on a routine basis for estimating the settlement of embankments on alluvial deposits (Jones 1975, Webb 1974). Although discussions about the theoretical interpretation of penetration testing data are continuing there is little doubt that the use of the technique on a semi empirical basis is justified. At present the drawback of sounding is that it gives no indication of the duration of settlement.

It is here reported that estimates of the required consolidation characteristics were made from penetration tests carried out at a constant stress, instead of at the more usual constant rate of penetration, on a series of laboratory samples on which consolidometer tests were also carried out.

TEST RESULTS

A standard mechanical friction cone penetrometer was mounted vertically in a frame as shown in Fig. 1. A loading platform was attached to an extended inner rod and an LVDT connected to a chart recorder was arranged to measure the movement of the platform. Soil samples were prepared in an inner bucket surrounded by a water jacket. The inner bucket had perforated sides and was lined with a filter fabric. The frame was designed so that the penetrometer could be moved to different depths in the bucket. In this way a number of tests could be carried out on the same sample. A piezometer was fitted into the head of the cone for some of the tests. It consisted of a pressure transducer located inside a cone with porous stone windows in the face.

The procedure was analogous to consolidometer testing in some respects. Loads were added to the platform and a series of graphs of deformation as a function of time was obtained. On completion of a test the cone

was lowered to a new position and a further test carried out. Three soil types were used, silty sand, clayey sand and a silty clay. The first two samples were prepared in the bucket whereas the clay was an undisturbed sample extracted by an excavator from a site currently being utilized for embankment studies (Jones et al 1975).

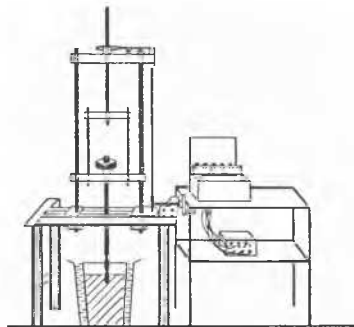


Fig. 1 Constant stress penetrometer

The classification test results on the three soils are given below:

Sample Description	Particle Size Distribution %			Atterberg Limits	
	> 60 μ	<60 μ >2 μ	< 2 μ	W_L	W_P
Silty clay	13	35	52	56	35
Clayey sand	55	22	23	33	20
Silty sand	93	7	-	N.P.	

The results of standard consolidation tests on the three samples are shown on Fig. 2.

The results of the deformation-versus-time penetrometer tests are given in Fig. 3. The tests on the clay showed evidence of what may be regarded as secondary consolidation. The end of primary deformation

was graphically determined for each material and all deformations were expressed as a percentage of these and plotted against time on a logarithmic scale. Pore pressures were also recorded during some of the tests on the clay samples.

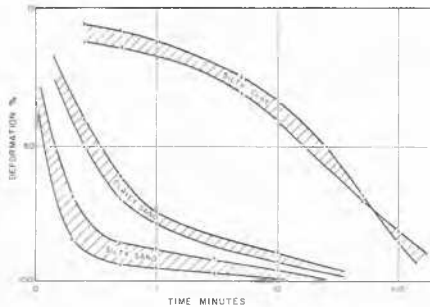


Fig. 2 Consolidometer deformation vs. time

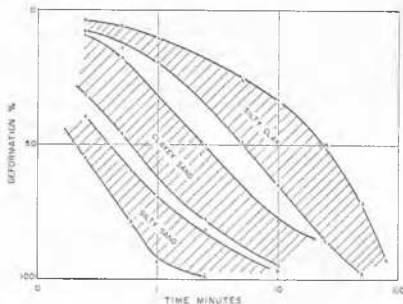


Fig. 3 Penetrometer deformation vs. time

DISCUSSION

The consolidation tests results for each material type see Fig. 2, show fairly narrow bands whereas the penetrometer results in Fig. 3 show much wider spreads. The pore pressures rose immediately on application of a load after which there was a gradual decay apparently consistent with the decreasing rate of penetration. However, as is well known, such pore pressure measurements can give rise to problems of interpretation (Holden, 1974; Schmertmann, 1974) although many have advocated their use (Hansbo, 1974; Janbu and Senneset, 1974; Ladanyi, 1976). A comparison of Figs. 2 and 3 shows that consolidometer and penetrometer test times tend to agree although there are clearly anomalies which require explanation. In order to use the proposed penetrometer test with any confidence it will be necessary to resolve these anomalies and to collect considerably more data. It was observed that in all the materials the shape of the deformation time plot could be significantly altered by changing the load. This was presumably because the materials failed at higher stresses with the result that consolidation effects were masked. In this preliminary series of tests the maximum deformation was not controlled by limiting the loads and it was arbitrarily decided to discard results where the deformation exceeded 10 per cent of the cone diameter. It was accepted that the laboratory tests indicated sufficient correlation between the consolidometer and penetrometer results

to justify field testing. This was found to be straightforward if the uppermost inner sounding rod was fitted a load platform. A standard 10-ton Goudsche Machinefabriek probe was used which had been fitted with an electrical strain gauge load measuring system with a chart recording device (Jones, 1975). Deformation measurements were taken with an LVDT connected to this system.

CONCLUSIONS

Constant stress penetrometer tests are considered to be feasible for the preliminary field estimation of the time-settlement characteristics of alluvial deposits. Just as conventional constant rate of penetration testing has required a great deal of field correlation so will constant stress tests require similar correlations with other time-dependent tests and field performance to prove their validity.

This paper is published by permission of the Director of the National Institute for Transport and Road Research. The author also wishes to thank Messrs van Loggenberg and Vorster of the Institute for their assistance with the design and construction of the equipment and carrying out the tests.

REFERENCES

- HANSBO, S. (1974), "Pore pressure sounding apparatus," Proc. European Symp. on Penetration Testing (ESOPT), Vol. 2:1, pp. 109-110.
- HOLDEN, J.C. (1974), General discussion, Proc. ESOPT, Vol. 2:1, pp. 100-107.
- JANBU, N. and SENNESET, K. (1974), "Effective stress interpretation of in-situ static penetration tests", Proc. ESOPT, Vol. 2:2, pp. 181-193.
- JONES, G.A. (1975), "Deep Sounding - its value as a general investigation technique." Proc. 6th Reg. Conf. for Africa S.M.F.E., Vol. 1, pp. 167-175.
- JONES, G.A., LEVOY, D.F. and MCQUEEN, A.L. (1975), "Embankments on soft alluvium - settlement and stability study at Durban," Proc. 6th Reg. Conf. for Africa S.M.F.E., Vol. 1, pp. 243-250 and Vol. 2, pp. 134-137.
- LADANYI, B. (1976), "Use of the static penetration test in frozen soils," Can. Geotech. J., 13 pp. 95-110.
- SCHMERTMANN, J.H. (1974), "Penetration pore pressure effects on quasi-static cone bearing," Proc. ESOPT, Vol. 2:2, pp. 345-351.
- SCHMERTMANN, J.H. (1974), General Discussion, Proc. ESOPT, Vol. 2:1, pp. 146-150.
- WEBB, D.L. (1974), "Penetration testing in South Africa," Proc. ESOPT, Vol. 1, pp. 201-215.