

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.

Quality assurance in laboratory testing

Le contrôle de qualité dans les essais de laboratoire

G.SÄLLFORS, Associate Professor, Department of Geotechnical Engineering, Chalmers University of Technology, Sweden

SYNOPSIS: Quality assurance is used in a steadily increasing number of geotechnical projects. This paper deals with three examples, where quality assurance would increase the reliability primarily of laboratory test results and their further use in the analysis.

1 INTRODUCTION

Quality assurance is a very important matter, and rightly so, given much attention in a steadily increasing number of projects. In certain fields quality assurance has been imperative for a number of years while in other areas quality assurance for different reasons is not accepted.

Soil engineers traditionally use a deterministic analysis and mention little about uncertainties. This has resulted in an exaggerated belief in lab test data. Furthermore, while balances in the labs for example are checked and approved every year, other vital test equipment is left without any external check-up whatsoever.

This paper pin-points three subjects which, if correctly treated, can improve the reliability of geotechnical investigations and design, namely

- 1) Natural scatter of laboratory test results
- 2) Regular check-up of laboratory equipment
- 3) Resistance against to using new type of data or technique

The above items may seem simple and obvious to many, but unfortunately are overlooked too often in practice.

2 SCATTER OF TEST RESULTS

Considering the environmental conditions of soil deposition it is only to be expected that strength and deformation properties of soils show some natural variation. Also sampling and testing contribute to the variation in test results. Therefore a certain scatter in the test results are to be expected.

Sampling and laboratory testing are expensive and therefore prior knowledge must be used when estimating the scatter. Harr (1987) has shown that the coefficient of variation ($V=s/x$, where s = standard deviation and x = mean value) can be considered as a constant for a given type of soil and a certain parameter. Thus with the coefficient of variation given, only the mean value needs to be determined.

In Sweden a research project focusing on Constant Rate of Strain consolidation tests on soft clays, were carried out (Magnusson et al.).

In one case the scatter in the results due to the fact that sampling was made by different consultants was investigated (all CRS-tests were then carried out by the Swedish Geotechnical Institute). In the other case sampling was made by personel from Chalmers University of Technology while the CRS tests were made by different laboratories. In both cases the coefficient of variation for the preconsolidation pressure was 8 to 12%.

In another project more than 50 CRS tests were carried out on samples taken from 10 to 70 m depth. The scatter along the trend line of increasing preconsolidation pressure with depth was small and corresponded to a coefficient of variation of 9%. This piece of information should be utilized in the settlement analysis since the preconsolidation pressure is an important parameter. Such an analysis taking into account the uncertainties involved is fairly simple (Harr 1987). In this way the quality of the analysis is quantified.

3 ERRONEOUS TEST RESULTS

Another type of scatter is obtained due to deficiencies in the testing apparatus. Everybody is aware of the importance of regular calibration of transducers, and the inspection of the apparatus in general. Rarely are, however, identical samples tested at different laboratories, which is a very good way of performing a quality assurance control. In such a test in Sweden, where CRS-tests were made on identical samples at 8 different laboratories, two were found to have oedometer rings which were a few tenths of a millimeter too wide. In Fig. 1, CRS-results obtained by oedometer tests using two different rings with slightly different diameters are given. The preconsolidation pressure differs consistently more than 10% for tests performed in these two rings. A careful inspection of the curves themselves shows that curve B is somewhat "disturbed", which is most clearly demonstrated by the pore pressure changes during the test. Thus a notch in the "poor" curve can be seen followed by a decrease in effective stress at a vertical stress of twice the shear strength almost indicating a pure shear failure.

Without a good quality assurance, erroneous results like these (curve B) can mislead soil engineers over a long period of time.

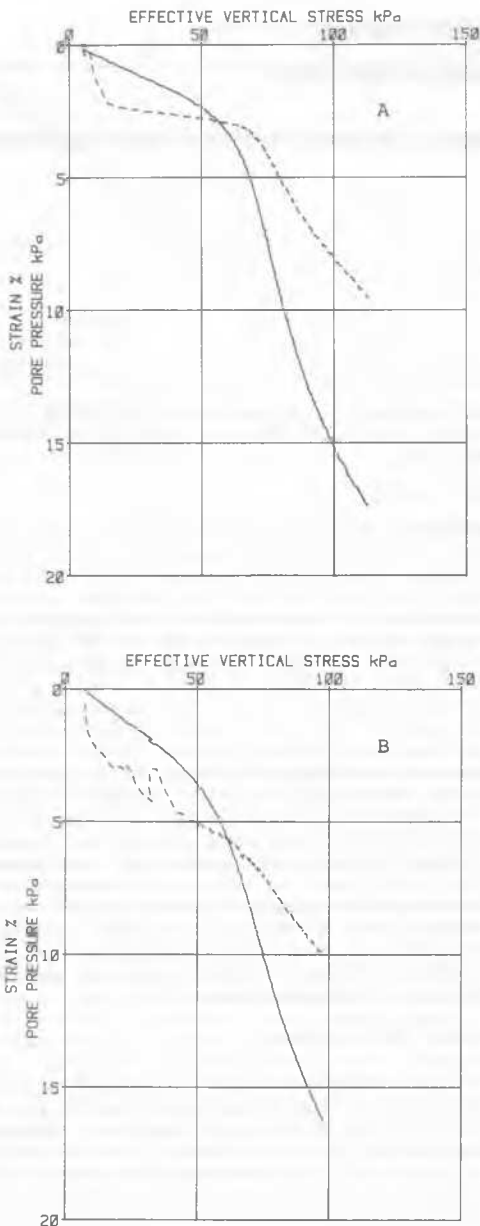


Fig. 1 Consolidation test data on soft clay from Bäckebol
 A high quality equipment
 B oedometer ring 2/10 mm too large

4 RESISTANCE TO USING NEW TYPE OF DATA OR TECHNIQUE

The rapid increase in the use of electronics in laboratory testing has in most cases resulted in higher quality of data and sometimes also in that parameters which earlier could not be determined, now can be determined with great ease. One such example is the coefficient of consolidation, which from incremental consolidation test, is determined with the use of curve-fitt-

ing methods. Through the derivation of Terzaghi's theory of consolidation it is known that

$$c_v = k M / g \rho_w$$

where k = permeability
 M = oedometer modulus

Still a constant value of c_v throughout the clay layer is often used, in spite of the great scatter and uncertainties in the results. Furthermore, a soil profile which is known to consist of different layers, is treated as a homogeneous soil with a constant permeability and modulus when the time settlement curve is to be determined. From CRS-tests the permeability for the samples can be determined with rather great accuracy, (coefficient of variation of about 20%). Rather simple numerical programs based on finite differences can then be used to calculate the settlements, then incorporating depth variations of k and M .

5 CONCLUSIONS

In this paper the question of quality assurance in laboratory testing has been brought up. A number of factors can be considered which all will improve the reliability of the analysis. It is clearly illustrated that a scatter in a parameter exists, and when this scatter is quantified, a basis for a sounder analysis is obtained.

The second important point is calibration and inspection of laboratory test equipment. The need for a regular check-up and possibly occasional parallel testing at different laboratories cannot be over-emphasised.

Thirdly, it is stated that the conservatism among many soil engineers delays the use of new superior data and means of analysis.

If all the above - mentioned aspects are taken into consideration the analysis can be more correct and also give relevant information on the uncertainties.

REFERENCES

- Harr, M., 1987. Reliability-based Design in Civil Engineering, Mc Graw Hill, New York
 Magnusson, O., Larsson, R. and Sällfors, G., 1988. The Effect of Sampling and Laboratory Testing on the Preconsolidation of Soft Clay (In Swedish). Nordic Geotechnical Conference. pp. 77-81, Oslo.
 Terzaghi, K., 1943. Theoretical Soil Mechanics. (John Wiley & Sons Inc.) New York.