Portable Geotechnical Field Equipment

Equipment Portatif pour l'Etude des Sols In Situ

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SYNOPSIS A new light and portable set of geotechnical boring devices for field investigations has been developed. With the equipment, one person can perform probing, disturbed and undisturbed sampling and in situ vane testing. Tests in areas with soft clay have shown that the equipment functions satisfactorily in practice and gives geotechnical data with acceptable accuracy. Intended applications include geotechnical surveys, mapping, pre-investigations, inspections, geological investigations, etc.

INTRODUCTION

The conventional tools for geotechnical field investigations are mostly heavy, bulky and have to be transported and handled with specially designed apparatus. For some investigations, especially where the purpose is to obtain preliminary geotechnical data, it often seems both practically and economically unsuitable to use these conventional devices.

A set of light and portable boring equipment has been developed and tested by the Swedish geotechnical institute to obtain inspection equipment for use in field investigations in connection with geotechnical and geological surveys. Using such a set, one person can perform probing, disturbed and undisturbed sampling and vane testing.

A few important pre-requisites were defined before the development work was started. The equipment should:

- be light and portable
- use the same type of rods for probing, sampling and vane testing
- be easy to handle and use
- be of appropriate size and design.

INSPECTION EQUIPMENT

The equipment was developed with these important requirements in mind. Prototypes of the tools were manufactured and have been tested in practical applications. Fig. 1 shows a complete set, with a few rods; from the bottom: the piston sampler, with an extra tube, auger and vane test equipment with different vanes. The whole set is designed for 10 mm dia. solid extension rods. The total weight, including 10 one-metre long rods, is about 10 kg and the equipment can be transported in a case and a tube, Fig. 2.

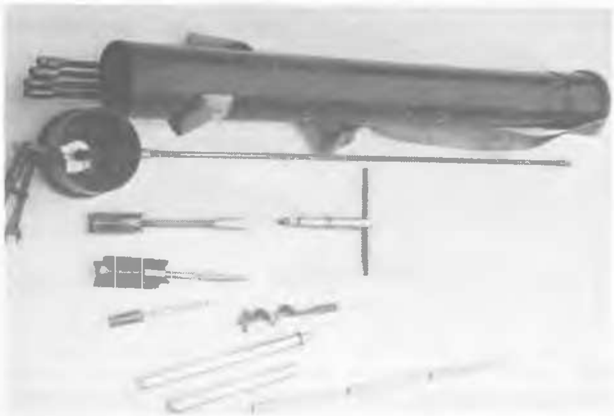


Fig. 1 Inspection equipment

Fig.2 The equipment can be transported in a case and tube.

Probe

Probing is performed to assess the type of soil, its thickness and relative firmness. The probing tip is pyramidal, with 15 mm sides, Fig. 3. The tip is screwed on to the rods and then pushed down into the ground. During probing, the soil firmness is assessed according to a subjective scale:

- very soft = the probe penetrates the soil under a load of less than 25 kg
- soft = a load of between 25 and 50 kg is required for penetration
- firm = a load in excess of 50 kg is required for penetration
- very firm = the probe must be hammered down.

The load is estimated by the operator.

Fig.3 Probing tip

Auger

The auger can be used to make holes in the dry crust through which disturbed sampling can be carried out.

A 150 mm long sampler with diameter 40 mm was found to be appropriate as regards the withdrawal resistance, Fig. 4.

Fig. 4 Auger

Piston sampler

"Undisturbed" samples which are 200 mm long and 21 mm diameter can be taken with the piston sampler.

The sampler consists principally of three parts, Fig. 5:

- Sample tube with piston
- Inner rod
- "Head" , with locking device.

Fig.5 Piston sampler

The sampler is connected to the 10 mm dia. rods by the inner rod. Sampling is performed as follows, Fig. 6.

1) A hole is made in the dry crust using the auger.
2) The piston sampler is pressed down to the desired level. During this action, the inner rod prevents the piston from moving.
3) The inner rod is then locked in an upper position and the piston released by lifting the rods about 200 mm.
4) The sampler is then pressed down a further 200 mm forcing the sample into the tube.
5) The sampler is then lifted and the tube containing the sample removed from the sampler. Another tube is connected if more sampling is to be carried out.

Sample tube with sample is then transported to the laboratory for testing. The device shown in Fig. 7 can be used to press out the sample and to carry out Swedish fall cone tests to determine the undrained shear strength. Compression tests can be carried out by inserting a piece of the sample in a special oedometer unit designed for the standard oedometer apparatus(see Fig.16).

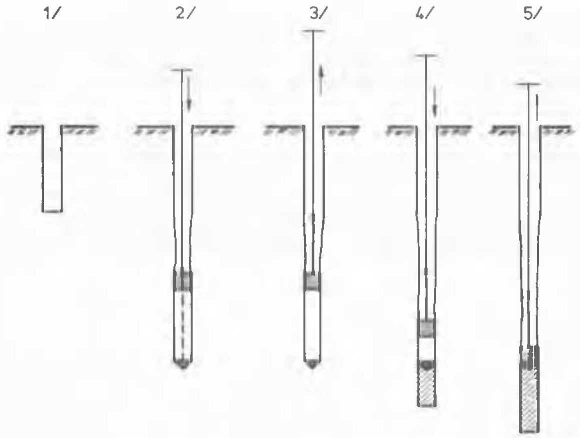


Fig.6 "Undisturbed" sampling with the 21 mm dia. piston sampler.

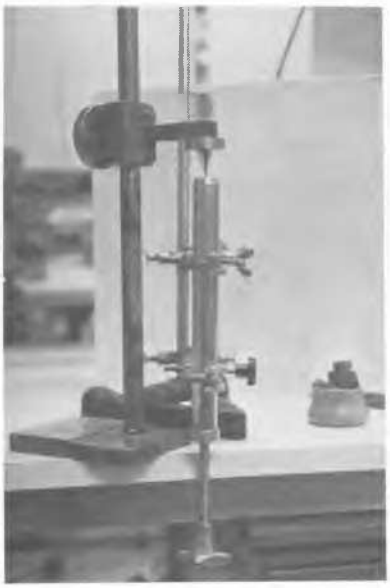


Fig.7 Fall cone tests in laboratory. The device at the bottom of the sample tube is used to press out sample.

Vane test equipment

The vane test equipment consists of three parts Fig. 8.

- Vane
- "House" with loose-coupling device
- Instrument (type Geonor)

Three different vane dimensions have been manufactured: 55 x 110 mm (τ_f < 10 kPa), 40 x 80 mm (10 < τ_f < 30 kPa) and 25 x 50 mm (τ_f > 30 kPa)

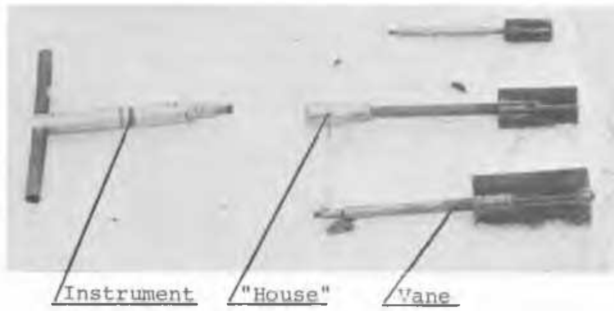


Fig.8 Vane test equipment

The instrument is provided with a scale on which the torque can be read directly. The vane test equipment is used in the following way:

The vane is pushed down to the desired level. The instrument is turned until failure occurs and the torque is noted. The skin friction along the rods is determined by lifting the rods 1 cm, thus releasing the vane, and then turning the instrument. The rods are then again pushed down 1 cm and the rods engage the vane. If the sensitivity is to be measured, the system is turned 25 times and the measurement is repeated. The system is then pushed down to the next level and the measurement is repeated.

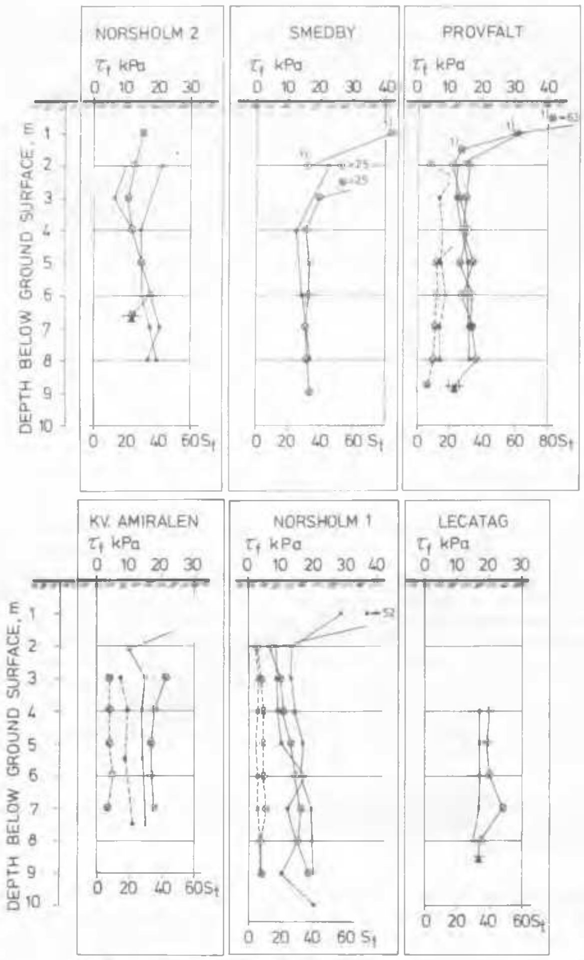
TEST RESULTS

Tests have been carried out in several areas with soft clay to study the practical function of the equipment, its reliability and the accuracy of the geotechnical data obtained. All the test sites have been investigated earlier using conventional techniques and the test results obtained using the light inspection equipment have been compared with this "reference" data. This paper shows results from tests with the light vane equipment and samples from ϕ21 mm piston sampler.

The clay in most of the test areas is soft, with an undrained shear strength between 10 and 25 kPa. The upper dry crust is about 1.5-2.5 m thick and very firm, so 40 mm dia. holes have been bored down to the underlaying soft clay, using the auger. Undisturbed sampling and vane testing have been carried out at various depths not exceeding about 10 m.

Light vane tests

The undrained shear strengths from the different test sites measured with the light vane test equipment are shown in Fig. 9 in comparison with "reference" data. The 40 x 80 mm vane was used in most of the tests. A few tests were carried out in the dry crust using the 25 x 50 mm vane. The vane was loaded continuously and failure occurred in about 30 sec.



Fall cone test

Conv. vane test

Light vane test

Results with 25x50 mm vane

Sensitivity

Fig.9 Vane test results from the different test sites.

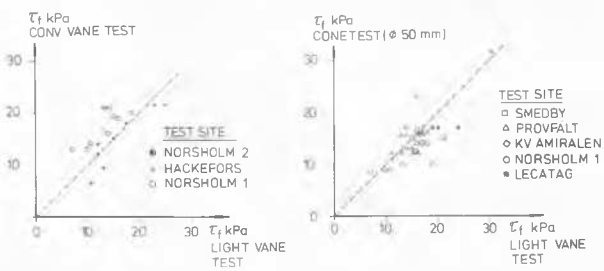


Fig.10 Undrained shear strength from light vane test compared with
a) conventional vane test
b) fall cone test.

In Fig. 10, the undrained shear strengths measured using the light vane test equipment are compared with the results obtained using conventional vane equipment and fall cone tests on 50 mm dia. samples.

It appears that the light vane test equipment gives slightly lower values than conventional vane equipment but slightly higher than the fall cone test results. However, differences are usually small and may be regarded as natural variations.

21 mm dia. samples

Samples from the 21 mm dia. piston sampler have been analysed in the laboratory, and undrained shear strength, sensitivity, water content, liquid limit and density have been determined. Compression tests have been performed on a few samples. The lower parts of samples have been used for cone tests, the middle parts for compression tests and the upper parts for density determination, Fig. 11.

Fig.11 21 mm dia. sample

The comparison between undrained shear strenghts determined by cone tests on 21 mm dia. and 50 mm dia. samples shows close agreement, Fig. 12.

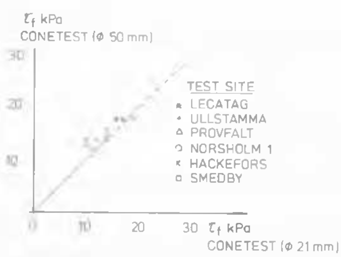


Fig.12 Comparison between shear strength determined by fall cone tests on 21 mm dia. and 50 mm dia. samples.

Fig. 13 shows a comparison between the results from laboratory investigations on 21 mm dia. samples and 50 mm dia. samples from three test sites.

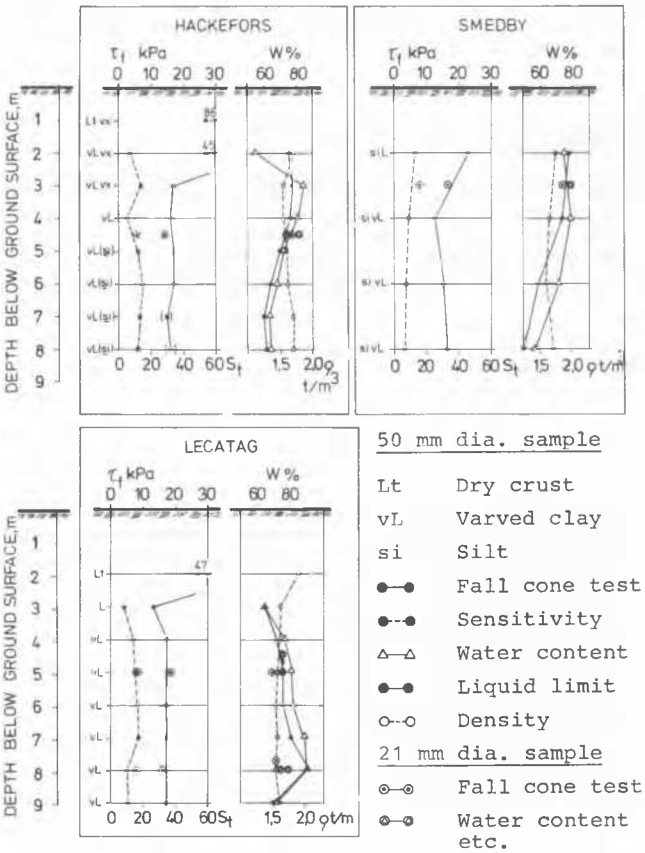


Fig. 13 Results from laboratory investigations. Results from 21 mm dia. samples are marked with a ring.

All the fall cone tests were carried out with 6-8 impressions, using a 100 g,30° cone on each sample. The variation was usually less than 25%. The values shown are average values. Shear strengths determined on different sections of a few samples are shown in Fig. 14. As expected, the sample is most disturbed in its upper part, while the middle and lower parts show consistent values. The lower part of the sample from the Smedby test site is disturbed because the sampler was pushed down about 10 cm too deep.

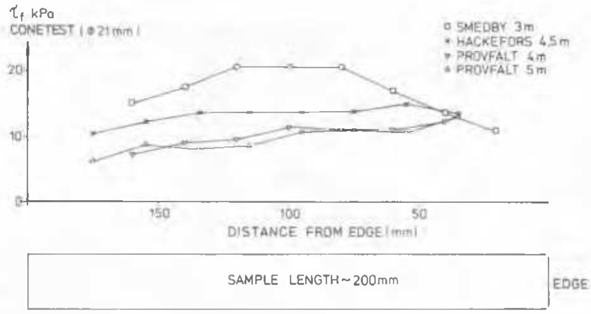


Fig. 14 Undrained shear strength on different sections of four 21 mm dia. samples.

A few compression tests have been carried out using the special oedometer unit. The sample height in all tests was 20 mm. The results are shown in Fig. 15 compared with tests on 50 mm dia. samples. The oedometer apparatus is shown in Fig. 16.

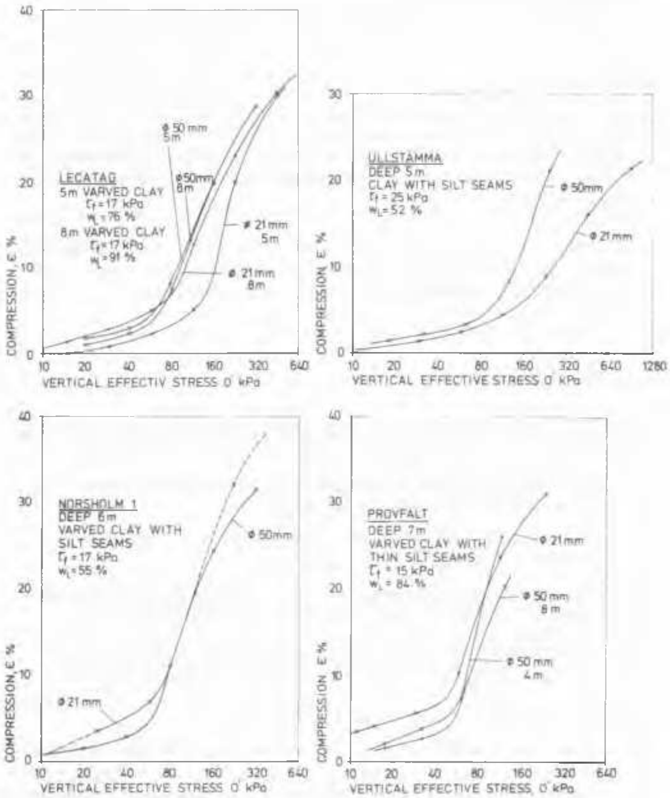


Fig. 15 Results from compression tests.

Fig.16 Oedometer apparatus.

The curve is difficult to evaluate for clay with a high preconsolidation pressure (Ullstämma). The curve can be evaluated for clay with a lower preconsolidation pressure using for example, the Casagrande method and consolidation properties determined.

It should be noted that only a few compression tests have been carried out and no general conclusion can therefore be drawn yet.

APPLICATIONS

The light inspection set has several advantages which make it suitable for many applications.

- It is easy to transport and store because of its small weight and size.
- It is simple to use and maintain because of simple construction.
- One person can carry and operate the equipment, without any special arrangements.
- The geotechnical data obtained shows acceptable accuracy for intended applications.

The main field of applications are

- geotechnical surveys, mapping, often performed over large areas, sometimes in rough terrain and with long distances between investigation sites,
- inspections and pre-investigations in which preliminary geotechnical data can be obtained quickly and simply,
- geological investigations, for the execution of chemical analyses, pollen analyses, diatomé-analyses, etc.

CONCLUSIONS

The tests have shown that the equipment works satisfactorily in practice and, in comparison with conventional techniques, gives acceptable geotechnical data. More tests will be performed, especially compression tests, to obtain better clarification of the accuracy and reliability of the data obtained.

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