Sounding, Measurement of Shear Strength in Situ, and Sampling by Means of the Helical Sounding Borer Driven by the Boring Machine Asond

Sondage, mesure de la résistance au cisaillement in situ et prélèvement d'échantillons au moyen de la tarière helicoïdale, actionnée par la machine de forage « Asond »

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Summary

The Asond boring machine (an abbreviation of « automatic sounding »), is a mechanical adaptation of the old Swedish static weight-sounding method. The development of the Asond method, including the sampling operation, has led to the design of a helical sounding borer.

This machine consists of a central rod provided with a thin screw-shaped flange, the screw being divided into two parts. When driven down, the parts are pressed together. When withdrawn, the upper part of the screw is first lifted, and the lower part follows. In this way it is possible to measure the force required to shear off the soil and thereby to calculate its shear strength.

After the borer has been extracted, the soil left between the flanges of the screw can be examined. The specimens have shown very little disturbance in their central parts when measured by the fall-cone test.

The results obtained with this apparatus have been compared with field vane tests and laboratory tests. Results have been very satisfactory, and it has been possible to carry out simple sounding, sampling and in-situ shear strength measurements with a single equipment.

Sommaire

La machine de forage « Asond » (une abréviation du terme « automatic sounding » sondage automatique) est une adaptation mécanique de l'ancienne méthode suédoise de sondage par pénétration statique. Le développement de la méthode Asond qui permet le prélèvement d'échantillons, conduisit à la construction de l'appareil dénommé « foreuse hélicoïdale ».

La foreuse hélicoïdale consiste en une tige centrale munie d'une vis ; celle-ci est partagée en deux parties. Pendant l'enfoncement, les parties sont en contact. En tirant, on lève d'abord la partie supérieure de la vis et ensuite sa partie inférieure. De cette façon il est possible de mesurer la force nécessaire au cisaillement du sol et ainsi de calculer sa résitance au cisaillement.

A l'extraction de la tarière, le sol entre les pas de vis peut être examiné. Il est surprenant de constater que les échantillons sont très peu remaniés dans leur partie centrale, à en juger par les mesures de l'essai au cône.

Les résultats obtenus par la méthode de sondage hélicoïdal ont été comparés à ceux de l'essai au moulinet tant au chantier qu'au laboratoire. Les résultats s'accordent bien et la méthode s'est montrée utile, car elle permet de réaliser, avec sensiblement le même équipement, le sondage simple, le prélèvement d'échantillon et la détermination in-situ de la résistance au cisaillement.

Introduction

In Sweden, exploratory boring is generally done by static weight-sounding, where a 20 mm diameter rod with a screw point is exposed to a series of weight-loadings up to 100 kg; in hard soil it is rotated with this load and the sinking is recorded for every 25 half turns. The next step is often sampling with a piston sampler, or vane boring.

Weight-sounding, which is performed by hand, often takes a long time at great depths and in firm ground. This stimulated the development of a method which resulted in the Asond equipment (automatic sounding machine). When testing this device, it was found that after altering the shape of the screw point and making special arrangements for withdrawing the borer and mesuring the pulling force, the shear strength of the soil could be measured.

This led to the development of the helical sounding borer, which can take the place of the vane borer without changing any part of the Asond machine apart from the screw point. The samples obtained were practically undisturbed, so that the undrained shear strength could be determined by the fall-cone test, and moisture content could also be measured.

The Asond Machine

The Asond Machine is shown in Fig. 1. It consists of a tripod scaffold (max. load 2 tons) with an electric motor (2 *HP*) and a transmission gear attached to guides on the scaffold and movable upwards and downwards; a portable generator supplies the necessary electric power. The motor is suspended via a dynamometer from the tripod and can be worked by a hand-operated winch. It rotates the drilling rod through a coupling. The weight of the motor including the gear is 100 kg.

The boring scaffold can be folded up and is provided with two rubber-tyred wheels, enabling it and the power generator to be hauled by an ordinary car (Fig. 2).

Use of the Asond Machine

Weight Sounding

As mentioned above, sounding with the Asond Machine follows the same principle as the existing sounding method. When sounding with the machine, the electric motor is placed on the top of the sounding rod, and the proportion of its weight that is transferred to the rod to drive it down at an even speed can easily be recorded. When the sounding rod does not sink by itself with a load of 100 kg, i.e. the weight of the motor, the motor is started and the rod is rotated. The rate of rotation is constant, 30 r.p.m., and adjusted so that during

Fig. 1 Asond boring machine during measurement of shear strength. Observe the guiding arrangement with the same pitch as that of the helical point (cf. Fig. 3).
La machine de forage Asond pendant des measures de la résistance au cisaillement. Remarquez le dispositif de guidage, de même pas que celui de la vis hélicoïdale de la pointe (comparez Fig. 3).

continuous working the operators can record the sinking on a fixed scale and the number of half-turns on a counter.

If, during rotation, a soft layer (< 100 kg load) suddenly appears, the falling of the motor is automatically stopped because of its suspension, allowing an accurate measurement of the extension of the soft layer.

The results of the soundings with the Asond Machine are plotted in the same way as those of the conventional weight-sounding method.

Another advantage of the Asond Machine is that sounding can be made continuously, which gives greater penetration capacity compared to manual sounding. It has proved that sometimes the penetration is even better than with ram boring, especially in hard moraine clays.

Fig. 2 Asond boring machine ready for transport.
La machine de forage Asond en position de transport.

Taking Disturbed Samples

By replacing the standard sounding screw point with a helical auger, the diameter of which can be varied (40 to 100 mm), and the length varying between 0·5 and 2·0 m, it is possible to take disturbed samples for occular examination, sieve analysis, etc. It has been shown to be suitable for most soils not containing very large stones. (In very hard and stony soils a bigger machine is used, the driving force being about ten times greater than that of the standard Asond Machine.)

Measurement of Shear Strength by means of the Helical Sounding Borer and Sampling, both Procedures Operated by the Asond Machine

Helical Sounding

The Asond Machine is also used to operate the helical sounding borer, shown in Fig. 3. It consists of a central rod

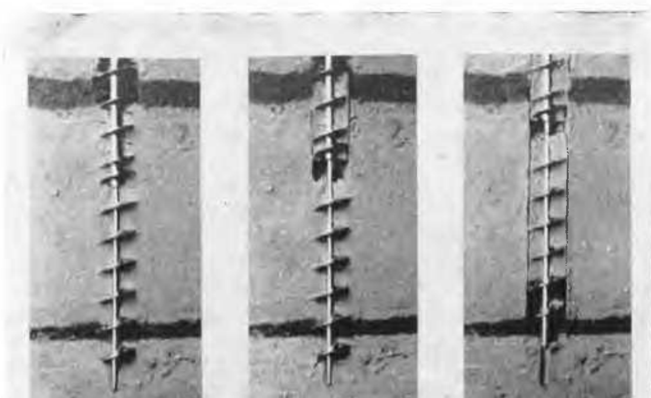

Fig. 3 Method of operating the helical sounding borer.
Mode de fonctionnement de la tarière hélicoïdale.
a) Driving position of the helical point
Position d'enfoncement de la pointe hélicoïdale.
b) Upper part of the point lifted.
La partie supérieure de la pointe est retirée.
c) The whole borer, including the lower part of the point, lifted.
Toute la tarière, y compris la partie inférieure de la pointe, est retirée.

provided with a thin screw-shaped flange and divided into two parts, an upper part and a lower part. Two sizes of helical points are used, one with a diameter of 70 mm and the other of 49 mm. In order to cause minimum disturbance to the ground as the borer is driven down, there is a guiding arrangement on the machine that forces the borer into the ground at the same pitch as that of the helical flange. There is also an arrangement for withdrawal which enables a slow, continuous lifting motion to be imparted to the borer for measurement of the pulling force. The speed of lifting is about 2 mm per minute.

When starting the boring, the helical point is coupled to the free part of the guiding arrangement, and then the two parts of the helical point are pressed together by forcing the motor down a few centimetres. The guiding arrangement is now fitted into the scaffold by two screws, and when the motor is started the borer is screwed donwards (Fig. 3 a). When the desired depth has been reached, the motor is stopped and the guiding arrangement is brought into action, so that the measurement proper can begin.

At withdrawal, only the upper part of the helical point is lifted at the start. The force required to lift this, including the weight of the boring motor and the rod, and the frictional resistance along the rod, is read on the dynamometer. After the upper part of the helical point has been lifted to its maxium travel of 30 mm (Fig. 3 b), the lower part of the point follows the same procedure. Rupture then occurs along the periphery of the surrounding cylinder (Fig. 3c). At the instant of rupture the pulling force is registered by a maximum indicator on the dynamometer. The difference between these two forces is the force required to shear off the soil by the helical point. Since the area of rupture is known, the shearing resistance of the soil thus tested can be calculated.

The range of strength determination by the helical sounding borer is between 0 and 50 tons/m^2. The latter value is obtained in moraine clays using a smaller, more robust type of helical point.

Rupture curves for somes typical Swedish soils can be seen in Fig. 4. The shapes of the curves are about the same as those of the vane borer tests.

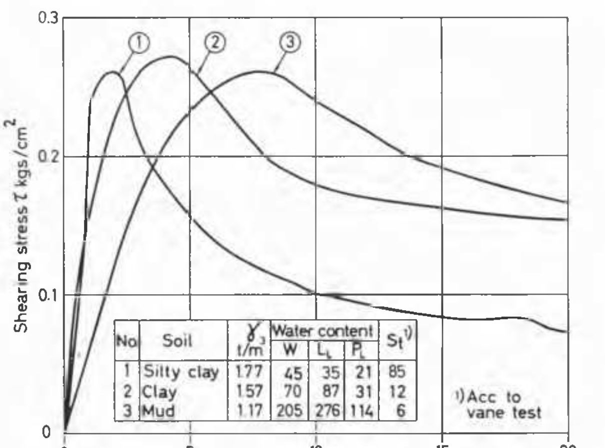

Fig. 4 Typical rupture curves from helical sounding in soils having different cohesive properties.

Courbes de rupture types relatives à des sondages helicoïdaux des sols de cohésion différente.

Taking Undisturbed Samples

When extracting the helical sounding borer, soil is left between the flanges of the helical point. Investigations of the specimens with the Swedish fall-cone test apparatus showed that the soil thus extracted is very little disturbed in its central part, i.e. it is possible to obtain representative samples with the equipment which will give reliable figures of shear strength, unit weight and moisture content.

The samples are punched out in small cylindrical containers of a diameter of 43 mm and a height of 20 mm, as shown in Fig. 5. The containers are placed in tens in a sample casing tube with special tight-fitting washers leather between the containers. Lids are put on the casing tube, which is then sent to the laboratory. If the samples consist of very sensitive (quick) clay, they are cone-tested on the site with respect to the undrained shear strength.

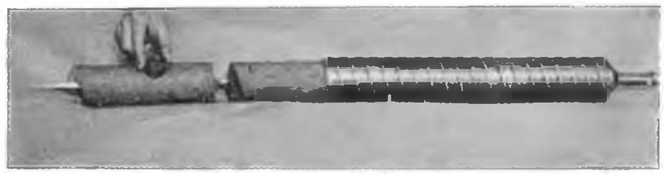

Fig. 5 Clay sample extracted with the helical sounding borer (the point pushed out of the sampling protection tube), and punching out of a specimen for laboratory testing. Note the distance between the upper and lower parts of the helical point.

Echantillon d'argile extrait au moyen de la tarière helicoïdale (la pointe du tube protecteur de prélèvement est sortie) et poinçonnage d'un spécimen en vue d'un essai de laboratoire. Remarquez la distance entre les parties supérieure et inférieure de la pointe hélicoïdale.

When first using the helical sounding borer as a sampler, there was a tendency for soft, sensitive soils to slip from the flanges. For this reason a protection tube was provided, with external threads of the same pitch as that of the point flanges, into which the point with its sample could be withdrawn when extracting the whole borer, mounted above the helical point.

The protection tube can be seen to the right in Fig. 5.

When sampling at great depths, the samples obtained first showed slight disturbance. This was due to excess pressure during driving into the ground from the sample protection tube, the upper part of which was closed. A vacuum below the tip of the helical point during withdrawal might also be regarded as the cause of possible disturbance.

A new protection tube was therefore constructed with a ventilation arrangement at its top. After this improvement, the shear strength values appeared to be as good as could be desired.

Comparison between results of tests with the helical sounding borer and other methods, and practical application

The helical sounding borer method has been used with success on many sites in Sweden and has also been tested on sites where the Swedish Geotechnical Institute (SGI) has performed borings for research and consulting purposes. Comparisons have been made with vane tests in the field, and with unconfined compression tests and fall-cone tests in the laboratory. Some typical results are given in Figs. 6 to 8.

As can be seen in Fig. 6, the two curves of the helical sounding borer follow the curve of the vane test very well. No noticeable disturbance can be observed in the region of the very sensitive (quick) clay between + 3 and — 5 m. Figs. 7 and 8 also show good agreement with the vane and laboratory test results.

The capacity of the helical sounding borer as driven by the Asond machine depends on the type of the soil to be tested.

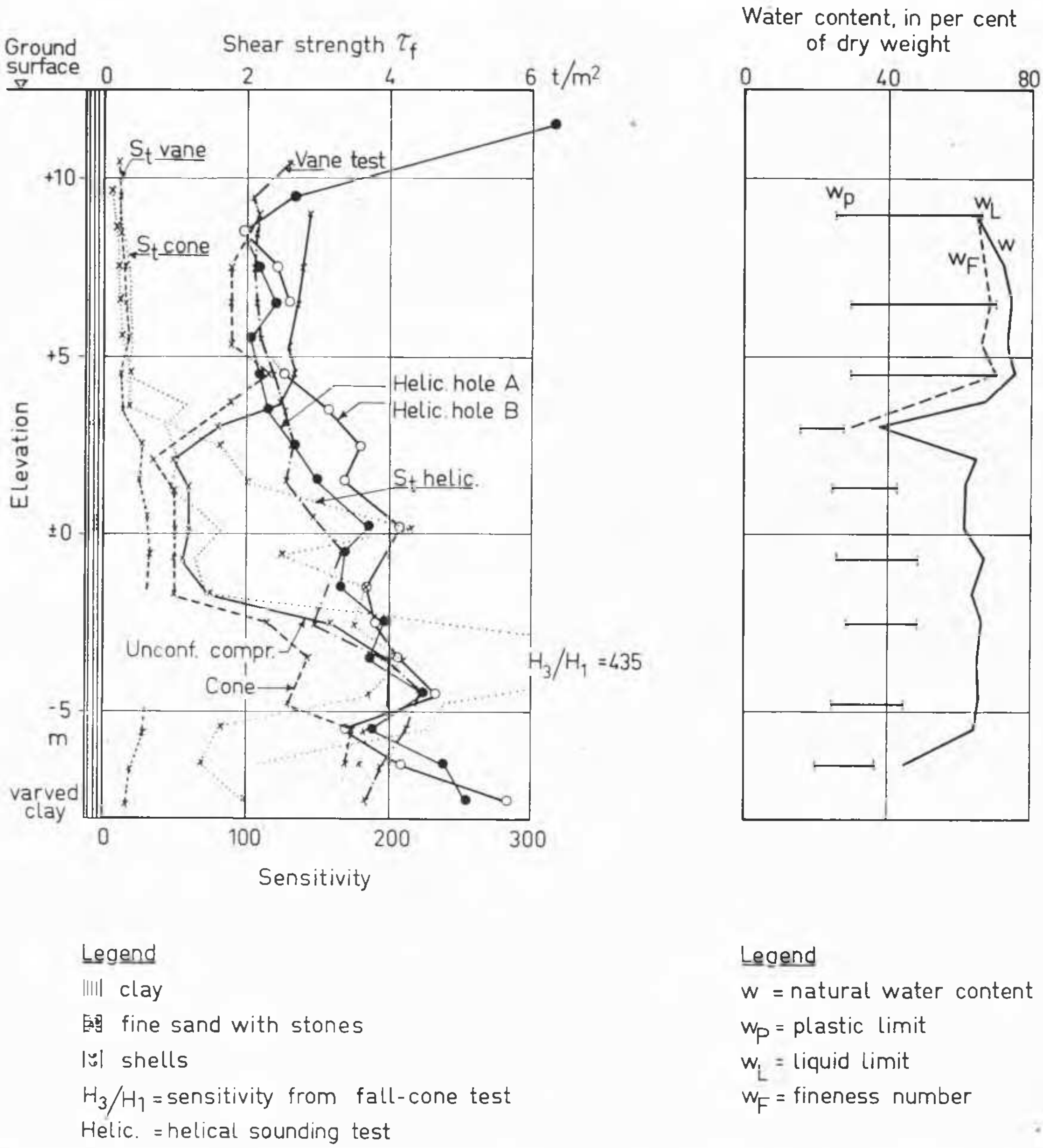

Fig. 6 Results from investigations by helical borings, vane tests and laboratory tests of very sensitive (quick) clay at Strandbacken, Göta River Valley, southwestern Sweden.

Résultats de recherches sur de l'argile partiellement très sensible au remaniement (fluide), relatives à des sondages hélicoïdaux, à des essais de moulinet et à des essais de laboratoire et faites à Strandbacken, vallée du Göta, au sud-ouest de la Suède.

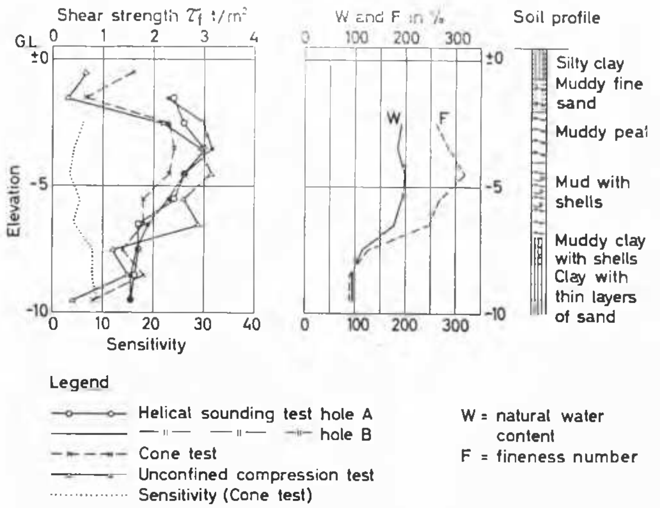

Fig. 7 Results from investigations by helical borings and laboratory tests of organic soils at Löddeköpinge, southern Sweden.

Résultats de recherches sur des sols organiques, relatives à des sondages hélicoïdaux et à des essais de laboratoire, faites à Löddeköpinge au sud de la Suède.

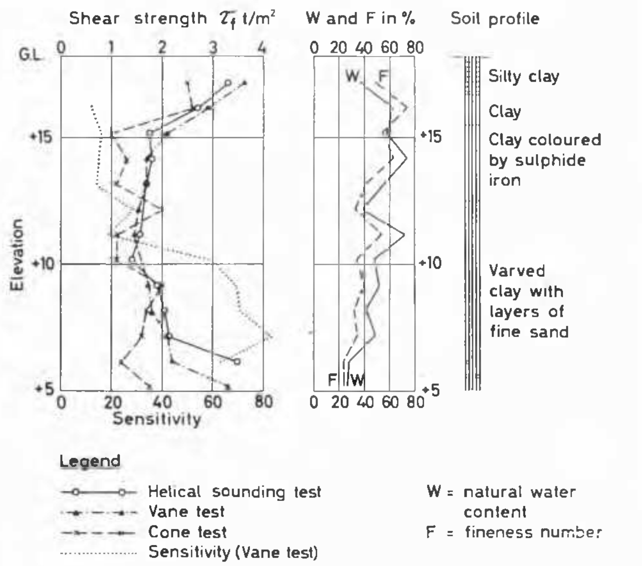

Fig. 8 Results from investigations by helical borings, vane tests and fall-cone tests at Örebro, central Sweden.

Résultats de recherches relatives à des sondages hélicoïdaux, à des essais de moulinet et à des essais au cône, faites à Örebro, au centre de la Suède.

For normal Swedish soils with a τ_f of 1 to 4 tons/m^2, 30 to 40 tests can be made in one working day of 8 hours.

For handling, one boring foreman and one or two workmen are required. One of the workmen is engaged in cleaning the equipment and helping in its transport.

It is intended to develop the method further and if possible to be able to measure the degree of compaction and the elastic properties of the soil.

Acknowledgements

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