III a 4

A METHOD OF EXTRACTING LONG CONTINUOUS CORES OF UNDISTURBED SOIL

W. KJELLMAN and T. KALLSTENIUS
The Royal Swedish Geotechnical Institute

INTRODUCTION.

When investigating ground conditions, it would be useful to be able to extract long continuous cores of soil with undisturbed structure. If however, for this purpose an ordinary tube is driven down into the soil, it appears that the tube owing to friction and adhesion on its inside to a certain extent drags the core, thus formed, with it downwards. This means that part of the soil mass immediately beneath the mouth of the tube is diverted instead of caught by the mouth. This tendency is stronger, the softer the soil beneath the mouth is and the harder and longer the core already formed. Consequently, the natural soil layers will appear in the core with a thickness, which is reduced to an unknown degree, and with a structure, which is disturbed to an unknown extent. On the whole, in most soils only very short cores, i.e. samples, can be obtained in this way.

In order to reduce the friction and adhesion between the tube and the core, the tube usually has a small "clearance", i.e. the inner diameter is a little less at the lower end of the tube than in the rest of it; further, as proposed by Hvorslev, the tube is forced down by one single rapid drive. Undisturbed samples of a maximum length (as far as we know) of 1,8 m have thus been taken in cohesive soils. Whether the same measures have any effect in cohesion-less soils, we do not know.

PRINCIPLE OF THE CORE-EXTRACTOR.

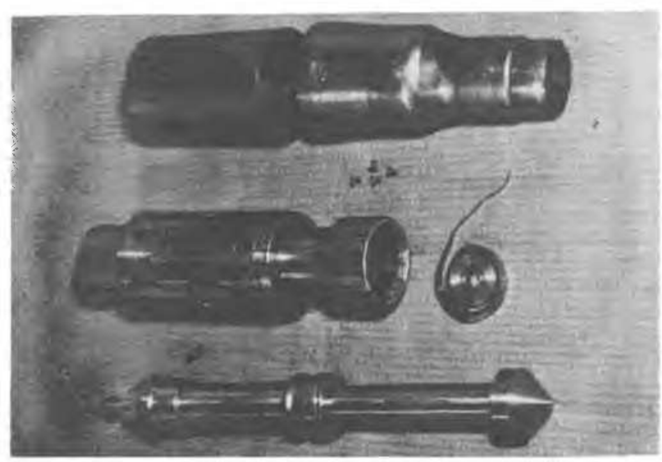
According to the method, described in this paper, the errors and difficulties caused by friction and adhesion between core and tube are eliminated by "insulating" the core from the tube by means of a number of thin axially running metal strips or foils, the upper ends of which are fastened to a piston, which is placed in the tube above the core and by means of a rod is attached to a driving scaffold on the soil surface. During the driving of the tube sliding occurs between the tube and the foils; friction thus produced causes a pulling force in the foils and their anchorage but does not affect the core. If for some reason the core should tend to move downwards or upwards, this movement is immediately prevented by friction and adhesion, which in such case arise between foils and core. Friction and adhesion, which hitherto were the main causes of all troubles, are in this way turned into useful agents, which compel each soil layer to keep its original thickness and structure unchanged on its way into the tube.

The lower part of the extractor is double-walled and serves as a magazine for the foils, being stored in a roll. Within the magazine each foil runs from its roll downwards to a horizontal slot, arranged in the inner wall at the bottom of the magazine. Here the foil runs through the slot and then in between the core and the wall, where it continues upwards to the piston.

DETAILS.

The inner diameter of the core-extractor is approximately 68 mm. Sixteen foils, each 12,5 mm broad, are used, together covering very nearly the whole circumference of the core. The foils are mostly made of soft iron, hard-rolled. Foils made from hardened steel have also been used with good result; these have a higher strength but will rust more easily. Foil thicknesses between 0,10 and 0,04 mm have been tried with good result. The maximum length of foil, that can be stored in each roll in the magazine, varies according to the thickness between 20 and 40 m.

In order to limit the maximum outer diameter of the extractor as much as possible, the foil rolls are placed, as can be seen on fig. 1, in four different stories, the axis



Core-extractor taken to pieces.

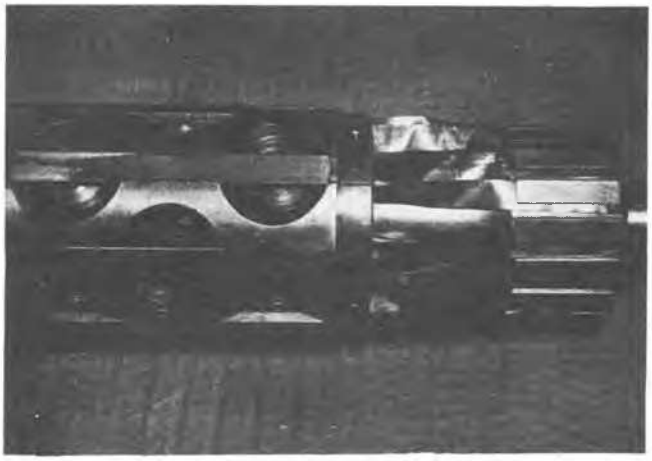
FIG. 1

of each roll being radially directed. Each roll is placed in a recess in the thick inner wall (as visible also in fig. 3) and kept in place by a vertical bar. Each foil on its way downwards from the roll to the slot is twisted 90° by means of guide slots, visible in fig. 2. (In fig. 3 the foils are shown only in the rolls.)

Below the magazine the extractor is extended downwards a certain distance, as shown in fig. 3. Here it is single-walled, the wall thickness being as small as advisable with regard to the strength. It ends in a thin and sharp steel cutting edge, kept in place by a threaded ring. By virtue of its shape the edge can easily be very well hardened. It is inexpensive and easily changed.

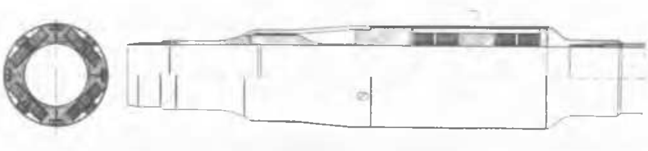
The outer wall is divided into an upper and a lower part, the former being kept in position by the latter, which is attached to the inner wall by four screws. The part below the magazine is screwed to the outer wall. Thus, by unscrewing the four screws and removing the outer wall, the rolls and foils are easily and quickly made accessible.

The inner wall is screwed to the single-



Inner wall with foil rolls and twisted foils

FIG. 2



Core-extractor in elevation, longitudinal section and cross section.

FIG. 3

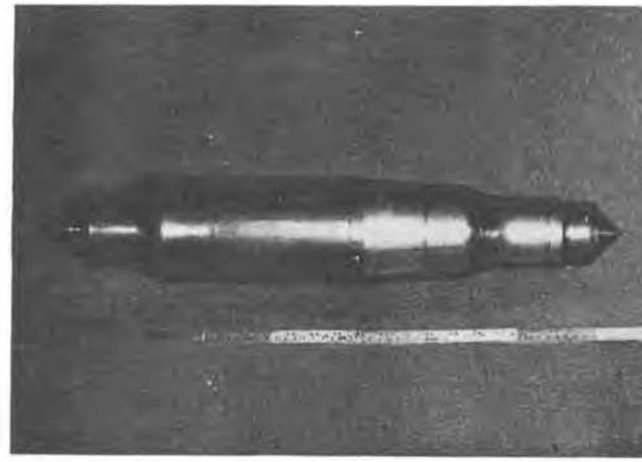
walled tube above the magazine. This tube consists of 2,5 m long sections, connected by coupling-boxes, which are so made, that they can be removed by dividing longitudinally. Thus the sections of the tube can be taken apart without being turned in relation to each other.

The piston is seen on the left of fig. 1. The upper ends of the foils are wedged securely to it by means of a conical ring, visible halfway up on the piston. On its upper end the piston is provided with such arrangements, that it can be fixed in its lowest position relative to the extractor. In this position the lower end of the piston covers the lower mouth of the extractor, as seen in fig. 4, so that if desired the extractor can be driven down into the ground without producing any core. When the depth has been reached, where core-extraction is to begin, the rod, provided with a special catch, is lowered in the tube until it engages the head on top of the piston, visible in fig. 1 and 4. The piston is thereby released from the extractor and attached to the rod, which is then clamped to the driving scaffold, the lower mouth of the extractor being thus freed to admit the core.

A provisional driving scaffold, used so far, is seen in fig. 5. The driving force is produced by two chain-jacks, and the reaction force is taken by four screw-shaped soil anchors. (When the photo was taken, a thin chain was used instead of a rod for anchoring the piston to the scaffold.) A much better type of driving scaffold, mounted on a cart, is under construction.

STRESSES IN THE CORE.

If a tube without foils is driven down into clay, downward directed shear stresses are transmitted by adhesion from the tube to the core. These stresses increase the vertic



Core- extractor assembled.

FIG 4

Driving scaffold.

FIG. 5

al normal stress in the core, so that at any given depth it will be greater than the stress outside the tube (at some distance from it). This difference increases with the driving depth, until no more soil can enter the tube.

By introducing the foils the core is protected from shear stresses, so that its stresses are reduced to equal those outside the tube. Because of the horizontal pressure from the clay on the foils, friction arises between the foils and the tube, causing a pulling force in the foils. As long as the depth is moderate, the foils can withstand this pulling force, but if very great depths are reached, the foils may break. (Probably the friction between the foils and the tube is reduced to some extent by remolded clay, coming from the core, but on the other hand some adhesion may appear.)

In order to reduce the pulling force in the foils a clearance is arranged in the core-extractor, amounting to a few thousandths of its diameter, i.e. essentially less than recommended by Hvorslev. In order to secure contact and adhesion between the core and the foils, the clearance begins only at a certain distance above the slot in the inner wall.

The clearance can reduce the horizontal pressure in the core considerably, only if the core adheres to the foils, so that the vertical pressure decreases. If the adhesion between the core and the foils exceeds 0,003 kg/cm^2, as it usually does, the entire weight of the core can hang on the foils, so that all stresses in the core become extremely small. In this borderline case there is no friction between the foils and the tube, and the foils need sustain the weight of the core only.

The pressure in the core must decrease from a certain value in the lower mouth of the extractor to a smaller value in the section, where the clearance begins. This decrease is effectuated mainly by adhesion and friction on the core between said sections. A length of this pressure-decreasing part of 2-4 times the inner diameter should do in clay, according to our experience so far.

When extracting cores from sand ground, the influence of the foils and of the clearance upon the stresses in the core is still more pronounced than described above.

Without foils the increase of the normal stresses in the core, caused by the friction from the tube, leads in its turn to an increase of the friction. This phenomenon is the reverse of the silo-effect and can be calculated in a corresponding way. It appears, that the stresses in the core increase enormously with the depth so that only very short cores, or rather samples, can be taken.

By introducing the foils the downward directed friction on the core is eliminated. Consequently the reversed silo-effect vanishes, so that the stresses inside the tube are reduced to the same values as outside it.

When in addition clearance is introduced, upward directed friction arises on the core. Thus the ordinary silo-effect comes into play reducing all stresses in the core to very low values.

DISCUSSION.

The rather considerable wall thickness of the core-extractor in cross section through the magazine may seem open to objection. However, according to our experience so far the distance from the magazine to the cutting edge is great enough to prevent the magazine from affecting the soil below the edge. The distance can easily be made still longer, if need be. Another model of the core-extractor, seen in fig. 6, is of extremely slender shape,

Special core-extractor for soft soil and small depth.

FIG. 6

and the foils are extended almost to the cutting edge. This model was made for softer ground and smaller depth than the robust model described above.

During the last two years a great number of cores have been taken by the core-extract-or in all kinds of soils varying from fat clay to coarse sand. Practically all cores seemed to be quite undisturbed. It may be mentioned, that the core-extractor is used now in Geochronology, which deals with counting and measuring the thin layers of the varved clay in such an accurate way, that up to now no sampler but only open shafts could be used.

The longest core so far was slightly above 20 m. Fig. 7 shows a core, 10 m long,

Core of clay 10 m long.

FIG. 7

resting in a wooden groove. Every core longer than 5 m is divided, when being lifted out of the ground, into sections of 5 m (or 2,5 m if desired) by removing the coupling-boxes and cutting the foils and the core. Such cores as are to be sent to the laboratory, are furnished with a cap and a seal on each end of the tube. The core is taken out of the tube by pulling the foils at one end of the tube. After it has been examined, recorded, photographed etc, representative samples for laboratory tests are cut out of its different layers.

Obviously a continuous core as described in this paper, gives a much better conception of the ground than any number of samples. Extracting one core, reaching from the soil surface to a given depth, needs less time and less work than taking one sample at each two metres down to the same depth. Even if sometimes one does not wish to take continuous cores from the surface to the firm ground, it may be of great help to be able to take cores of say 5 m length in order to be sure of obtaining samples of certain layers which are of special interest.

In very hard soils, where the driving of the core-extractor is difficult, a casing may be used and the soil, entering the interspace between the extractor and the casing, removed by jetting or otherwise. Hitherto ramming has been used in hard soils; the extractor and the foils have proved resistant to this hard treatment, and the cores have shown no sign of disturbance.

A core-catcher can easily be arranged in combination with the magazine. So far it was not found necessary.

SUMMARY.

The report deals with a quite new type of soil investigation device, called core-extractor. This device makes it possible to take very long continuous and undisturbed cores from any soil finer than gravel and not too hard. The extractor is described in principle and in detail. The stress system in the core during the driving of the extractor is analysed. Experience of the device, gained so far, is discussed.

-o-o-o-c-o-o-

SUB-SECTION III b

MEASUREMENTS OF SPECIAL SOIL PROPERTIES

III b 1

PERMEABILITY OF PEAT BY WATER

IR. J.L.A. CUPERUS
Netherland Railways

Obtaining a better insight into the behaviour of soft peat, when a load of sand is brought to bear into it, by previously determining the permeability of the peat by water with a suitable apparatus.

When in tract of land, consisting of soft peat, a road or a dike is constructed or - with some other end in view - a load of sand is brought to bear, the water in the peat comes under pressure and under this pressure the water is driven out into and outside the marginal region of the load.

When in 1938 an experimental section was executed in behalf of the strengthening of the railway between Utrecht and Rotterdam near Gouda, it has been found, that disturbance of equilibrium occurs at a certain excess water pressure in that marginal region, in consequence of which extensive slidings of earth have taken place.

In the above-mentioned case (I) the condition was as indicated in fig. 1.

At that place the railway was situated in a tract of very soft peat and it had to be strengthened because of inadmissible subsidences. 1)

The existing ditches beside the track were dredged out to 2.50 m beneath the level of the ground water. Subsequently sand was dumped into the ditches and after these had been completely filled up to the level of the surrounding area, they were heightened still further. When the heightening had reached about 2 m above the level of the ground water, a sliding took place (vide fig. 2).

At the commencement of this disturbance of equilibrium the excess pressure of the water in the pores in the marginal region of the load (point A) corresponded to a water pressure of about 1.50 m. 2)

During the further execution of the strengthening of the road-bed about 8 km east of the above-mentioned experimental section in a similar tract of land near Oudewater, (case II) an effort was also made to press away the soft layers of peat under the dumped sand, however, without any success. Even when heightening up to 3.50 m above the ground water no disturbance of equilibrium took place.

For the difference in behaviour three causes may be indicated:

1) Difference of thickness of the layer of peat.
2) Difference in the proportion of resistance of the peat.
3) Difference in the permeability of the peat by water.

I

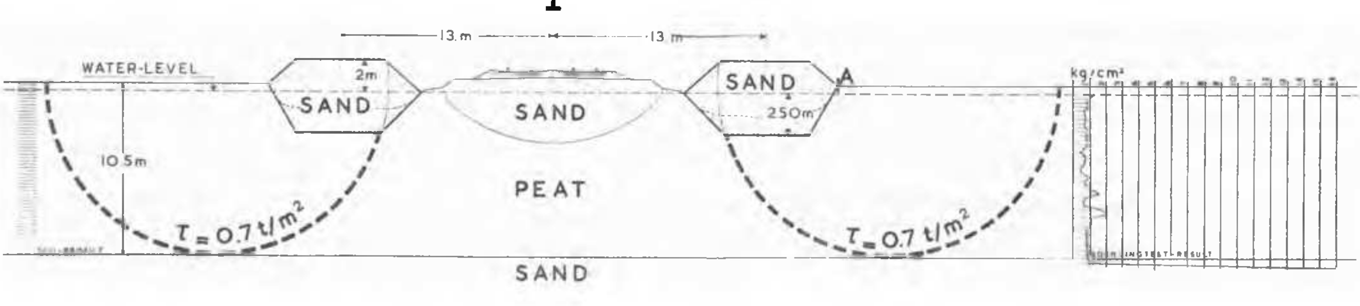


FIG. 1