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PRELIMINARY RESULTS OF CORING IN LOOSE STRATA

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In Switzerland it was relatively late that due attention was paid to earthwork mechanics and particularly to the obtaining of reliable information as to soils. The reason for this is that the Swiss diluvial and alluvial soils consist to a large extent of coarse grained strata and offer, as a rule, a sufficient bearing strength. Hence it was only recently that the need for mechanical investigation was evident in the Alps as well as in the lowlands, where the ground largely consists of fine grained strata.

The first coring operations in Switzerland were carried out in 1933 with the Burkhardt Borerod method (Schweizerische Bauzeitung, Zürich, 3rd June 1933). This is sufficiently well-known, and does not need to be described here. It may suffice to remark that the cores are taken by means of a specially constructed boretube, on the lower end of which a core-barrel is attached. The boretube and this apparatus are driven together into the strata which are to be bored. To overcome the outer friction, especially in boreholes of over 20 metres depth, a relatively great driving force is necessary. For this reason and also because of the springs contained in the apparatus to hold the cores, the samples suffer a great deal, and are therefore but little suited for physical investigations of the soil. In addition, the obtainable borehole length is limited by the friction of the tube.

The process (Hoch-und Tiefbau, Zürich, No. 47 & 48 1934. Patent A.eG. für Grundwasserbauten, Travaux Hydrauliques S.A., Berne.) developed by the author was put into action experimentally in the Autumn of 1932, but was first largely employed in Spring 1934 for the soundings in connection with the Nidau weir. By this method cores of about 30 cm diameter were obtained by using core-barrels of about 2 m in length, which were forced into the borehole by a special driving pipe. The process is developed in accordance with the following principles:

a. The core-barrel can be so constructed that it may be used for any set of pipes. It is thus possible to take continuous cores through the whole length of the borehole or to limit them to the strata which are of special interest from a mechanical point of view. The intermediate strata, which are not to be investigated, can simply be drilled up by the ordinary boring process. Any boring apparatus to carry out normal borings can be employed for such coring operations with slight adjustments.

b. The structure of soil-samples suffers considerably, as is well-known, even with the best sampling devices. The present method has been so developed as to minimize this, partly by reducing, to the greatest possible extent, the driving force for coring and partly by an especially developed core-catcher. Experience has shown that the coring of cohesive soils is most practicable when using a canvas casing (Swiss Patent No. 181191) fixed inside of the core-barrel. (Fig. 1) In strata which are but slightly cohesive a trap is used at the bottom of the core-barrel consisting of four flaps in two planes. (Patent pending Fig. 2).

c. It has been experienced that the inner structure of the cores is least disturbed when the apparatus is driven into the strata in question. But not more than 30 strokes a minute should be given. If the number of driving strokes is too great, the strata are set in continuous vibration, which has a very bad effect on the structure.

d. The inner core-barrel, or the core-container, consists of two semicircular parts, from which the core can easily be taken. On the site the cores are preserved in special boxes. (Fig. 2, etc.)

e. By telescoping the bore-tubes it is possible to obtain cores to any desired depth. Obstructions such as tree trunks or rocks can be chiselled through. Coring continues after drilling through such obstacles.

f. Special attention is paid to the economy of the coring operation. The boring apparatus is movable. The core-barrel is run into the borehole with strong drive pipes 2 metres long. The drive pipes are connected by bayonet joints of special construction, which enables the rapid introduction and withdrawal of the core-barrel. (Fig. 3)

The conclusions obtained from this boring process may be summarized as follows:

a. The speed of work depends on the depth of the boring and the nature of the strata to be pierced. In soft strata, e.g. chalk, silt, turf, etc., the progress is naturally much greater than in hard moraine. The table on the following page gives a summary.

b. It has been demonstrated by these borings that the process is very well suited for obtaining undisturbed cores. Fig. 4 and 5 show that the disturbance of the cores in moraines, even when these have intermediate sand, is very slight.

Coring is naturally more difficult and less satisfactory in cohesionless materials (Fig. 2). It must however be observed that this core had to be cut out with the scoop around large stones and therefore shows an irregular shape.

c. Disturbances of the core are caused principally by the driving, by the friction of the core on the inside of the core-container and by the fact that the latter is narrower than the driving shoe. The participation of the individual forces to the general disturbance depends on the nature and composition of the strata and is extremely difficult to determine. The disturbance depends besides on the coring method.

The driving-force generally results in a compression of the side strata, but also to some extent of those under the driving shoe. It is therefore essential that driving should take place with as light a weight as possible and a short stroke-length. The locus of the driving shoe (Fig. 8) shows that the work of driving is smaller in the upper part of the core than in the under portion. This observation is confirmed by the determinations of the water-content. In strongly water-bearing materials a greater water-content was found in the upper layers of the cores than in the lower layers, although apparently

Fig. 3
Setting up a drive pipe
(Shannon River)

Fig. 9
Whole core (test 25) and dissected core (test 26)
Obtained with driving shoe without an inner angle.

Place	Max depth of bore-holes	Internal dia. of bore tube	Core Dia.	Strata bored	Daily progress ex. installation & withdrawal Av.	Max.
Nidau Weir	15.0 m	350 mm	300 mm	Moraine & molasse	0.75 m	2.15 m
Steinbacher Viaduct	35.0 m	350/300 mm	300/225 mm	Fine sandy mud and clay mud	2.63 m	5.02 m
Hühnermatt-damm	40.0 m	350/300 mm	300/225 mm	Hard moraine, clay & gravel locally	1.17 m	3.20 m
Shannon, Ireland	20.0 m	350 mm	264 mm	Sandy clay, hard sand & gravel	1.69 m	3.32 m

the whole core contained the same material. For the carrying-out of soil investigation it is recommended to core short samples at a time.

The part of friction on the inside of the core-container is small in comparison to the total disturbance. Its amount depends on the shape of the shoe (See Fig. 6 and 9). The friction is at a minimum when the shoe runs vertically, and it increases with the fall from the vertical.

The chief influence of the disturbance is due to the difference in width of the shoe and the container. If the shoe is formed with an inner angle (Fig. 6a) the core becomes longer. In entirely plastic material the length of the core obtained in relation to the effective length is proportional to the square of d_1 and d_2. But as the cores are generally composed of different strata, the prolongation does not obey this law exactly. Still more troubling than the prolongation of the core for the physical investigation of the soil, is the disturbance of the structure caused by the variation of the section.

Clay cores (Hühnermattdam material) taken with an inward sloping shoe showed longitudinal cracks, as seen in Fig. 7. These disturbances are the result of the driving, the interior friction and the variation of the sections together. From this figure it can be seen that in a core of 300 mm diameter, the inner core portion of 240 mm diameter shows no disturbance. This part of the core is therefore quite suitable for physical examination of the soil. As the disturbance influences only the outer portions, cores with the greatest possible diameter should be taken. In the case of a less cohesive soil, conditions are naturally less suitable.

d. Exact observation of the locus of the core top and of the core bottom allows the correction of the core, that is to say, the determination of the effective length of the single strata composing the core (Fig. 8) (The diagram of determination was proposed originally by Dr. Burkhardt). But it must be observed that the bottom of the core breaks off on withdrawal and remains in the bore-hole. The length of this part of the core depends on the catcher of the core barrel.

The locus of the core top indicates the variations in the length of the core, while the locus of

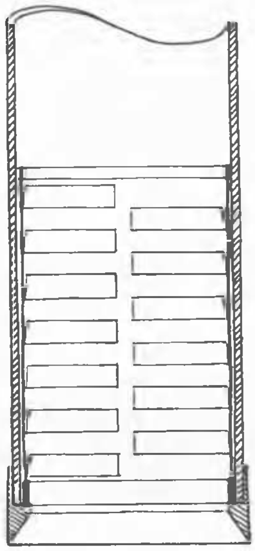

Fig. 1 (above). Core sampling tube with an inside canvas cover.

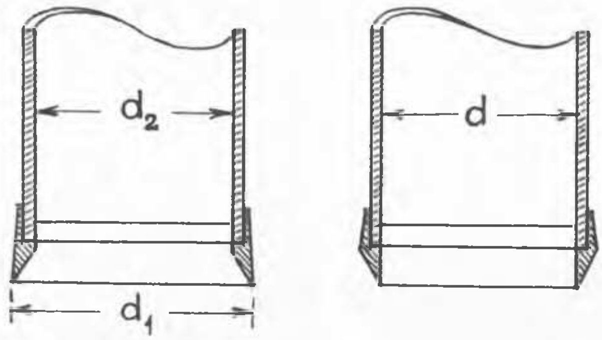

Fig. 6 a & b (above). Details of the Driving Shoes.

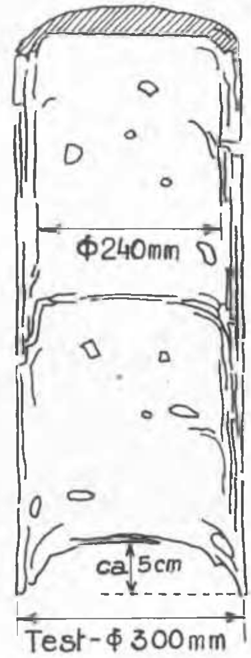

Fig. 7 (above). Defoliation of a core from moraine clay after drying.

the core bottom reveals the resistance, which the various strata opposed to the penetration of the container. This resistance increases with the depth on account of the exterior friction and the pressure of the superposed strata, so that the locus of the core bottom approaches a parabolic curve in homogeneous material. For this reason, the determination of the lengths of the single core parts in proportion to the total lengths of the core, is inexact. In spite of this fact, the composition of a core is never known in advance, with the result that the core top and core bottom must be observed continually.

e. Cores taken with a drive pipe shoe with inward angle allows an accurate granulometric analysis, and when corrected, also a geological analysis of the pierced strata. Such cores extracted from compact strata, e.g. moraine, compact clay, etc., having a sufficient diameter are useful also for physical investigations of the soil. Whereas such cores are not satisfactory when taken in loose strata.

f. For the above-mentioned reasons, and especially for extracting slightly coherent cores, the shoe should always be constructed without an inner angle. (Fig. 6 and 9) On the other hand the difficulty of coring will be increased by this shape of shoe, because the friction of the core on the inside of the container is an important factor in the extraction.

If the drive pipe shoe and the container have the same section everywhere, the chief causes of the disturbances, that is to say, the influences of the difference in width and the inside friction, are eliminated. In consequence, only the disturbance caused by the driving work remains. In spite of the foresight, investigations have shown that the driving force is not much greater by employing a properly constructed shoe without an inward angle, than by employing a shoe with an inner angle. Definitive results, however, are not yet to hand as investigations are still being continued.

It is obvious that the extraction of cores must be carried out with the greatest care, if they are to serve for physical examinations. In order to avoid disturbances through transportation of the cores, it is advantageous to carry out the investigations on the site with simple apparatus. These include especially the determination of the water-content, density, volume of voids, porosity, and sieve analysis down to 2 mm.

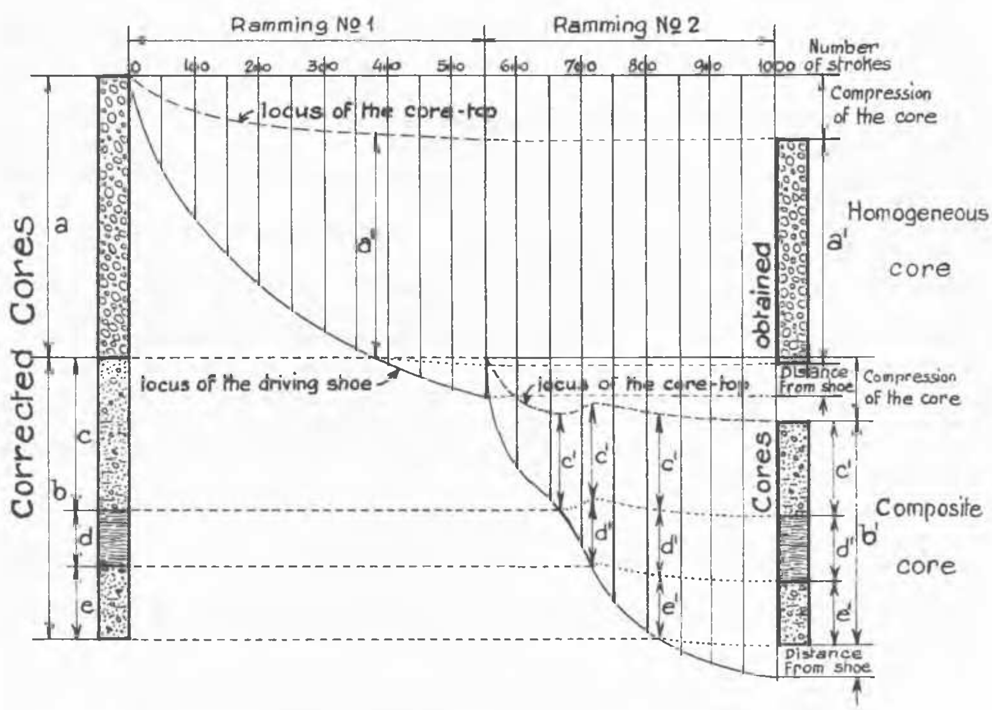

Fig. 8