SECTION III

FIELD INVESTIGATIONS

GENERAL REPORT

W. KJELLMAN (Sweden)

For preliminary field investigation sounding methods are extensively used in Scandinavia (1) and Holland (2), but in most other countries they are hardly employed at all and even distrusted (3). According to Plantema (IIIb 6) and Vermeiden (IIIb 7) the Dutch sounding device has now been improved as to the driving and measuring systems and also as to the tightening between rod and tube at the lower end, which seems to have been the weak point of the device. Further, the latter author describes facillities for sounding in deep tidal waters. The sounding device is said to furnish quite reliable information on the capacity of sand or gravel layers to sustain the load from pile points. It would be interesting to learn also to what extent the resistance, when sounding in clay, is correlated to the shear strength of the clay.

The art of taking "undisturbed" soil samples, which is essential in most field investigations, has developed a good deal (4 and 3) since the first conference on soil mechanics. The chief improvements are: the reduced wall thickness of the sampler, the inside clearance and the rapid continuous drive. Hvorslef (IIIa 6) has elaborated a condensed account of the very valuable results of his thorough investigations of these problems. Fadum (IIIa 3) and Parsons (IIIa 5) have studied the disturbances caused in samples taken by the old type sampler and by the improved sampler, respectively. They found that the latter samples have a lower compressibility and a higher unconfined compression strength than the former but a lower shear strength according to the consolidated-quick triaxial test. Rather surprising is the result obtained by Fadum (III a 3) that the modulus of elasticity should be extremely sensitive to disturbance and therefore during the sampling process be reduced to a very small fraction of its original value, even when a modern sampler is used.

For some actual slides in clay the computed shear strength was compared to the results of unconfined compression tests on samples taken by modern samplers. Tschebotarioff and Bayliss (IId 5), Skempton (IIa 2) and Parsons (IIIa 5) found good agreement. On the other hand Odenstad (IIIc 3) and Carlson (IIIb 3) found that on samples from greater depths this test gives much too low values of the shear strength. According to Odenstad this discrepancy in due to the loss of strength suffered by the sample during the sampling process: on account of the change of stress and of disturbance from the sampler the grains turn and slide on each other, so that the grain pressure decreases. This is in agreement with Terzaghi's conception (5) and also with the opinion stated in the opening discussion of section II of this conference.

A new type of field investigation device, called core-extractor, was constructed by Kjellman and Kallstenius (IIIa 4). By this device up to 20 m long, continuous, undisturbed cores can be taken in any soil not too hard and not containing too big stones. This is made possible by eliminating friction and adhesion between the core and the extractor and by forcing each soil layer to keep its original level and thickness when seized by the extractor. The method seems to be better and cheaper than ordinary. i.e. intermittent. sampling.

Another new type of field device is the rotating auger, constructed by Carlson (IIIb 3) by means of which the shear strength of clay layers, which are not too hard, can be determined directly in the ground. The accuracy of this method seems to be higher than is attained by laboratory tests on samples taken from the same ground. The cost of using the method is very small compared to ordinary sampling and testing.

In recent years the measurement of pore pressures in the ground has gained considerable interest. For such purpose Huizinga (IIIc 4) uses a Bourdon gauge connected directly to the upper end of the piezometric tube. Speedie (IIIc 1) prefere a pressure cell according to Goldbeck's system (which in fact seems more suitable for pore pressure than for earth pressure), placed in the lower part of the tube. Boiten and Plantema (IIIc 5), finally, use a pressure cell with electric strain gauges, placed in the same way. It seems doubtful whether the last-mentioned system can be relied upon for long-duration measurements.

As to earth pressure cells, the WES-type seems to be the chief advance of late years. It was invented by Osterberg, and it is described by Griffith and Woodman (IIIc 6). The earth pressure exerted on an outer membrane is rendered uniform by being transmitted through oil to an inner membrane provided with electric strain gauges. Even a small leakage or a slight change in the electric device would spoil the results. Therefore, it would be interesting to learn, whether the reliability of this cell has been checked in long-duration tests.

The same authors describe two devices for recording at a distance the deflections of a pavement. One is based upon the fact that two "selsyn"-motors, passed by the same current, rotate at exactly the same rate (the buried motor drives a screw axially, until electric contact is established); this apparatus is designed for slow deflections, even though of long duration, but it cannot be used for rapid movements. The other device measures the movement by electric strain gauges, after having mechanically reduced, it in a strange way;this apparatus is good for slow movements and, together with an oscillograph, for rapid movements but not for long-duration measurements.

Some reports deal with dynamic methods of soil investigation in the field. There are two such methods. In one of them, usually called the seismic method, the vibrations propagated through the surface soil layers are studied in comparison to those propagated through and reflected from deep layers. As described by Oosterbeek (IIId 2), the results can be used for computing approximately the thickness and stiffness of the different layers. This method seems suitable for pilot explorations for great projects. The other method consists in observing the surface vibrations only and computing therefrom the stiffness of the surface layers; this method is used in Sweden for determining the soil stiffness to be applied in computation of airfield pavements. Tschebotarioff and Ward (IIId 1) describe a new method of determining the resonance frequencies of machine foundations, which method is based on the analysis of actual field cases and does not require the computation of any soil coefficients.

Of late aerial photography has been used for purposes connected with soil mechanics activities. By scrutinizing on the photographs the shape and colour of the soil surface and also the vegetation the expert is enabled to draw certain conclusions about the nature of the superficial soil layer down to a few feet of depth. In regions, for which no geological map exists, this method will certainly be useful for projects of great horizontal extension as highways and flying fields. It must, of course, be supplemented by boring already in the first stage of the investigation.

LITERATURE

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3) Mohr: Exploration of soil conditions and sampling operations, Harvard University 1943.
4) Hvorslef: The present status of the art of obtaining undisturbed samples of soils,1940.
5) Terzaghi: Undisturbed clay samples and undisturbed clay, Jour. Boston Soc.Civ.Eng. 1941.

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SUB-SECTION III b

MEASUREMENTS OF SPECIAL SOIL PROPERTIES

III b 9

DISCUSSION

T.K. HUIZINGA (Netherlands)

In relation to a remark of Mr. Kjellman in his general report Mr. Huizinga said that in general it is possible to measure the shearing resistance with the cone penetration test.

Theoretically for saturated clays the bearing capacity of a wedge is without taken account on the weight of the soil $(2+\pi)\tau$. (Prandtl, Caquot).

Out of the experiments in the laboratory we found that for a cone in dune sand the bearing capacity is about 20-30% more.

Now it can be assumed that for the deep penetration test the sliding surface is about 2 times of that, if the cone was placed at surface of a subsoil. So we can expect a penetration value of the cone of about $14 \times \tau$.

This accounts only for saturated clays. For peat where the permeability is far more greater and some compression can take place, we found a higher figure of up to about 20τ.

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SUB-SECTION III c

MEASUREMENTS OF PRESSURES AND DEFORMATIONS

III c 8

DISCUSSION

D.W. Taylor (U.S.A.)

Mr. Taylor gives a review of his article: Filled measurements of soil pressures in foundations, in pavements and on walls and conduits, including a review of work of the fact finding survey and other filled investigations of the Corps of Engineers of the U.S.A. Army.

It is my belief that there are certain subjects which should take a very important part in the section no. III, not mentioned enough, and to these I should like to comment. Most of these comments are extracted from the paper presented to the conference under 6, 11, that came not in time to be published in the proceedings. One of my comments relates to the subject of earth pressure, though this is dealt within the paper in which is included a review of the programm of the Corps of Engineers of the U.S. Army on investigations of this type. Their work represents the broadest programm of investigation on field pressures that ever has been made. The programm includes the flexural strength and pressures, but my comment is limited to pressures. I now pass over quickly on the importance of the scope of such work already mentioned. That is to say the extreme importance rendered to field measurements of this type. And Mr. Kjellman already mentioned that the pressure cell is the device that has been used largely in this investigation in the programm of the Corps of Army Engineers. The experiment with the pressure cell has been used mainly within the last years and with the installation to determine pressures called the Carlson cell, that must come into use in the corosian cell described in the paper by Mr. Woodman and one of the Waterways Experiment Station men. To my opinion such a subject should not be brought up and presented to engineers, as for several reasons observed values of pressures often differ from the desired pressure values. Let us not think of such things. We get pressures that are, not the pressures we want.

The difficulties fall into four headings, first of all the inherent scattering which is used to represent differences between local pressures and the average pressure in the surrounding soil. The pressure reading has only a small probability of differing from the statistical average. In any case you must have an average otherwise you will be badly mislead.

Secondly, the cell action, a term used to represent the cause of the differences between the pressure acting on relatively rigid cells in homogeneous, typically compressible soil masses and the pressures that would exist at the same locations if the cells were not present. To this not much importance ought to be attached. The so called hard spots point at which the soil has a compressibility that is lower than the statistical average value, point pressures are greater than the statistical average values. Soft spots have relatively low pressures. Cell action gives over-registration: the pressures are too high. This can be analysed by picturing a bulb on both sides of the cell. Below at the footing and by analysing of the place there is shown quite well that the pressures are no more than a few percent amounting to ten or fifteen percent, and that an estimating correction easily can be made. We might say, that these corrections apply largely to vertical pressures. They also apply a great deal more to granular soil than they do to clays, but I believe the corrections to the whole are small indeed compared to other corrections.

The third item is the incorrect pressure readings resulting from the unsatisfactory mechanical performance of cells or cables. Study of pressure data from cells that are not well built point out emphatically that it is utterly unreasonable to adopt anything short of a perfectionist attitude in all development work and in all specifications pertaining to cells to be used for pressure measurements. For your work on the whole it is absolutely necessary that your first readings are perfect.

The fourth item is the incorrect pressure readings resulting from densities or compressibilities in the soil adjacent to the cells that are different from densities and compressibilities in the soil masses as a whole because of modified compaction procedures that often are required near the cells. If the surrounding soil of a cell is of lower density than the statistical average for the soil the cell reading will be only a small fraction of the correct average pressure. This phenomenon is given the name of pocket action. It is actually very easy to speak of a density control, but take care of that: the putting in of the cell is weighed out too much. For example you want to remove stones and to move in other hard samples. Then you will see that the soil property is a little bit more decompressible than its density. The compressibility was changed enormously and the cell went where it should not go. These four factors are fully considered in the project the Engineers Corps to work on and they had to use pressure cells that could be devided into three classes viz. cells placed in dams, placed in structures under below flexible basements and in a rigid structure of dradging the soil. In other words we have pressures within earth dams, soil pressure on masonry structures and pressures within the subgrades of pavements.

This paper was intended largely as a preliminary one of the symposion, whereas some other papers would not be presented.

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III c 9

DISCUSSION

G. PLANTEMA (Netherlands)

Also in the name of Mr. Boiten I want to say the following: Mr. Kjellman said in his general report that it was doubtful whether a pressure cell with electric strain gauges can be relied upon for long duration measurements.

It is difficult to say something about the reliability of an instrument for long periods of time, months or years under unfavourable conditions.

These instruments are rather new and of course it is impossible to speak about their behaviour after some years service unless you worked with them such a long time.

Nevertheless I am able to mention a few facts which may prove that a long trouble-free service is to be expected.

In the first place I have two designments of an earlier type in the soil from a period of 6 months and they have performed satisfactorily. They had no zero-drift and their calibration values have not altered.

Partly this is due to the fact that the

strain gauges are treated in a special way to give them the desired stability a manner, on which potentan applied for.

Other instruments with strain gauges treated in this way have not given any troubles what so ever.

To mention a few ones I have two pressure cells in use for field work.

They have a year service now and calibration checks have given not the slightest variation.

To give a good picture about the qualities of these measurements methods it may be practical to compare the stability with the well known Bourdon gauge. It is a well known fact that for accurate measurements a Bourdon gauge needs calibration after each test and with long duration test at least every month.

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