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.

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SUB-SECTION III b

MEASUREMENTS OF SPECIAL SOIL PROPERTIES

III b 1

PERMEABILITY OF PEAT BY WATER

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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

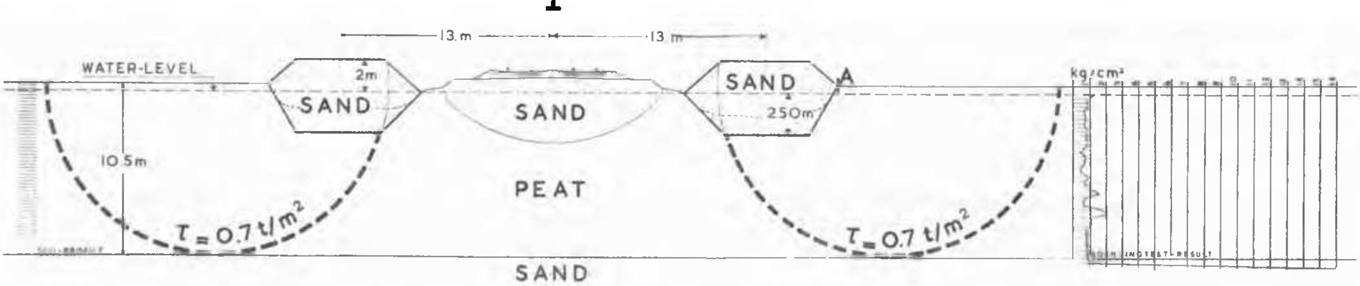

FIG. 1

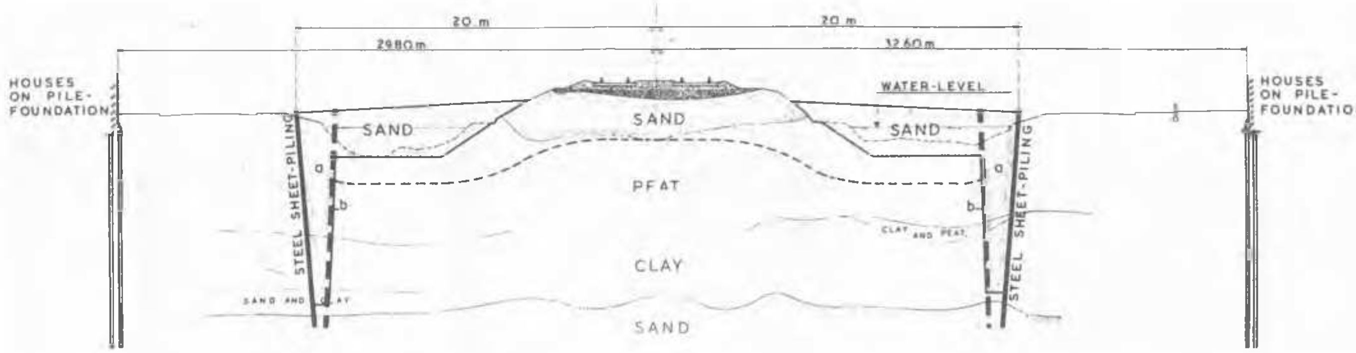

FIG. 2

FIG. 2 a

1. DIFFERENCE IN THICKNESS OF THE LAYER OF PEAT.

In case II the firm soil under the layer of peat lay considerably higher than in case I. One might imagine that this was the cause in consequence of which the disturbance of equilibrium failed to occur in case II.

The equilibrium computation executed in both cases, however, showed that in case I as well as in case II, despite the difference in situation of the planes of sliding a resistance against sliding of 0.7 ton/sq.m was necessary to retain equilibrium (fig. 1 and fig. 3), it appeared, that in both tracts the peat had to be considered equivalent in appearance and properties of resistance, so that this cause also failed to explain the difference in behaviour.

3. DIFFERENCE IN PERMEABILITY OF THE PEAT BY WATER.

As the difference in behaviour, when applying entirely equal methods of execution, could not be explained from what was described under 1 and 2, a third possibility was considered, viz. that in case I the pressing away of water took place with a lower velocity than in case II.

In the first case the excess pressure in the water of the pores might soon have reached the critical height (1.50 m) by insufficient flowing out, and disturbance of equilibrium might have occurred, which actually did happen.

In the second case flowing out of water under excess pressure might already have taken place to some extend immediately after the load had been brought to bear. The solid phase might have been more speedily adapted to the load and the resistance against sliding of the soil might have been increased sooner, simultaneously with compression of the soil.

In order to ascertain this the permeability by water of the peat was examined in both places.

This might have happened by taking undisturbed samples and by determining the permeability by water in a laboratory, but in that case one would have had to restrict oneself to a few points because of the expense.

II

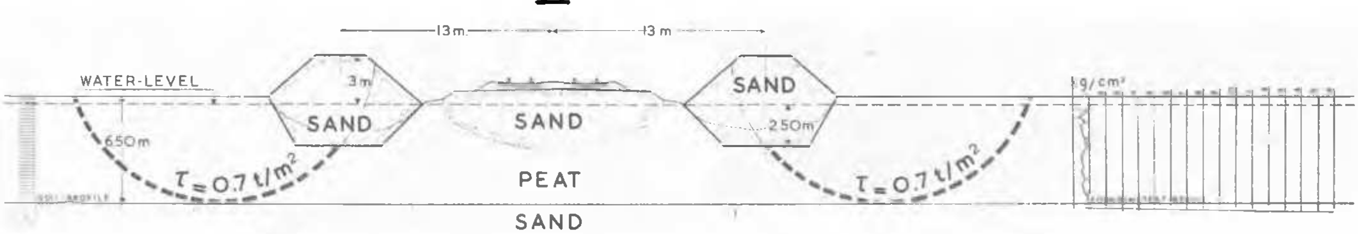

FIG. 3

2. DIFFERENCE IN THE PROPERTIES OF RESISTANCE OF THE PEAT.

From the borings as well as from the sounding tests with the Barentsen apparatus

That is why an apparatus was constructed with which the permeability by water of the soil might be determined in the field in a simple and swift manner. The values found with it were relatively applicable.

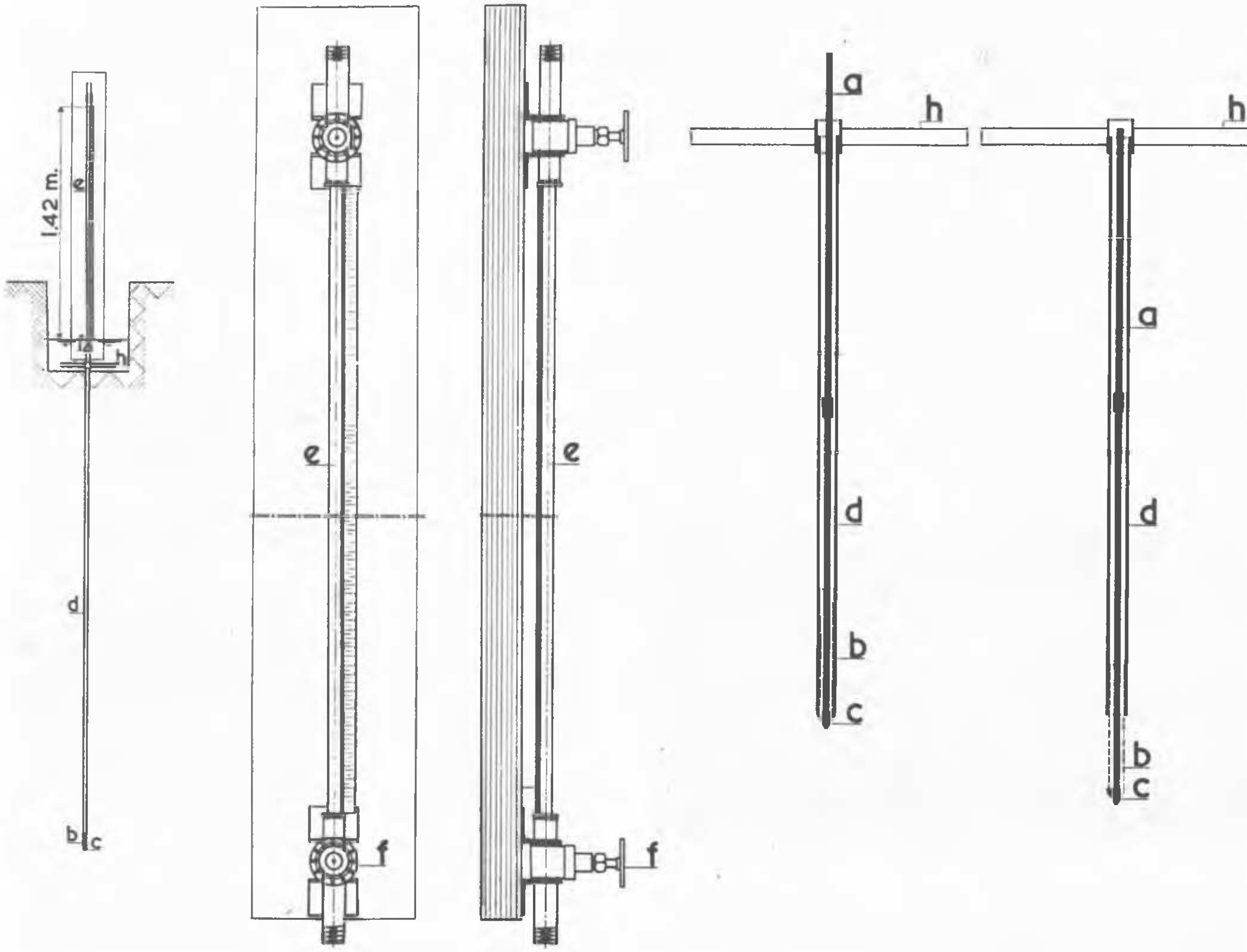

FIG. 4

FIG. 4 a

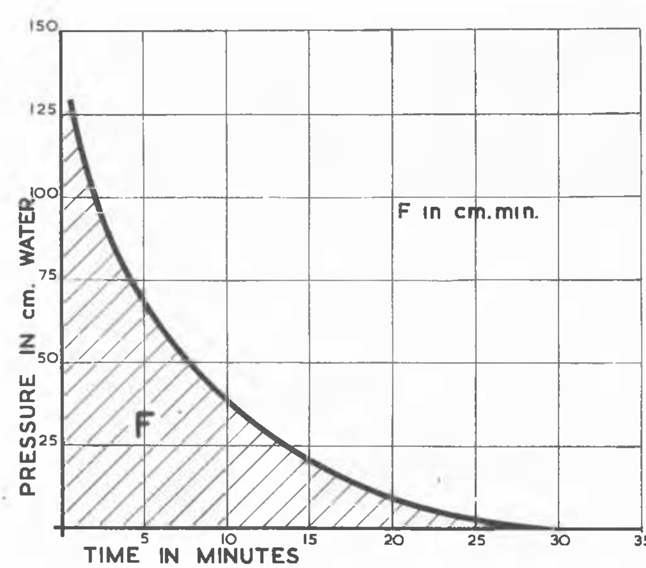

FIG. 5

Description of the apparatus (vide fig. 4 and 4 a).

A steel rod (a) provided with a filter (b) at the bottom and ending in a connus (c) is protected by a mantle tube (d). The rod projects 10 cm above the mantle tube. The whole apparatus is pushed into the soil with a handle (h) and filled with water. When the filter has reached the desired depth the rod (a) is pushed down 10 cm and so the filter comes into direct contact with the soil. On

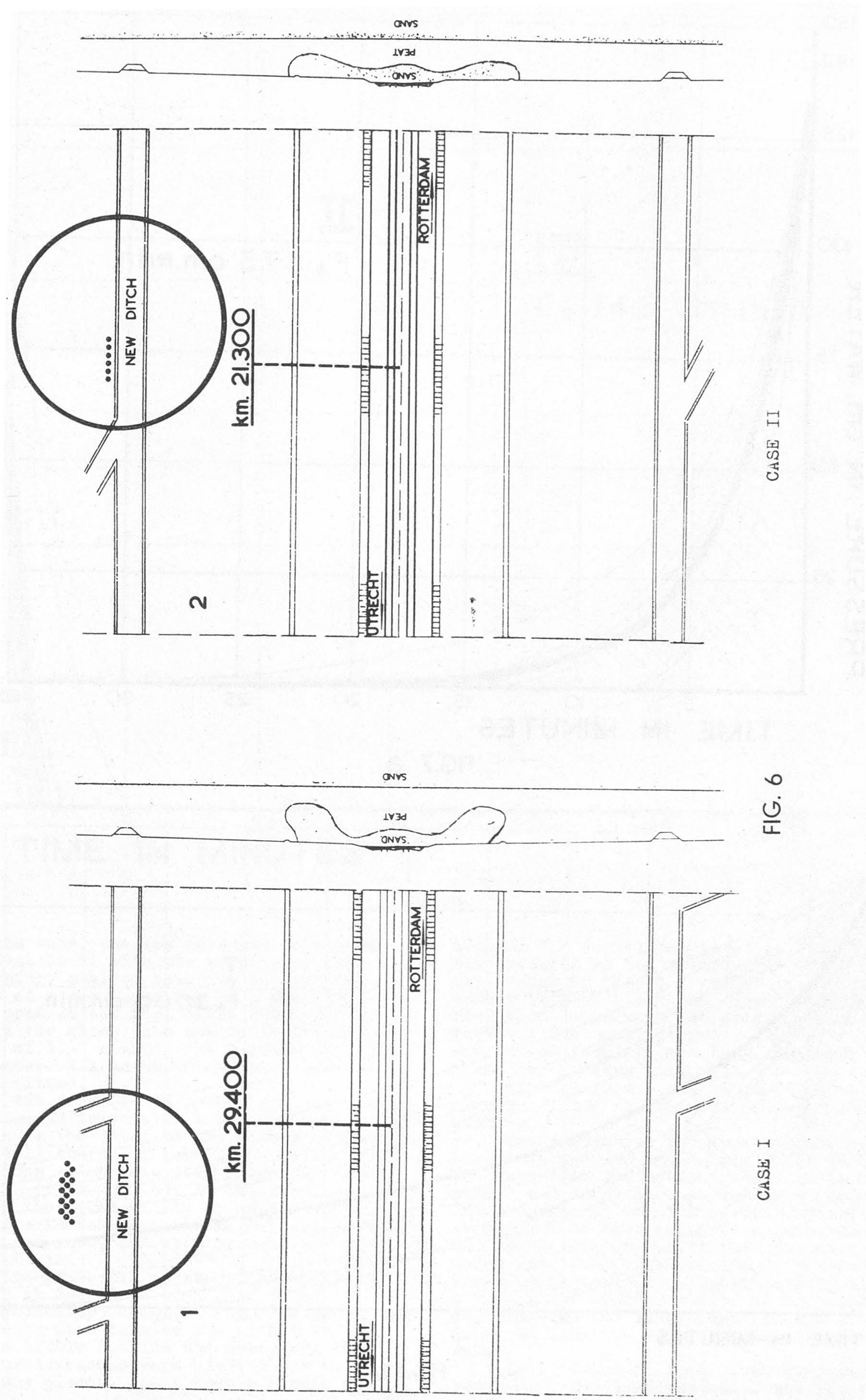
SAND
PEAT
SAND
NEW DITCH
km. 21.300
UTRECHT
ROTTERDAM
2
CASE II
SAND
PEAT
SAND
NEW DITCH
km. 29.400
UTRECHT
ROTTERDAM
1
CASE I

FIG. 6

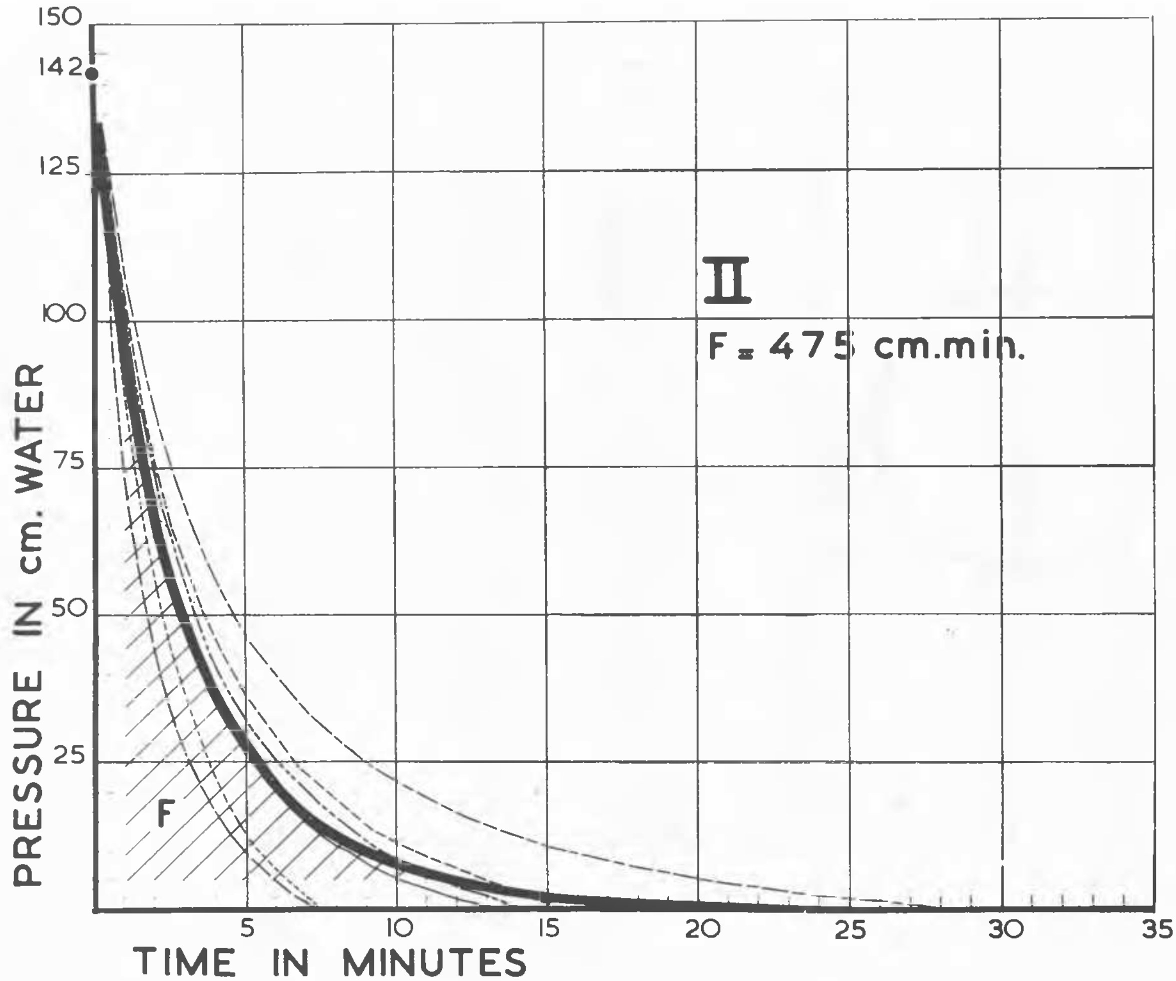
150
142
125
100
75
50
25
PRESSURE IN cm. WATER
II
F = 475 cm.min.
F
5
10
15
20
25
30
35
TIME IN MINUTES

FIG.7 a

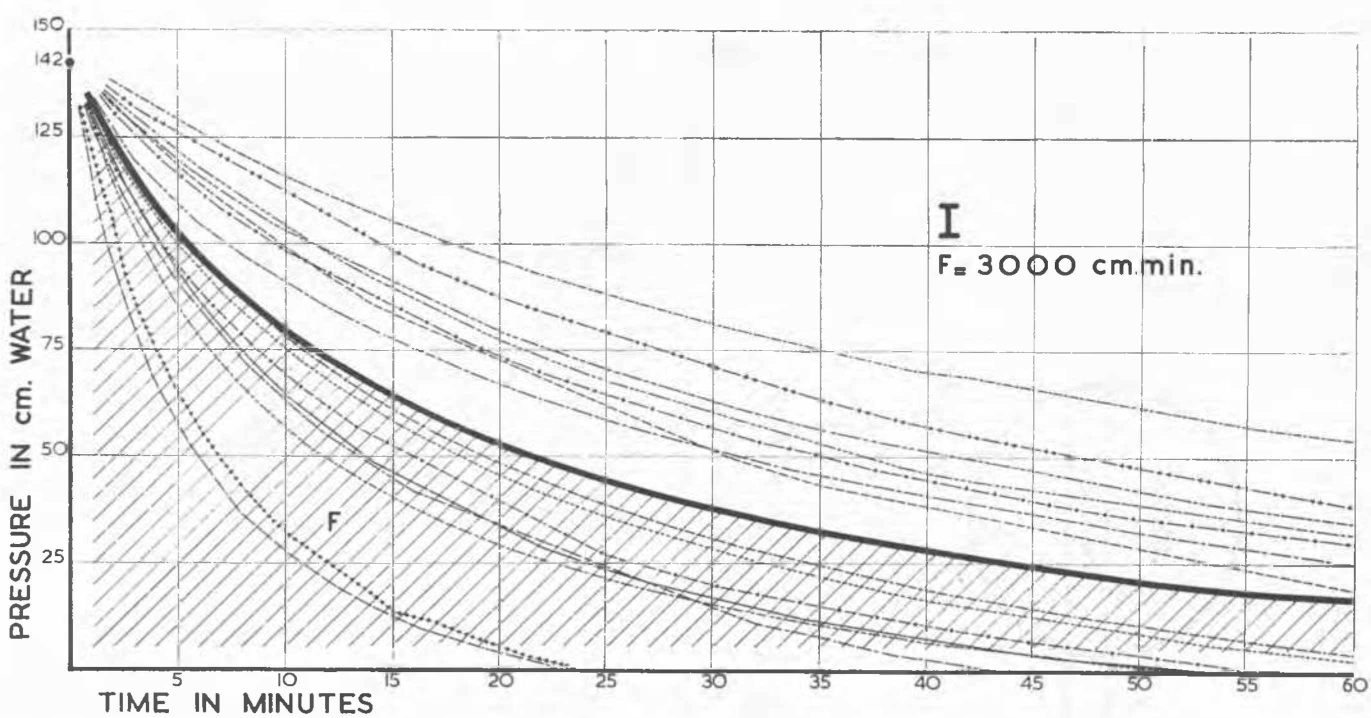
150
142
125
100
75
50
25
PRESSURE IN cm. WATER
I
F = 3000 cm.min.
F
5
10
15
20
25
30
35
40
45
50
55
60
TIME IN MINUTES

FIG.7 b

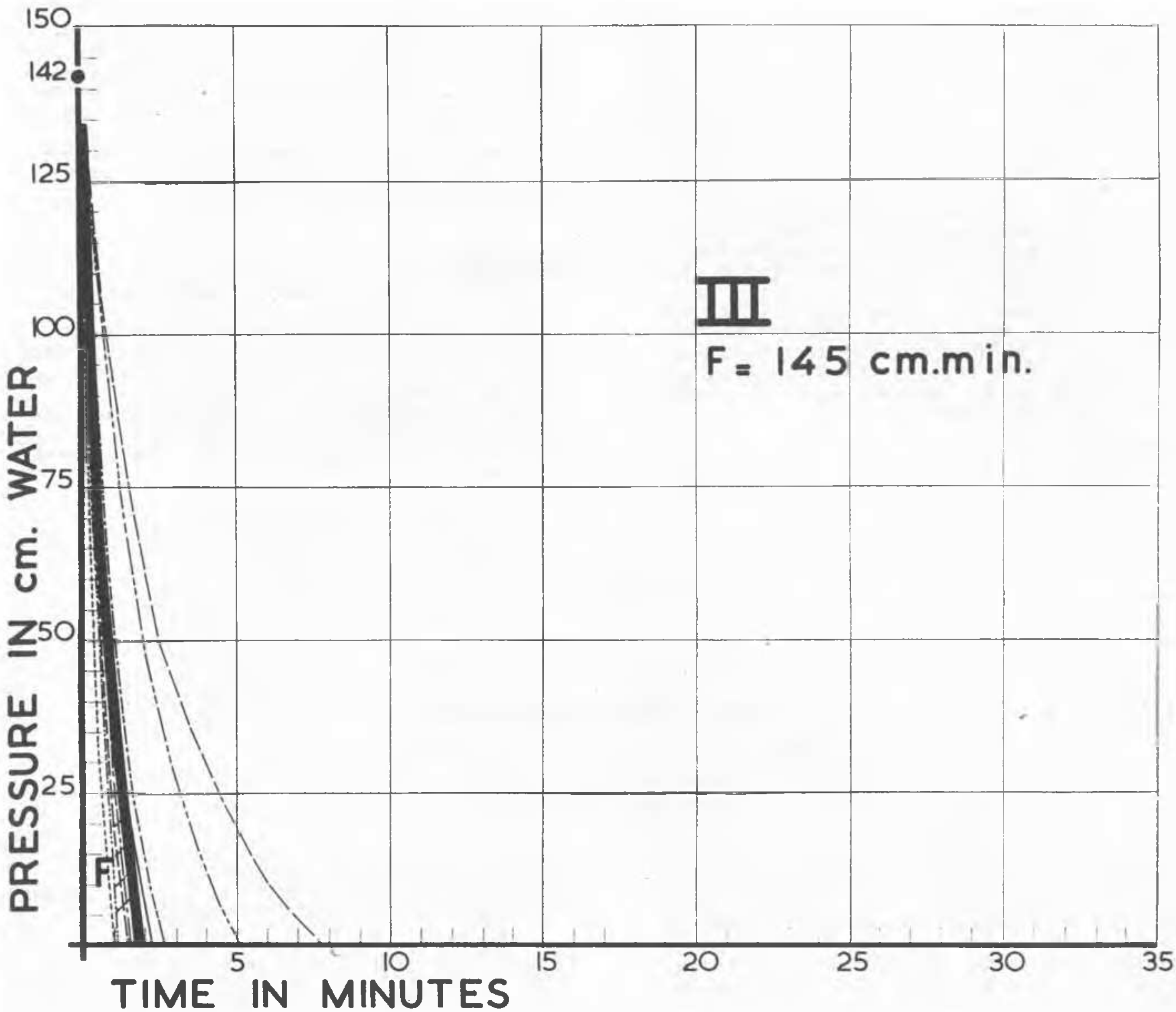

FIG. 8

the mantle tube, the top of which is places at an equal level with the surface of the ground water, a glass tube (e) is attached by means of a cock coupling (f). The glass tube is open at the top. While the cock (f) is closed the glass tube now is filled up to a height of 1.42 m above the surface of the ground water. Behind the glass tube a scale has been fitted.

Now the cock (f) is opened and the reading of time is taken with a chronometer. Every minute the level of the column of water is read till the glass tube is empty and the observations which have been found are noted in a graph (vide fig. 5). As the relative value for the permeability by water, the superficies is taken of the figure enclosed by curve and axes, and expressed in the dimension cm.min.

At the aforesaid points of the railway, i.e. near km 29.400 (Gouda) case I and km 21.300 (Oudewater) case II (fig.6) a number of measurements were carried out with this apparatus a little outside the newly dug ditch. All the measurements were carried out twice at the same places. Apart from a single exception the duplicates gave practically the same results as the first measurements. In the graphs of fig. 7 a and b the average values between first and second readings have been drawn with different types of lines. Moreover the total average value of all first and second readings has been indicated in the graph by a heavy line.

Near km 29.400 (I) 16 measurements and near km 21.300 (II) 6 measurements were carried out.

The reason for the great number of measurements near km 29.400 was to be found in the fact that the investigation at that place showed a considerable spreading of results. The presence of remains of wood and of vegetable fibre in the immediate neighbourhood of the filter will probably have strongly influenced the local permeability of the peat by water. Therefore it is imperative to choose a greater or smaller number of measurements, dependent on the local constitution of the soil, in order to obtain a reliable average value.

As a matter of fact, when comparing the results of the measurements I and II, it appeared that there was a considerable difference between the average values F_I = 3000 cm min and F_{II} = 475 cm.min, that is to say that there was an important difference in the permeability by water of the two samples of peat.

The greater permeability by water of the peat near II will probably have been the cause that the disturbance of equilibrium which had been expected at the outset dit not take place.

Further another 10 measurements were carried out near km 31.750 of this railway (III) where strengthening of the road-bed must be executed in the central part of the town of Gouda. 4)
From the values F_{III} = 145 cm.min (fig. 8) found in this case III it appears that the kind of peat in this region has a good permeability, which enables the strengthening of this section of the railway to be very simple and inexpensive.

CONCLUSION.

Carrying out measurements of permeability by water with the apparatus as described above in peat at any place is possible without great expense and will clear the insight into the behaviour which may be expected of the liquid phase and therefore of the soil as a whole, when a load is brought to bear onto it.

As to how far measurements in clay and sand soils may have practical significance should be investigated further.

REFERENCES.

1) Vide the author's article under section VIII.
2) For further particulars concerning the execution of this experimental section near Gouda we refer to the author's publication in "de Ingenieur" of 1947 nos.26 and 27.
3) Vide Proceedings of the International Conference on Soil Mechanics 1936 Vol. I page 7).
4) Vide the author's article on this subject in section VIII.

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III b 2

SIMPLE FIELD TESTS FOR SOILS

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1. Owing to the differences in soils encountered over a length of roadway it is not possible to perform the more elaborate soil tests on all the variations encountered. It is necessary to use those tests which give the greatest return of information for the least expenditure of time and labour in testing. Further, it is desirable that there should be established a system of tests which can be done by relatively unskilled operators, with a minimum of equipment, and which bear a known relation to the more difficult tests.

2. The simple linear shrinkage test has been used and provided that the mould is filled at a definite moisture content, e.g. either the Field Moisture Equivalent or the Liquid Limit, reproducible results are obtainable. The mould can be of any convenient length, e.g. 10 inches or 20 centimetres, and cross section, and may be formed by splitting a piece of 1 inch internal diameter tube longitudinally and attaching end pieces.

The soil, sieved through a No. 36 B.S. (No. 40 U.S.) sieve is brought to the Liquid Limit by the addition of water, the consistency being checked by the hand liquid limit test, (A.S.T.M. D423-39), but the actual moisture content is not determined. The mould is filled, struck off level, and then allowed to dry in air overnight and then in an oven. The percentage reduction of length of the soil pat is measured. Results of experiments with 282 samples of soils indicate that the test can be used to give an indication of the liquid limit and plasticity index. Regression equations fitted by the method of least squares to the means of arrays of linear shrinkage are shown in Table 1.

TABLE 1

Percentage of all tests in which (a) or (b) occurs	(a) Actual Plasticity Index will exceed	(b) Actual Liquid Limit will exceed
1%	P.I. = 3.08(LS) + 3.6	L.L. = 30.5 + 3.11(LS)
5%	P.I. = 2.74(LS) + 2.8	L.L. = 26.4 + 2.87(LS)
10%	P.I. = 2.61(LS) + 2.3	L.L. = 23.9 + 2.81(LS)
50%	P.I. = 2.34(LS) - 0.49	L.L. = 15.5 + 2.71(LS)
90%	P.I. = 2.03(LS) - 2.9	L.L. = 7.2 + 2.59(LS)
95%	P.I. = 1.96(LS) - 3.7	L.L. = 4.7 + 2.54(LS)
99%	P.I. = 1.58(LS) - 4.3	L.L. = 0.2 + 2.34(LS)