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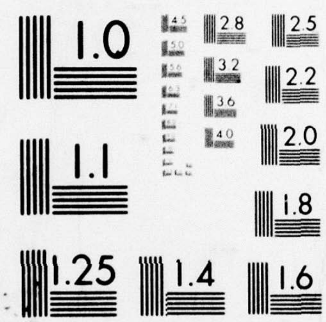

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RESEARCH ON PERMEABILITY OF CERTAIN KINDS OF WEAK WATER-SATURATED SOILS

B. Kirov

CORPS OF ENGINEERS, U.S. ARMY
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE

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Permeability is an exceptionally important soil characteristic for the planning of engineering structures. This report discusses how to calculate the consolidation of the earth mass.

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RESEARCH ON PERMEABILITY OF CERTAIN KINDS OF WEAK WATER-SATURATED SOILS

by Engineer Borislav Kirov

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Permeability is an exceptionally important soil characteristic for the planning of engineering structures. It must be determined precisely in order to calculate the consolidation of the earth mass.

The Weak-Soil "Problem" Research Laboratory headed by Docent Candidate of Technical Sciences M. Yu. Abelev in the Soil Mechanics and Foundations Department of the V. V. Kuybyshev Moscow Civil Engineering Institute performed a series of filtration experiments with undestroyed samples of the following varieties of soil: sandy mud, clayey mud and buried peat. Previously vacuum-evaporated sea water was used for filtration. The purpose of the research was to determine the variation of permeability as a function of the degree of soil compaction and pressure gradient. The experiments were performed with the help of an F-1M filtration compressor (Figure 1). It is a compressor with a hermetically sealed holder permitting the passage of water through a soil specimen according to "top-to-bottom" and "bottom-to-top" flow patterns under varying pressure. The installed soil specimen is 0.04 meter high and has a cross-section $F = 50 \cdot 10^{-4}$ square meter.

Three undestroyed samples of each variety were tested. The characteristics of the various soils in the natural state are given in Table 1.

The first task we set ourselves in conducting the experiments was to determine whether the so-called phenomenon of "initial pressure gradient" is observed during filtration through these varieties of weak water-saturated soils, i.e., whether there is some certain pressure gradient value, although there are smaller values, from which no filtration is observed, or if it is observed, it will be many times weaker [1].

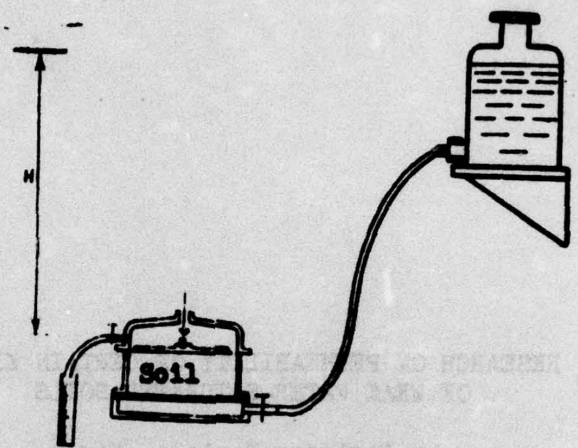

Figure 1

Table 1

1 Вид почва	5 Обемна плътност ρ [g/cm³]	6 Специфична плътност ρ_s [g/cm³]	7 Водно съдържание ω [%]	8 Коефициент на порите e
2 Песъчлива тиня	1.42	2.65	118	3.06
3 Глинеста тиня	1.40	2.63	83	2.44
4 Погребан торф	1.01	1.95	430	9.23

Key:

1. Soil type
2. Sandy mud
3. Clayey mud
4. Buried peat
5. Bulk density
6. Specific density
7. Water content
8. Porosity factor

Darcy's equation then assumes the following form:

$$V_f = K_f(i - i_o),$$

where V_f is filtration rate,

i is pressure gradient, and

i_o is initial pressure gradient.

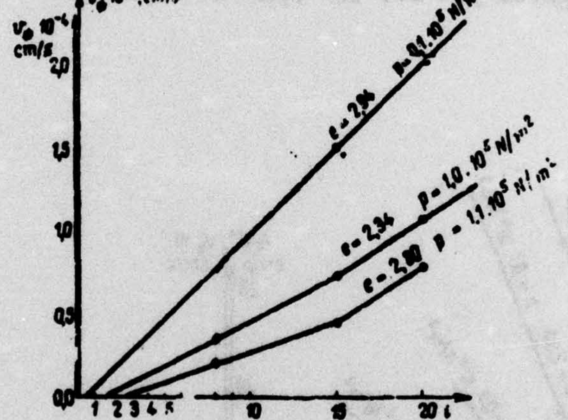

Figure 2a. Sandy mud

The instrument used is so constructed as to permit filtration to take place at different pressures. Pressure is created by moving the reservoir of water to a different height relative to the tested specimen. Water was passed through a specimen according to the "bottom-to-top" flow pattern, after which it was collected in a graduated cylinder. Lest the water evaporate from the graduated cylinder, several drops of oil were dropped into it. All experiments were performed at pressures of 0.32 meter, 0.60 meter and 0.80 meter. Filtration rate and coefficient were determined several times for each one of the given pressures [2]. Water temperature was measured constantly during the experiments and all results have been referred to a temperature of +10° C. Experiments were conducted at various vertical loads with a wait at each loading step for subsidence to stabilize at $0.01 \cdot 10^{-3}$ meter in 12 hours. Graphs were constructed for every value of vertical load according to the obtained data for variation of filtration rate as a function of pressure gradient. Extensions of the straight lines joining individual experimental points to their intersection with the axis of pressure gradients mark off on it the initial gradient value at which filtration begins (Figure 2). The initial pressure gradient obtained according to the thus-described methodology was checked by filtering water through the same soil sample at a gradient less than the initial gradient. From the graphs in Figure 2 it can be seen that for sandy mud the initial gradient increases as the vertical load increases. For clayey mud the initial gradient remains practically unchanged with an increase of the vertical load in the tested range due to low compressibility (the porosity factor varied from 2.44 to 2.25). For buried peat the same pattern as for sandy mud was observed, i.e., the initial pressure gradient increases with an increase of the vertical load. Given $p = 1.0 \cdot 10^5$ N/m^2 it equals 1.2, while given $p = 2.0 \cdot 10^5$ N/m^2 it increases to 3.2.

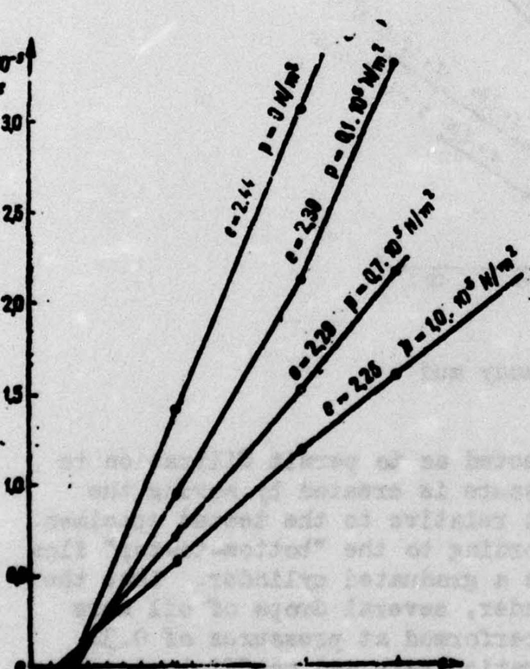

Figure 2b. Clayey mud

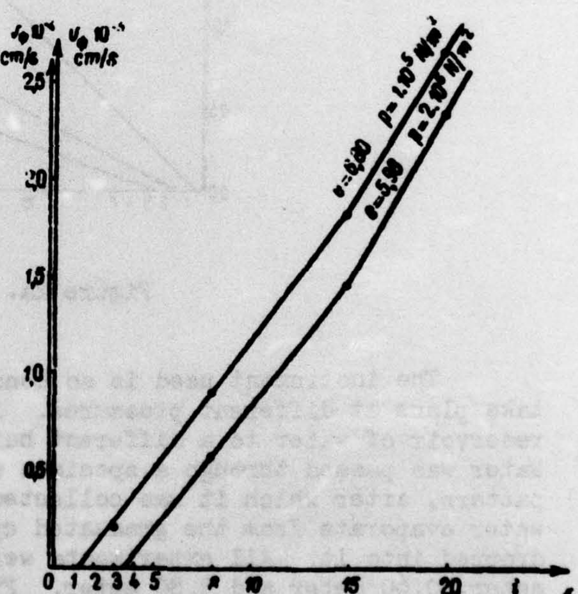

Figure 2c. Buried peat

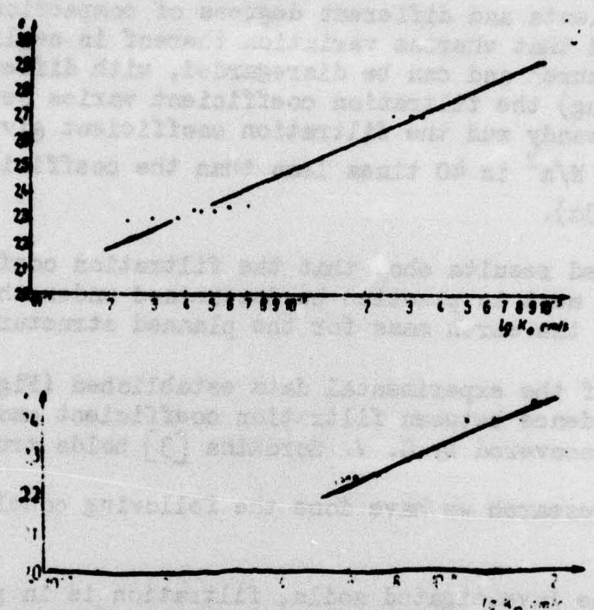

Figure 3a, b. Sandy mud; clayey mud.

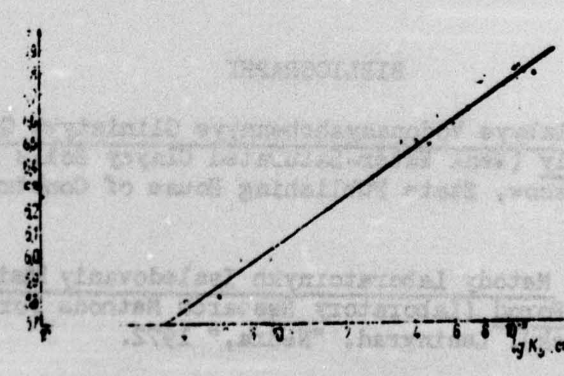

Figure 3c. Buried peat

The second task we set ourselves in the experiments here conducted was to investigate the variation of the filtration coefficient at different pressure gradients and different degrees of compaction (vertical loads). The results showed that whereas variation thereof is negligible for the investigated pressures and can be disregarded, with different degrees of compaction (loading) the filtration coefficient varies several fold. Thus, for example, for sandy mud the filtration coefficient given vertical load $p = 1.1 \cdot 10^5$ N/m^2 is 40 times less than the coefficient given $p = 0.1 \cdot 10^5$ N/m^2 (Figure 3a).

The obtained results show that the filtration coefficient for these varieties of soil must in practice be determined under the same vertical loads under which the earth mass for the planned structure will find itself.

Analysis of the experimental data established (Figure 3) that the logarithmic dependence between filtration coefficient and porosity factor in muddy soils discovered by G. V. Sorokina [3] holds true.

From the research we have done the following conclusions can be drawn:

1. For the investigated soils, filtration is in practice observed only at gradients greater than the initial gradient, which increases as the porosity factor declines, i.e., as the vertical load increases.

2. For the investigated soil varieties there is a logarithmic dependence between the filtration coefficient and porosity factor.

3. Filtration research for weak water-saturated soils must be conducted under the vertical loads that will be observed at the planned structure.

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