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Irina Mosicheva, Ph.D., Associate Professor
Maria Kolodka, student
Olga Koval, student
Odessa State Academy of Civil Engineering and Architecture, imosicheva@gmail.com

EXPERIMENTAL JUSTIFICATION OF THE NEED TO CONSIDER THE EFFECT OF VERTICAL SAND DRAINS COLMATATION DURING THEIR DEVICE IN WEAK WATER-SATURATED SOILS

One of the assumptions of the existing methods for calculating the compaction of weak clayey water-saturated soils when vertical sandy drains are installed in them is the unlimited filtration capacity of the material from which the drains are made [1, 2].

In fact, this material (sand) initially has a finite value of the filtration coefficient, which significantly exceeds the value of the filtration coefficient of the compacted soil.

However, as the consolidation process proceeds, the soil particles surrounding the drain penetrate into it with the current of pore water squeezed out of it, and the filtration capacity of the drain decreases.

The purpose of our experimental studies was to establish the influence of the filtration coefficient of the drain material on the rate of consolidation of silty water-saturated soil with sandy drains.

At the same time, the effect of drain silting in the process of consolidation was studied by making them from a material with different values of the filtration coefficient. Mixtures of pure quartz sand with a fraction of 0.25–0.50 mm and silt powder with a fraction of 0.10–0.25 mm were used as such material at different ratios of their volumes.

4 series of experiments were carried out on the consolidation of cylindrical samples of silt paste with a diameter of D = 140 mm and a height of H = 50 mm with a central drain with a diameter of d = 20 mm ($n = D/d$ = 7.0):

– Series I: experiments with a drain of pure sand;
– Series II: tests with a drain of a mixture of sand and silt in a ratio of 3:1 (by volume);
– Series III: the same, in a ratio of 1:1;
– Series IV: the same, in a ratio of 1:3.

In the experiments of all series, the initial moisture content of the silt paste was equal to twice the yield strength of the original soil – $W_n=2W_L$.

The experiments of each series were carried out with 3 repetitions (12 experiments in total) in non-standard devices (odometers) of a special design, which excludes the extrusion of weak clay water-saturated soil from under the stamp and its distortion during the experiment.

The sealing load on the test specimens, equal to 0.1 MPa, was created over a period of 10 minutes by five equal steps of 0.02 MPa each with holding each load step for 2 minutes, which ensured that the soil was not squeezed out from under the stamp.

The results of the performed experiments on the consolidation of samples of silt paste with the radial direction of pore water filtration (into the central drain) were processed according to the methods of Taylor and Casagrande [3] and presented in the form of tables [4]. The values of the consolidation coefficient C_R in the radial direction, by analogy with the determination of the consolidation coefficient C_V in the vertical direction of filtration, were determined by the formula:

$$C_R = T_R \frac{D^2}{t_{50\%}}, \tag{1}$$

Where T_R – time factor corresponding to the value of the degree of consolidation during radial filtration of pore water Q_R = 0.5, determined by the formula:

$$T_R = -\ln(1 - Q_R)\frac{F(n)}{8} = 0.11 \tag{2}$$

Where

$$n = \frac{D}{d_{dr}} = \frac{140\ mm}{20\ mm} = 7; \tag{3}$$

$$F(n) = \frac{n^2}{n^2 - 1}\ln\ n - \frac{3n^2 - 1}{4n^2} = 1.24. \tag{4}$$

Here (formula 1) $\boldsymbol{t_{50\%}}$ – the time of 50% filtration consolidation, determined from the dependence graph $S_t = f\,(lg\boldsymbol{t})$ [4], as the time corresponding to the average value of 50% filtration sediment $\boldsymbol{S_{50\%}}$ for each series of experiments.

Table 1 shows the normative values of the characteristics of deformability ($\bar{a}$, MPa^{-1}), consolidation ($\overline{C_R}$, sm^2/s) and water permeability ($\bar{k}_f$, m/day) of the studied soil, obtained as a result of the performed compression-consolidation tests.

It follows from the data in the table that the maximum discrepancy (up to 15%) in the values of the degree of consolidation at fixed values of the consolidation time occurs at 75% colmatation of the sand drain with silt, which corresponds to the time of practical stabilization of the sample settlement.

Table 1 – Normative values of the silty paste characteristics

Name of characteristics	Series I	Series II	Series Ш	Series IV
Consolidation coefficient $\overline{C_R}$, sm^2/s	1.2×10^{-3}	1.1×10^{-3}	1.0×10^{-3}	0.9×10^{-3}
Compressibility coefficient $\bar{a}$, MPa^{-1}	0.12	0.11	0.114	0.141
Filtration coefficient $\bar{k}_f$, m/day	3.95×10^{-4}	3.56×10^{-4}	3.19×10^{-4}	2.91×10^{-4}

According to the data given in Table 1, graphs of the dependence of the filtration and consolidation coefficients on the %-th content of silt in the composition of the drain filling material were plotted [4].

These graphs can be used when performing compaction calculations for weak clayey water-saturated bases with vertical sand drains, taking into account their real filtration capacity.

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