Laboratory Tests for Dispersive Soil Viscosity Determining

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Abstract. There are several widespread methods for soil viscosity determining now. The standard shear test device and torsion test apparatus are the most commonly used installations to do that. However, the application of them has a number of disadvantages. Therefore, the specialists of Moscow State University of Civil Engineering proposed a new device to determine the disperse soil viscosity on the basis of a stabilometer with the B-type camera (viscosimeter). The paper considers the construction of a viscosimeter and the technique for determining soil viscosity inside this tool as well as some experimental verification results of its work.

1. Introduction
The aim of the new proposed device is the adaptation of the viscosity meter construction for examining the properties of soil and decreasing the labor intensity of special laboratory examinations as well as widening of the application area for investigating the rheological properties of dispersive soil [1-10].

2. Viscosity meter construction
Please Taking into account drawbacks of the existing devices and methods for determining soil viscosity, under the management of Prof., Eng.Sc.D. Z.G. Ter-Martirosian, Eng.Sc.D. A.Z. Ter-Martirosian, Candidate of Engineering Sciences A.Yu. Mirny and Candidate of Engineering Sciences E.S. Sobolev developed a new device for defining the soil viscosity - the viscosity meter - on the basis of the stabilometer with a cell of type B [11-15].

The experimental viscosity meter is a stabilometer cell of type B, where lateral strains are transferred on the cylindrical soil specimen through the rubber cover. The vertical force is applied to the vertical metal rod passing through the central axis of the device cell and specimen. The rod travels freely in the vertical direction and is fixed to the loading device of the loading frame.

When conducting tests the test rig UL60-4 produced by APS Antriebs- Pruf- und Steuertechnik GmbH (FRG) was used [16-20]. The rig consists of the pneumatic loading frame, triaxial compression cell, pneumatic and servo drive control unit, unit for data processing obtained from pressure and displacement sensors, air pressure control unit, phase separator, burette with volumetric deformation differential sensor and control computer.

3. Viscosity determination procedure
Let's set a task of determining the viscosity of a soil specimen, if the speed of rod vertical displacement is known. We assume that the resistance of the rod lower end is equal to zero. We assume as well that the shearing deformation mechanism of the soil surrounding the rod prevails [21-26]. In such case the speed of the soil shearing deformation will be determined taking into the account the following dependence

$$\frac{\tau}{\eta} = -\frac{d\dot{u}}{dr}$$  \hspace{1cm} (1)

The expression (1) is correct at the moment, when the rod resistance on the lateral surface is exhausted and the rod starts submerging into the soil with the constant speed.

The value of the vertical force, transferred to the rod, depends on the value of tangential stresses on the rod lateral surface which can be determined with regard to the following condition

$$\tau = \frac{F}{2\pi r l_{cm}}$$  \hspace{1cm} (2)

where $r_c$ and $l_{cm}$ - radius and length of the rod, m; $F$ - vertical force transferred to the rod, kN.

Assuming that the rod material almost cannot be constricted, it is possible to define the value of settlement.

Making the substitution of the expression (1) into the expression (2) we obtain

$$\dot{u} = \frac{F}{2\pi r_c l_{cm} \eta} \ln r + C_1$$  \hspace{1cm} (3)

and taking into account boundary conditions:

with $r = r_3 \rightarrow \dot{u} = 0$, then $C_1 = -\frac{F}{2\pi r_c l_{cm} \eta} r_3$,

with $r = r_0 \rightarrow \dot{u} = \text{const}$

$$\dot{u} = \frac{F}{2\pi r_c l_{cm} \eta} (r - r_c)$$  \hspace{1cm} (4)

4. Experimental check

Mean size sands were tested for the purpose of the experimental check of obtained dependencies [27-29]. The analysis of the obtained results demonstrates that the viscosity of sand soil decreases while the rod submerge speed increases. Graphical processing of experiment results is shown on Fig. 1-2

**Figure 1.** Viscosity $\eta \cdot \sigma$ (Pa·s) v/s rod vertical displacement speed $\dot{u}$ (mm/min) dependence.
5. Experimental check
Based on the conducted tests in the experimental device for determining the dispersive soil viscosity the following main conclusions can be made:

1. The viscosity of sand soil depends on the speed of vertical displacements of the rod. The soil viscosity decreases if the speed increases.
2. The viscosity of sand soil depends on the rate of lateral squeeze of soil. The soil viscosity increases if the lateral squeeze increases.
3. The presented test results allow forecasting the value of soil viscosity with any values of rod deployment speed.
4. The construction of the soil viscosity meter proposed by the authors can be used for calibrating modern rheological models which utilize the viscosity parameter

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