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Investigation of Lateral Friction Forces

Etude de Forces Latérales de Frottement

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SYNOPSIS Owing to its highly advantageous features, the wall-in-soil method, also known as the slurry trench construction method, is finding wider and wider application in world foundation engineering practice. It is based on the use of a slurry which acts as timbering in soil working operations.

The bearing capacity of a supporting structure is the sum of two quantities: the reaction under the footing and the friction forces acting on the lateral surfaces. The latter are manifested in the zone of contact of the bearing structure with the soil walls of the trenches which are coated with a clayey cake (layer).

To begin with, investigations were conducted in the Gersevanov Research Institute of Bases and Underground Structures on the lateral friction of two fragments of reinforced concrete structures built by the wall-in-soil method at two depths but which had no bearing in the bottom of the trench 36m long, 0.6m wide and 9m deep. The trench was treated with bentonite slurry having a unit weight of 1.1 g/cm^3 . The friction force determined at a depth of 4m was 5.93 tnf/m^2 and at a depth of 7m, 6.19 tnf/m^2 (Fedorov, Smorodinov and Ivanov, 1976).

The subsequent (and principal) investigations of lateral friction, continued in the laboratory, began by the use of a slurry made with a kaolinite clay having the following properties: specific weight $\gamma = 2.75 \text{ g/cm}^3$, plasticity index $I_p = 25$ and granulometric composition - sand 10.6%, dust 43.9% and clay particles 45.5%.

The slurry had the following quality indices, determined by the indicated apparatus according to the procedure stipulated by the pertinent USSR State Standards: unit weight $\gamma = 1.13 \text{ g/cm}^3$ (AG-1 areometer), one-day stability $C = 0.4 \text{ g/cm}^3$ (TsS-1 cylinder and AG-1 reometer), spreading coverage $P = 24 \text{ cm}$ (AZNII one), clayey cake thickness $K = 2 \text{ mm}$ and water yield per 30 min $B = 8 \text{ cm}^3/30 \text{ min}$ (VM-6 apparatus).

Sodium carbonate (Na_2CO_3) was used in an amount corresponding to 0.4% of the density of the slurry as a cheap and effective reagent.

In all the tests the fragment of the bearing structure was produced by displacing the slurry with a one-to-one sand-cement mortar.

The special experimental apparatus (Fig. 1) in which the investigations were conducted

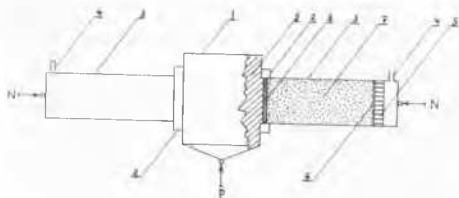


Fig. 1. Schematic diagram of the apparatus for investigating lateral friction forces. 1-chamber, 2-seal (removed after the cement-sand mortar sets in the chamber), 3-cylinder with soil, 4-pipe connection, 5-stiff grate, 6-screen, 7-soil, 8-clayey cake layer, 9-cement-sand mortar after setting

is of a design which practically excludes the development of any subsidiary stresses that could influence the stresses being investigated.

The slurry, in contact in the chamber of the apparatus with two vertical soil surfaces of equal area, was held at a pressure of 2.26 at for 24 hours with the slurry being circulated during the first 1.5 hours. Then (after 24 hours) the slurry was displaced by the cement-sand mortar with the slurry being drained off into another reservoir. After this, a pressure of 4.5 at was applied to the cement-sand mortar. Four hours later, when the mortar had begun to set, the pressure was re-

moved. Twenty-four hours after the slurry was displaced, the pressure N , required by the conditions of the experiment, was applied to the cylinders with soil which constituted a dry medium-grain sand. Another twenty-four hours later, the cement-sand stone was displaced with respect to the clayey cake layers located on the two soil surfaces. The curve plotted from the experimental data (Fig. 2) shows

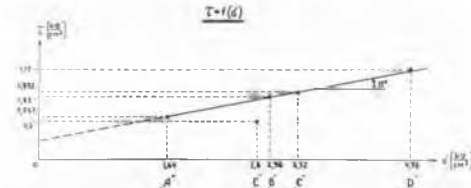


Fig. 2. "A", "B", "C" and "D"—results of experiments with a slurry or kaolinite (ordinary) clay. "E"—result of an experiment with a slurry of bentonite

the dependence of the limiting shear stresses τ_{\max} in the clayey cake layer on the lateral soil pressures directed perpendicular to the shear plane.

Curves of $S=f(\tau)$ are shown in Fig. 3 for the same four experiments using a slurry of the above-specified kaolinite clay and one of the experiments ("E") with the more typical results obtained in using a bentonite slurry. For convenience in representation, the scale of the last of these curves has been reduced by one half. As is evident in the illustration, the displacement curves in experiments "A", "B", "C" and "D" are more gene-

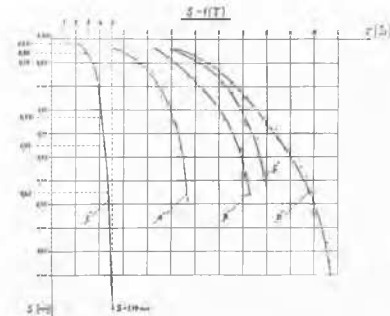


Fig. 3. The scale for curve "E" is reduced by one half along axes σ and τ and as compared to curves "A", "B", "C" and "D"

rally inclined toward the τ axis than the curve showing the development of displacement in experiment "E". This indicates that layers of clay cake from a bentonite slurry have higher elasticity.

Slurries of kaolinite (ordinary) clays contain more large clayey particles than in slurries of bentonite. Consequently, the clayey cake in the experiments with a kaolinite slurry constitutes a coarser disperse system with a higher free water content between the hydrated coatings on the clay particles. This circumstance should be the cause of higher compressibility of this layer of clayey cake. And, as a matter of fact, the thickness of the clayey cake layer averaged 5mm in experiments "A", "B", "C" and "D", but was 8mm in the experiments with a bentonite slurry. But an increase in compressibility of the disperse system at the same pressure leads to a higher coefficient of friction and, in the final analysis, to a higher limiting shear stress. This is confirmed by the fact that when all other conditions were maintained equal, the friction forces in the experiments with a kaolinite slurry were approximately 1.6 times as much as for a bentonite slurry whose composition met all requirements of the quality indices.

CONCLUSIONS

- (1) In construction by the wall-in-soil technique, ordinary clays can be efficiently used for preparing the slurry instead of the more expensive bentonite.
- (2) The application of ordinary (coarsely disperse) clays for preparing the slurry may raise the bearing capacity of deep foundations.
- (3) The lateral friction force on foundations (laid by the wall-in-soil (slurry trench construction) method reaches values of several tons per square metre. If these friction forces are taken into consideration during design, the cost of construction can be reduced.

REFERENCES

- Ivanov Y. D., B. S. Fedorov and M. I. Smorodinov (1976) "Investigation of Side Friction in Foundations of Reinforced Concrete Structures Under Slurry", Proc. 6th European Conf. on SMFE, Vienna.