Field Investigations of Clay Soils

Les Etudes du Sol Argileux In Situ

B.I. DALMATOV Doctor of Sc., Prof.,Institute of Civil Engineering, Leningrad, USSR
A.V. GHOLLY Master of Sc., Docent, Institute of Civil Engineering, Leningrad, USSR
F.G. GABDRAKHMANOV Engineer, Institute of Civil Engineering, Leningrad, USSR
B.I. KULACHKIN Engineer, Research Institute of Bases and Underground Structures, Moscow, USSR

SYNOPSIS In excavating the trench there have been made the observations of loosening of clay soils below the excavation level, which is due to the release of the natural pressure. Some recommendations on determining the depth of the loosening of soils and on evaluating the influence of the character of the loosening of soils upon the soil deformability under compression are given. It is recommended to consider the heterogeneity of the soil in its stretch by means of the impeller.

THE INVESTIGATION OF SOIL LOOSENING DURING EXCAVATION

The settlements observed in constructions in many cases do not conform with the designed ones. This is partly explained by the fact that the calculation procedures for the settlements which are applied in Soil Mechanics do not take into account the influence of the release of the natural pressure and the actual loosening of soils during excavation on the deformation properties of the soil in the base.
The foundation settlement, in a common case, may be presented as the function of the loosening of soils during excavating the trench and its compacting under the load from the erected construction.
The loosening of the soil during the excavation can be seen in the upheaval of the trench bottom to the value which can exceed 0,1 m (Maslov, Shnitnikov, 1936), and depends on the trench dimensions and the properties of the soil. The static sounding of the soil below the trench bottom, which was carried out before and after the excavation works, showed a considerable reduction of the soil resistance to the penetration of the sound after the release of the natural pressure (Begeman,1976). This is the evidence of the increase of soil compressibility and the decrease of its shear resistance. For revealing the boundaries of the area of the loosening of the soil there have been made the investigations on the site which is made up of high plastic loams. For this purpose the observations were made to ascertain the upright movement of the marks established before excavating the trench in three boreholes at different levels below the trench bottom. (the trench dimentions in plan - 18 × 12 m, the depth - 4 m). Fig. 1 shows two epures of the upright movements of the marks during 20 days after excavating the trench. The upright movements show that the loosening of the soil takes place within the limited depth. In general, the loosening of soils is observed in the layer just below the trench bottom.

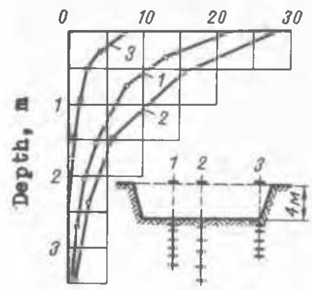

Fig. 1

At the slopes of the cut the loosening manifests itself in the less degree than near the centre. Hence, the homogeneous in properties soil after excavation becomes heterogeneous at different depths and in its stretch. The investigations carried out with the help of the impeller showed that as the soil was loosening, its shear resistance was greatly decreasing, and in 20 days after excavating the trench it decreased 2,5 times just below the trench bottom (fig.2).

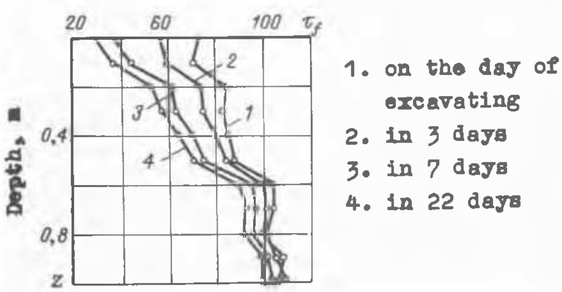

Fig. 2

The thickness of the layer z_o , where the reduction of the soil strength occured, increased with time. The value of z_c for one-dimensional problem with wide excavations ($b/h > 2$) can be determined as the zone of the critical equilibrium by the equation.

$$z_c = \frac{K_o (Kh - h_o)}{1 - K_o K} \qquad (1)$$

where K is the coefficient of the lateral soil pressure in natural conditions; K_o is the coefficient of the lateral pressure in rest; h is the excavation depth; h_o is the reduced thickness of the soil layer which is determined by the expression.

$$h_o = p_s/\gamma \qquad (2)$$

$$p_s = \frac{2c \cdot \cos\varphi}{1 - \sin\varphi} \qquad (3)$$

where o, φ are the shear parametres; γ is the unit weight of the soil with the natural structure. With narrow excavations it is necessary to consider the affect of the cut edges which reduces the depth of the development of the loosening deformation and the decreasing of the soil strength to a great extent.
Equation (1) permits to predict the depth within which the natural soil structure is disturbed while sampling the monoliths in the trial pits. If the value $z_c \leqslant 0$, with the release of the natural pressure the disturbance of the natural soil structure does not occur. If in releasing the natural pressure the disturbance of the natural soil structure does occur, it is advisible to determine the values of its physicomechanical characteristics with consideration of their changing after excavating the trench, as they may greatly differ from the values obtained before the excavation work, which will cause some errors in estimating the foundation settlement.
When the natural soil structure is disturbed ($z_c > 0$), it is advisable to apply the following technique of sampling the monoliths for considering the change in deformability of the soil. On the spot of the future trial pit the hole is bored in which the depth marks are established (the borehole should be located at a distance from the centre that is equal to the distance between the centre and the place of sampling the monoliths). The movements of the marks are observed and the value of the relative softening strain ε_{v1} is determined at the levels where the sampling of the monoliths is carried out. The micromarks are forced into the walls of the monoliths and the distance between them is measured at the moment of cutting out a monolith and before testing the soil in the laboratory. The movements of the micromarks permit to estimate the change of the monolith dimensions during its handling and storing, and also to calculate the corresponding relative deformations of the soil, ε_{v2}. The porosity of the soil with the natural structure is calculated by means of the inverse recalculation according to the porosity of the monolith, which is obtained in the laboratory, and the values of ε_{v1} and ε_{v2}.

THE TECHNIQUE OF ESTIMATING THE HETEROGENEITY OF THE SOIL

The layer of the homogeneous soil, from the engineering geological point of view, is often heterogeneous in properties as the result of different stress conditions in depth. And in plan at a certain depth it posesses some heterogeneity which is sometimes to be studied. And, besides, however, it is important to make a strict demand on the possible errors in the system of measuring the soil characteristics, for the values obtained will depend both on the heterogeneity of the soil and on the errors in measuring them. In consequence of this it is necessary to predetermine such estimation of the errors for the measuring system that is obviously less, than the corresponding estimation of the predicted non-uniformity of the soil characteristic under consideration. For the investigation of the soil heterogeneity it is recommended to apply the static sounding with the sound construction having the error of the measuring system not higher than 3-5% of the value being measured.

CONCLUSION

1. With the release of the natural pressure clay soils show loosening (at $z_c > 0$), and the soil in the base below the excavation level becomes heterogeneous in depth and stretch.
2. Soil loosening leads to the change of the soil characteristics of porosity and deformobility. It is recommended to determine the values of physicomechanical characteristics of the soil with consideration of their changing after excavating the trench, for they can greatly differ from the values obtained before the release of the natural pressure.
3. For the investigation of the soil heterogeneity it is advisible to test it by means of the impeller and the static sounding with the sound construction having the error of the measuring system not higher than 5% of the value being measured.

REFERENCES

Begeman, B.K.S. Ph.(1976). The influence of excavation on soil strength below excavation level. Proc. 6th Eur.Confer.Soil Mech. and Found. Eng., Wienna.

Maslov, N.N., Shnitnikov, D.V. (1936). On the estimation of the settlements and deformations of structures. Proc. "Svirstroy". b.IX.