Laboratory tests of soils on triaxial compression apparatus

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ABSTRACT

The article compares the results of laboratory tests for the determination of the mechanical properties of soils in triaxial compression conditions. Triaxial soil compression has become more and more widespread in the manufacture of engineering-geological research for construction projects of various engineering constructions. Tests of soils in triaxial stress state conditions produced on a special device called triaxial. All studies presented in this paper were carried out on the device of triaxial compression in the L.N.Gumilyov Eurasian National University. According to the results of this work, recommendations on the practical application of the obtained soil characteristics for a geoinformation geotechnical database in Astana have been compiled.

Keywords: clayey soil, shear strength, cohesion, friction angle, stiffness

1 INTRODUCTION

Triaxial soils tests conducted for determination of strength and deformation properties of soils - the internal friction angle φ, the coefficient of adhesion, deformation modulus e and others. In our case, the purpose of the test was to determine the triaxial deformation modulus of soils in triaxial compression chambers, with the possibility of lateral expansion of soil sample (as opposed to compression).

Soils tests were carried out at constant value comprehensive $\sigma_3 = 0$ d stress, under specified test programme of vertical loading sample. Triaxial tests were conducted on the scheme of consolidated-drained tests, which is held to determine the deformability of soils in a stable condition. This scheme involves the testing of samples of the soil on the unlimited compression (due to open the drainage valve during the whole test) with very low voltage.

The test is carried out using a triaxial apparatus wich shown in Fig.1.

Fig. 1. Triaxial compression device

2 THE METHODOLOGY OF TRIAXIAL TESTS OF SOILS

Soil tests on the compression performed in the following sequence:

-preparation of sample addition breached in a specially built stand dimensions 40x40x60;

-installing the sample in triaxial chamber, preparing for tests, according to GOST 12248-96;

- stage sealing of the sample with comprehensive pressure in the chamber according to the test program with open drain valves, to ensure that water is released from the soil sample (Table 1);

-vertical multi-stage loading sample, constituting 20% of the full pressure.

Table 1 - Levels of application of load by triaxial testing of soils

Levels	Load, MPa
1	0.02
2	0.04
3	0.06
4	0.08
5	0.1
6	0.12
7	0.14
8	0.16
9	0.18
10	0.2
11	0.22
12	0.24
13	0.26
14	0.28
15	0.30

Sample preparation of loamy soil was carried out similarly to compression tests, sequential compaction of soil layers.

Each step of loading is maintained until conditional stabilization of the sample's vertical deformation, the criterion of which is taken as an increment of relative vertical deformation not exceeding 0.001 in 6 hours of observation. Recording samples of instruments for measuring the strain of the soil sample was conducted every 1, 5, 15, 30 minutes, 1, 2, 4, 6, 8 hours.

Comprehensive pressure σ_3 on the soil sample was determined from the condition of the initial stress of the soil as a result of household pressure. When calculating the stress-strain state of the soil, as a rule, the hydrostatic law of the distribution of the initial (natural) stresses in the soil mass is used. In this case, the initial voltage is assigned based on the depth of the soil in question, and is defined as the product of the specific gravity of the soil and the depth of the monolith selection, i.e. $\sigma_3 = \Upsilon \cdot z$. In our case, when triaxial tests will be considered three different values of σ_3 based on the depth of the stamp tests.

Triaxial modulus of deformation E, MPa, determined by tests conducted at a constant value of comprehensive stresses, and calculated by the formula:

$$E = \frac{\Delta\sigma_1}{\Delta\varepsilon_1}, \qquad (1)$$

where:

$\Delta\sigma_1$- increment of stresses in a given range, MPa;
$\Delta\varepsilon_1$ - increment of the relative vertical deformation of the sample.

Fig. 2. shows a graph of the initial stress distribution for clay soils at different densities, for sandy soils in Fig. 3. Table 2. presents the values of comprehensive pressure σ_3 on the soil sample taken for triaxial tests of loamy soil at various humidities and densities, for sandy soils in Table 3.

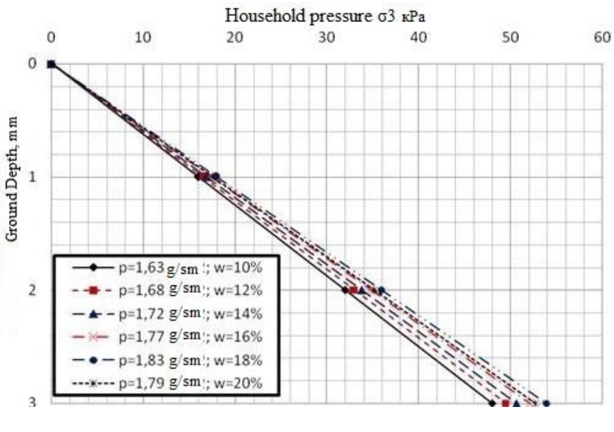


Fig. 1.2 Distribution of domestic pressure of loamy soil depth

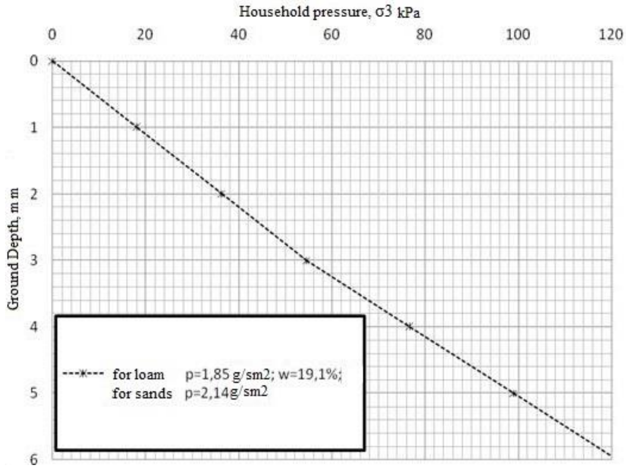


Fig. 2. - Distribution of domestic pressure of sandy soil depth

Table 2. Accepted all-round pressure σ_3 on samples of loamy soil at various values of humidity w and density ρ

Soil moisture w (%)	Soil density ρ (g/sm^2)	Ground depth, m		
		1	2	3
		All-round pressure σ_3, кPa		
10	1.63	16	32	48
12	1.68	16	33	49
14	1.72	17	34	51
16	1.77	17	35	52
18	1.83	18	36	54
20	1.88	18	35	53

Table 3. Accepted all-round pressure σ_3 on sand samples for various depths

Soil density ρ (g/sm^2)	Ground depth, m		
	3-4	4-5	5-6
	All-round pressure σ_3, кPa		
2.14	77	99	121

3 RESULTS OF STABILOMETRIC TESTS OF GROUNDS

The results of triaxial tests of soil samples at various values of density and humidity are presented in the form of graphs in Fig. 4. - for loamy soils, in Fig. 5., 6. - for sandy soils.

The obtained values of the triaxial modulus of deformations are presented in table 4. - for loamy soils, in Table 5.- for sandy. According to the results of statistical processing of the obtained values of the sand deformation moduli, it can be concluded that a high density of test results with a slight variation of 5-6%.

Table 4. Results of triaxial modulus of deformation of loamy soils at different values of all-round pressure

Soil moisture w (%)	Triaxial deformation modulus, E (кPa)		
	σ_3 at a depth 1m	σ_3 at a depth 2m	σ_3 at a depth 3m
	Pressure section, 0,1…0,2 MPa		
10	7630	8930	9270

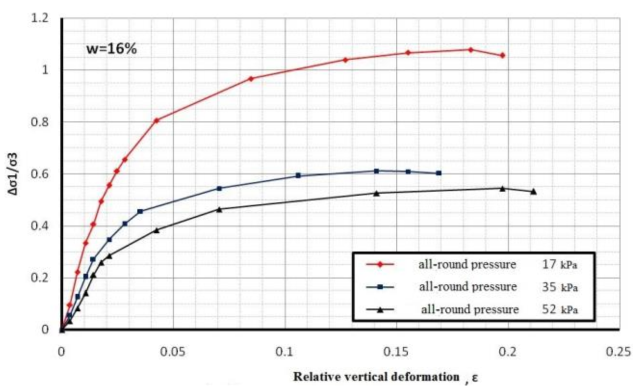
12	7290	8350	8992
14	6280	7890	7890
16	5980	7220	7250
18	5680	6430	7130
20	5550	6120	6380
	Pressure section, 0,2…0,3 MPa		
10	7120	8550	8760
12	6780	7850	8240
14	5930	7330	7320
16	5510	6780	6980
18	5170	6120	6430
20	4820	5780	5990

Table 5. Results of triaxial modulus of deformation of sandy soils at different values of all-round pressure

№ sample	Triaxial deformation modulus, E (кPa)	
	σ_3=77 кPa	σ_3=121 кPa
1	17668	22591
2	17121	23779
3	18853	21131
Average value, *E*	17880	22500
Coefficient of variation, v	0,06	0,05

Since samples of loamy soils are in a limited range of humidity and density characteristic only of the studied construction site, namely (14.4-18.7%, according to engineering and geological surveys), these studies can be applied to loamy soils of a limited range of humidity and can be used for loamy soils of the same composition, but different moisture and density. Therefore, samples of the soil were subjected to the study, both in the undisturbed and disturbed state, with different sample humidity and density, and the results of samples of the damaged structure were used to determine the pattern of change in the deformation modulus from the humidity of a wide range inherent in loamy soils of Astana, the test results of the samples in the undisturbed state (as a result of the limited range of moisture content of the site) were applied to correct the underestimated values of the deformation moduli in the broken state on structural durability.

When triaxial tests of soils, there is no need to adjust for the structural strength of the soil, because it is compensated by the comprehensive pressure in the chamber, simulating the domestic pressure of the soil.



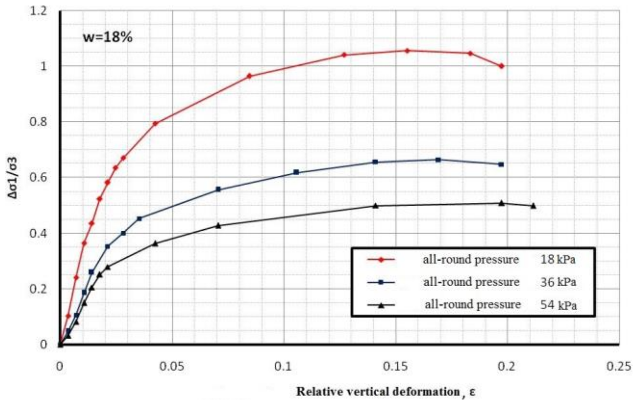


Fig. 4 Results of triaxial testing of samples of loamy soil with moisture content of 16%, and 18% (Table 1.)

Soil testing in laboratory and field conditions to determine its deformation characteristics should be performed in accordance with current government regulations. It should be noted that laboratory tests of soil samples taken under the base of the designed or reconstructed building or structure and, accordingly, under a load for a long time, should be performed taking into account the effective pressures under the base of the foundation.

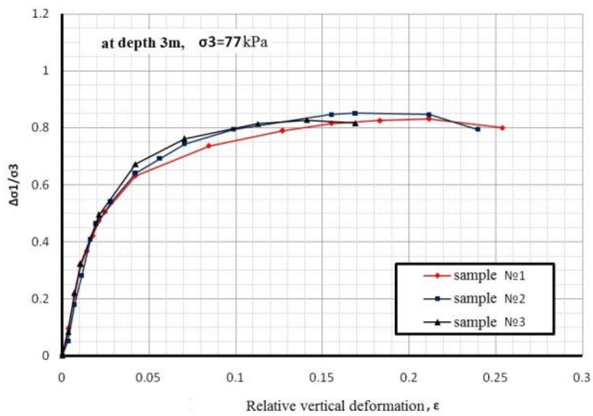


Fig. 5 Results of triaxial tests of samples of sandy soil at a comprehensive pressure of σ_3 = 77 kPa

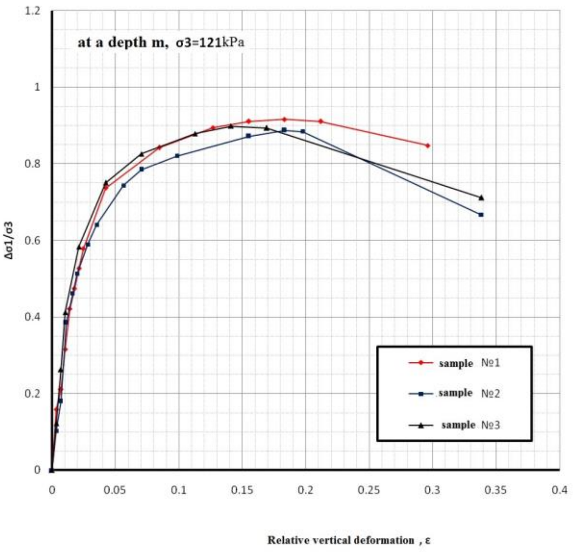


Fig. 6 Results of triaxial tests of samples of sandy soil at a comprehensive pressure of σ_3 = 121kPa

Fig. 7. and 8. show the dependencies of the triaxial deformation modules on the moisture content of loamy soil, expressed by three linear equations for different values of household pressure (depth). Fig. 7. shows the values of the modules in the normal pressure range of 0.1 ... 0.2 MPa, in Fig. 8. in the range of 0.2 ... 0.3 MPa. Distribution modulus of deformation depending on the depth of sandy soils are presented in Fig. 9.

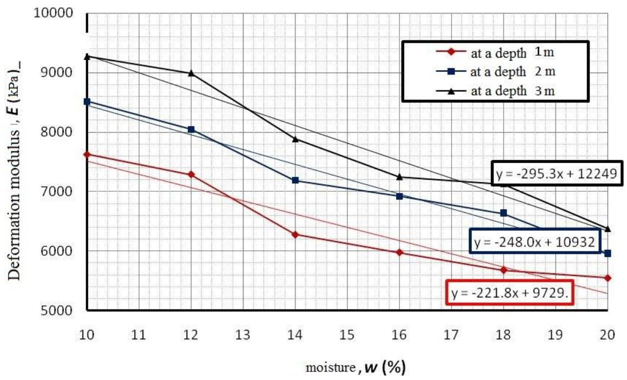


Fig. 7 Dependence of the triaxial modulus of deformation moisture content of loamy soil (0.1 ... 0.2 MPa)

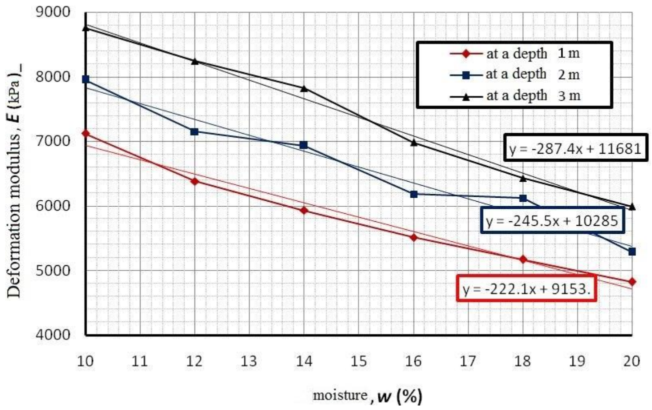


Fig. 8 Dependence of the Triaxial modulus of deformation moisture content of loamy soil (0.2 ... 0.3 MPa)

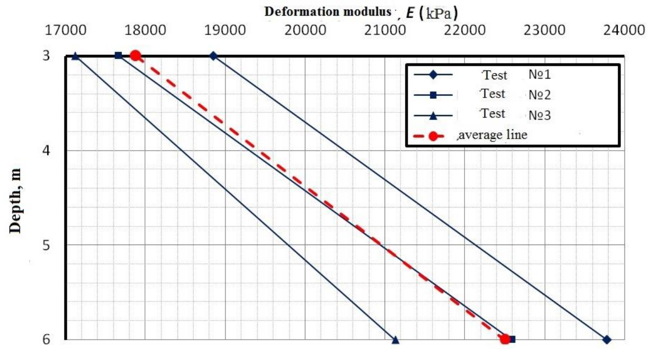


Fig. 9 - Distribution of deformation modulus by depth for sandy grounds

4 CONCLUSION

Triaxial tests of the deformability of soils were carried out, based on the results of which the deformation moduli were determined at different depths (different density, porosity) taking into account the moisture content of soils of disturbed and natural composition. The values of the averaged correction coefficients of the strain modules, determined by triaxial tests, for loamy soils depending on their humidity are presented. Dependencies of triaxial modules of deformations on moisture content of loamy soil related to EGE 2 at various pressure ranges, as well as dependencies of modules of deformation from depth of sandy soils belonging to EGE 3 of Astana have been obtained.

The research process showed that a distinctive feature of the soils of Astana is that the soils of the same addition within one geological element are anisotropic structure and have uneven strength, density, humidity, etc. in depth. For example, the moisture content of loam in Astana city varies within 10.2 - 27.7%, density 1.84 - 2.09, porosity coefficient 0.51 - 0.68. Such different soil characteristics do not give an unambiguous value of the deformation modulus within one geological element.

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