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DEFORMATION OF MOISTENED LOESS FOUNDATIONS OF BUILDINGS UNDER STATIC AND DYNAMIC LOADS

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Abstract:

This scientific article is devoted to the study of the dependence of the magnitude of subsidence and seismic subsidence of subsiding loess soils on an increase in moisture. The results of laboratory experimental studies on the study of subsidence and seismic subsidence of moist loess soils are presented.

Keywords: moisture; loess soil; deformation; drawdown; seismic deformation; subsiding soil; water-saturated soil; moistened soil; vibration unit; fluctuations.

INTRODUCTION. Depending on the natural-historical conditions and the formation of loess rocks, their composition, properties, capacity, as well as depending on the depth of groundwater, the amount of subsidence varies.

It is known that a significant part of the territory of Central Asia is located in difficult engineering and geological conditions. Such territories also include the areas of distribution of loess subsidence soils, in particular the territories of our republic, where the complexity of engineering and geological conditions is aggravated by high seimicity and the possibility of their moistening during the urbanization of lands. These conditions call for the use of such construction techniques that would ensure high reliability and durability of structures [1,2,3].

The design and construction of buildings and structures on loess soils in seismic areas with ensuring their strength, stability and reliable operation is one of the complex problems of modern construction.

The study of the causes of deformations of buildings and structures erected on moist loess soils under seismic influence shows that uneven subsidence of the foundation and deformations of erected structures occur even with minimal pressure on the ground, and the nature of the deformation of the structure depends on ground conditions and the intensity of seismic activity.

Thus, in the presence of weak water-saturated loess soils capable of transitioning into a dynamically disturbed state, it is not always possible to ensure the strength and stability of the structure by calculating their bases according to the first limit state (bearing capacity).

One of the main factors determining the magnitude and nature of the manifestation of soil deformation is the degree of its density, humidity and the prevailing type of structural bonds. Humidity plays a significant role among these factors. With an increase in the humidity of loess soils, compressibility increases and this process entails significant deformations of structures. At the same time, loess soil from one variety to another, characterized by completely different properties. Loess subsidence soils are capable of producing subsidence measured in several tens of centimeters, and sometimes meters, both from additional moisture and vibration.

Research methodology. To study the effect of humidity on deformations of moistened loess soil, a series of laboratory experiments were conducted. For laboratory experiments, samples of loess soils were taken from objects located within the city of Tashkent.The average indicators of the physico-mechanical properties of the studied loess soils are given in Table.1. The experiments were carried out under static and dynamic conditions at a load of P = 0.3 MPa. A dynamic laboratory experiment was carried out on a vibration installation of TASHPI structures. The vibration installation allows you to reproduce harmonic horizontally-forced vibrations with an amplitude from 0.1 to 0.6 mm and a frequency of 1-12 Hz., a load from a given vertical pressure can be applied to the surface of the tested soil sample in a wide range.

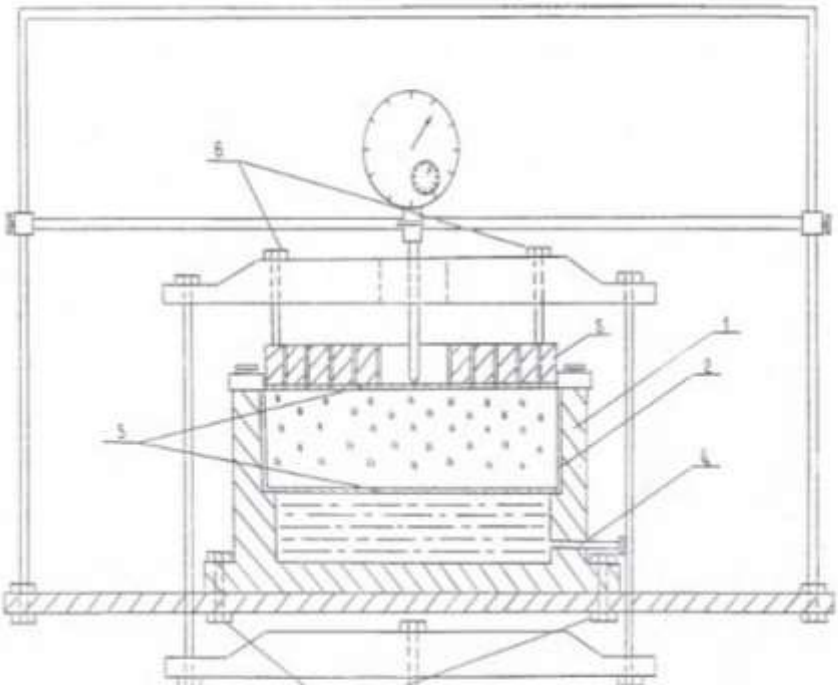

Fig.1 Schematic section of the vibration compression device.
1-special chamber; 2-cutting ring; 3-discs with holes;
4- nozzles; 5-pressure ring; 6- upper pressure bolts;
7-lower clamping bolts

Smooth adjustment of the motor speed by changing the voltage in the motor circuit using a laboratory autotransformer, allows you to create vibration effects of different intensity, taking into account the amplitude and frequency of the oscillation. The intensity of the vibration effect is estimated by the harmonic oscillation formula:

$$\alpha = 4\pi^2 f^2 A$$

where, α- acceleration of oscillation;
f- oscillation frequency;
A- oscillation amplitude

Indicators of physical and mechanical properties of the studied loess soils

Table 1

Ground No.	Natural humidity, %	Soil density, t/м³		Porosity, %	Porosity coefficient	Degree of humidity	Soil moisture		The angle of internal friction, deg.	Specific coupling, MPa	Relative drawdown at P=0,3МПа	Name of the soil
		natural	dry				at the limit of rolling out	at the yield point				
1	3	4	5	6	7	8	9	10	11	12	13	14
1	10	1.54	1.40	48	0.92	0.29	19.8	27.8	29^0	0.015	0.060	Loess - like loam
2	11	1.60	1.44	46	0.87	0.34	20.5	27.5	29^0	0.025	0.053	Loess - like sandy loam
3	13	1.70	1.50	44	0.79	0.44	18.0	26.7	28^0	0.010	0.043	Loess - like loam
4	15	1.79	1.56	42	0.73	0.55	19.0	26.1	30^0	0.050	-	Loess - like sandy loam

At the installation, it is possible to examine soils, both disturbed and undisturbed structures at various oscillation accelerations. With this formula, we can create any value of seismic acceleration on a vibration installation.To perform only preliminary calculations, it is allowed to use the seismic acceleration value given in Table 2.
The acceleration values of ground vibrations during earthquakes (according to S.V.Medvedev).

Table 2.

Scores	Acceleration, $мм/с^2$
6	$250< \alpha \leq 500$
7	$500< \alpha \leq 1000$
8	$1000< \alpha \leq 2000$
9	$2000< \alpha \leq 4000$

When testing soils of an undisturbed structure, the sample got mixed into a compression device that is rigidly fixed on a vibrating plate. The compression device consists of a special chamber, a cutting ring (D = 90mm, h = 30mm), disks with holes (water and air are squeezed out through the upper disk when the sample is deformed, and the soil is soaked through the lower one), a branch pipe through which the soil is soaked. A rubber tube (hose) of the required length is put on the nozzle. The device is equipped with an upper pressure ring, pressure bolts. The device is bolted to the vibrating plate (Fig. 1).
With the help of a cutting ring, twin samples were cut out of a monolith of soil for conducting a series of tests. After preliminary compaction, the ground was soaked in the device. The soil was soaked to various degrees of water saturation (up to ($S_т$=0,8-1,0). After stabilization of the deformations from the lock, the sample was subjected to vibration on a vibration unit in the acceleration range from 100 to 10000 $мм/с^2$ with an oscillation frequency from 1 to 12 Hz and an amplitude of 0.2-4.0 mm.The experiments were carried out at a constant vertical load P = 0.3 MPa and at different oscillation durations.
The vertical deformation of the sample was recorded by hour-type indicators with an accuracy of 0.01 mm. The test sample placed in the compression device is fixed rigidly on the vibrating plate of the installation. A certain amount of oscillation acceleration was applied to the surface of the sample, if necessary.

RESEARCH RESULTS. The results obtained (Table.3) showed that with an increase in the humidity of loess soils, an increase in their subsidence modulus is observed. At the same time, it was also possible to trace an increase in the compressibility of the soil under these conditions.
It should be noted that in some varieties of soils (for example, No. 4), compressibility is insignificant at a pressure on the soil of up to 0.3 MPa, even with an increase in humidity to full water saturation. This is apparently due to the very high density (the density of dry soil is more than 1. 55$т/м^3$) and their strength (Table 3).

Deformation of moistened loess soils under static loads
Table 3

Number and name of the soil	Density of dry soil, in t/м3	Deformation of moistened loess soil under static loads P = 0.3 MPa, in mm/m										
		11%	13%	15%	17%	19%	21%	23%	25%	27%	29%	31%
1. Loess - like loam	1,40	0	2	7	12	20	29	39	47	58	63	65
2. Лёссовидная супесь	1,44	0	2	6	11	18	23	32	40	47	51	53
3. Loess - like loam	1,50	0	0	4	8	13	18	23	28	31	32	32
4. Loess - like sandy loam	1,56	0	0	0	3	5	8	9	10	10	10	10

Deformation of moistened loess soils under dynamic (seismic) loads
Table 4

Number and name of the soil	Density of dry soil, in t/м3	Deformation of moistened loess soil under dynamic loads P = 0.3 MPa, in mm/m										
		11%	13%	15%	17%	19%	21%	23%	25%	27%	29%	31%
1. Loess - like loam	1,40	0	18	32	44	52	58	62	66	67	68	69
2. Loess - like sandy loam	1,44	0	10	23	35	43	50	53	56	58	59	60
3. Loess - like loam	1,50	0	8	16	26	33	40	44	47	49	50	50
4. Loess - like sandy loam	1,56	0	0	8	16	22	27	30	32	33	33	33

It follows that the higher the degree of density, as well as the lower the pressure on the soil, the greater its humidity is needed to begin the destruction of the existing soil structure. This circumstance is clearly seen from Table 4, where the dependences of additional seismic deformation of the soil on its humidity are shown.

Additional deformation (seismic subsidence) during an earthquake can have a significant value exceeding 2-3 times the usual subsidence. These circumstances, along with other factors, lead to catastrophic phenomena associated with the death of a large number of people during earthquakes [3,6,7,8].

CONCLUSIONS. It is known that among geological and engineering-geological processes, the greatest danger to buildings is the subsidence and seismic subsidence of loess rocks. Any moistening of the base of structures erected on such soils can lead to subsidence, and in seismic conditions, in addition to seismic subsidence, it enhances the effect of subsidence processes. The reasons for soaking may be the penetration of atmospheric precipitation under the foundations as a result of weakly compacted backfill around the foundations, water leakage from sewer and water supply systems, etc.

It follows from this that for the occurrence of compaction of loess rocks, it is not at all necessary to moisten them to full water saturation.

As a result, it can be concluded that, when calculating the bases for deformations, it is necessary to take into account additional seismic subsidence of structures.

These results can be taken into account when designing and constructing buildings and structures on moist loess soils in the seismic regions of the Central Asian republics.

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