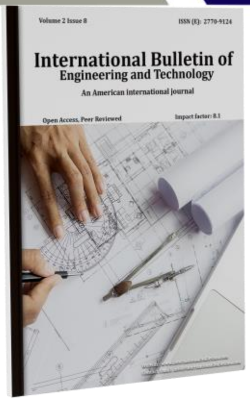

INFLUENCE OF HUMIDITY ON CHANGES IN THE STRENGTH CHARACTERISTICS OF LESS SOILS UNDER SEISMIC INFLUENCE

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Annotation. This article presents the results of analyzes of changes in the strength characteristics of loess soils with an increase in their moisture content. The experiments were carried out in laboratory conditions with static and dynamic loads. These analysis results can be used to determine the bearing capacity of a wet loess base in seismic areas.

Key words: humidity, cohesion, cohesion, angle of internal friction, strength characteristics, static conditions, dynamic conditions, degree of humidity, density, water saturation, loess soil, sandy loam, loam, fluctuations, intensity.

Introduction. The decrease in the strength of loess-like rocks with increasing humidity has been noted by many researchers and is mainly explained by the softening of natural cement, the wedging effect of water films, and a number of other factors. The cohesive force is subjected to a significant decrease with increasing humidity due to the thickening of the water shells of the particles. In this case, the soil particles move away from each other, leaving the zone of molecular attraction, as a result of which the bonding forces between the particles are weakened. Therefore, when the soil is oversaturated with water, it sharply loses its connectivity. Simultaneously with the connectivity, the angle of internal friction of the rock also decreases, which makes it difficult to quantify one or another factor (angle of friction or connectivity). Connectivity is a kind of all-round pressure, which in total replaces the action of all cohesion forces. The adhesion determined by the ball punch method should be considered as some complex characteristic that allows one to evaluate not only adhesion, but also internal friction for plastic soils to a certain extent, which can be used, for example, when calculating the ultimate load on clay soils.

Methodology and results. In order to determine the quantitative changes in the strength parameters of the loess-like soil, depending on the moisture content, a series of laboratory shear tests were carried out.

In accordance with the task of determining the strength characteristics of the studied soils, the shear was carried out slowly under conditions of completed consolidation (with preliminary compaction of soil samples) at a given moisture content.

When tested according to this scheme, the samples were kept at a given vertical pressure (P=0.1; 0.2; 0.3 MPa) until the bottom stabilization (0.01 mm in 3 hours) of compression deformations. During the tests, the shear forces on the pre-compacted specimens were transferred in stages. In this case, each new step was applied after conditional stabilization (not exceeding 0.01 mm/min) of shear deformations from the previous step.

The obtained results on the study of the strength characteristics of loess-like soils show that with an increase in soil moisture, the strength characteristics decrease according to a certain pattern (Fig. 1.2).

In this case, 3 areas should be distinguished:

1. Area of minor changes in the strength characteristics of soils. This is observed in experiments carried out with loess-like soils of natural composition with a moisture content of 4-5% less than at the rolling limit. In this case, there is a slight change in the angle of internal friction and the adhesion force.

2. Area of significant changes in the strength characteristics of soils. As the soil is further moistened to water saturation (humidity degree S = 0.8), the adhesion force and the angle of internal friction decrease significantly (the adhesion force decreases by 2-10 times, and the angle of internal friction is 1.05-1.2).

3. A site where there are no changes in the strength characteristics of soils. A further increase in humidity (from the degree of humidity S=0.8 to S=1.0) up to complete water saturation has practically no effect on the change in the strength characteristics of loess-like soils.

The results of determining the strength characteristics of the studied soils are summarized in Table. 1.

It follows from the tabular data that with an increase in the moisture content of loess-like soils, the adhesion force undergoes a significant change.

The highest values of the adhesion force and the angle of internal friction correspond to the minimum soil moisture, and the minimum values correspond to their water-saturated state.

Also, experimental studies were carried out with various loess soils of an undisturbed structure to study the factors that affect the violation of the connectivity of moistened loess during vibration. For this purpose, the ball stamp method proposed by N.A. Tsytovich was used.

The experiments were carried out according to the following methodology:

1. Two samples were taken from a single monolith. After preliminary compaction at a given load, the initial value of adhesion was determined on one of them.

2. The second sample was subject to dynamic impact while maintaining the same static load. After the shaking ceased, a new connectivity value was determined.

All experiments were carried out in triplicate. The immersion of the ball into the ground and its speed during vibrations showed a decrease in the value of the connectivity of moist loess-like soils. Figure 3 shows the effect of shaking duration when the connectivity of moist loess-like soils changes. As follows from the graphs, the magnitude of the decrease in soil cohesion within 60-120 s. when fluctuating with an intensity of α = 2500 mm/s^2, it is approximately 5-15 times or more.

With further shaking, the cohesiveness of the soil begins to gradually increase. The beginning of intense deformation of moistened loess soils during the oscillation process corresponds to 5–30 s. and more from the moment of applying the dynamic load on the ground. From these experiments, it was also possible to trace that short-term dynamic loads applied to the soil violated only the weakest structural bonds of the soil, and subsequent, relatively long-term vibrations violated these bonds more effectively.

Change in the strength characteristics of loess

soils when moistened

Table 1

№ soil	Density of dry soil, т/м^3	Natural mixture, %	Cohesion values C in MPa and angle internal friction φ in deg			
			With natural humidity		At water saturation	
			C	φ	C	φ
Soil -1	1,40	10	0,0150	29	0,0025	25
Soil -2	1,45(1,44)	11	0,0350	29	0,0025	24
Soil -3	1,50	13	0,0100	28	0,0050	26
Soil -4	1,60(1,56)	15	0,0500	30	0,0100	26
Soil -5	1,36	13	0,0050	28,5	0,0001	23,5

As the test results show, the resistance of cohesive soils under successively increasing loads increases not only due to the angle of internal friction φ, but also due to an increase in cohesive forces under conditions of increasing soil density and decreasing soil moisture.

This circumstance, apparently, is associated with the value of normal stresses acting in the thickness of the soil, as an indicator of the dynamic stability of the soil structure (due to an increase in cohesion).

Figure 4 shows the increase in shear resistance as normal stresses increase.

Figure 5 illustrates the results of experiments to determine the change in the connectivity of loess-like soil depending on humidity at fluctuations of 3000 mm/s2. According to these graphs, one can also trace the decrease in the soil cohesion value as its moisture content increases during the experiment.

It can be seen from Fig. 6 that the values of the connectivity of loess soils, other things being equal, depend on the intensity of the dynamic impact, i.e. decrease with increasing intensity.

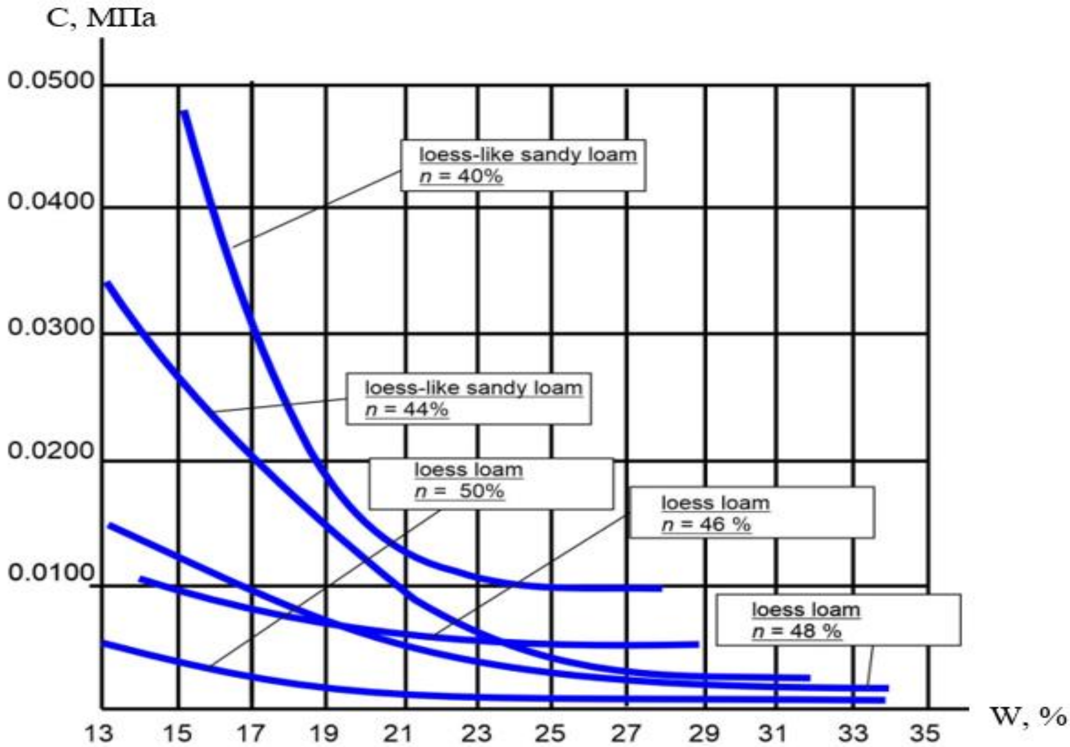

Figure 1. Change in the adhesion force of loess-like soils with increasing humidity

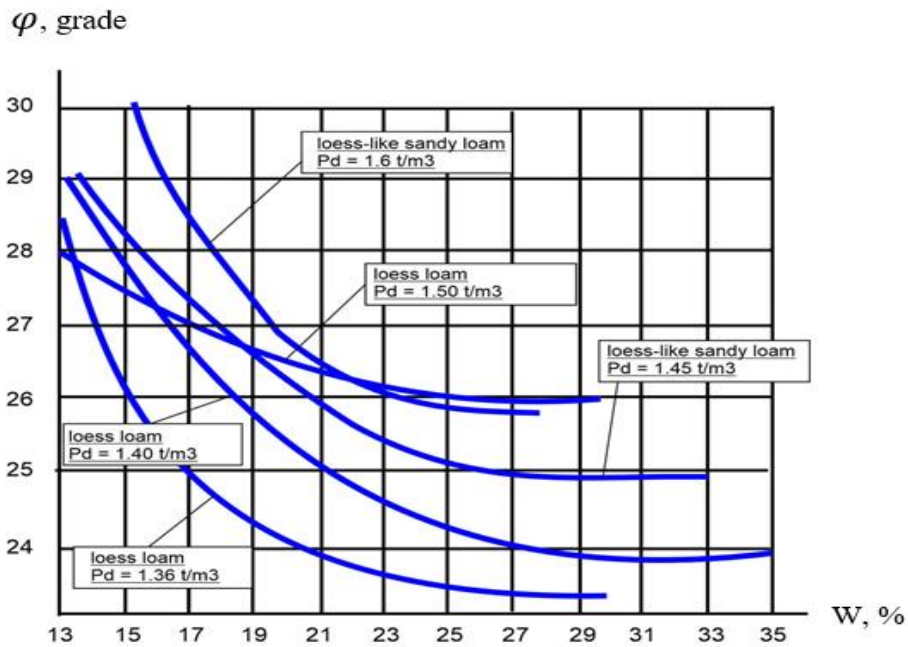

Figure 2. Change in the angle of internal friction of loess-like soils with increasing humidity.

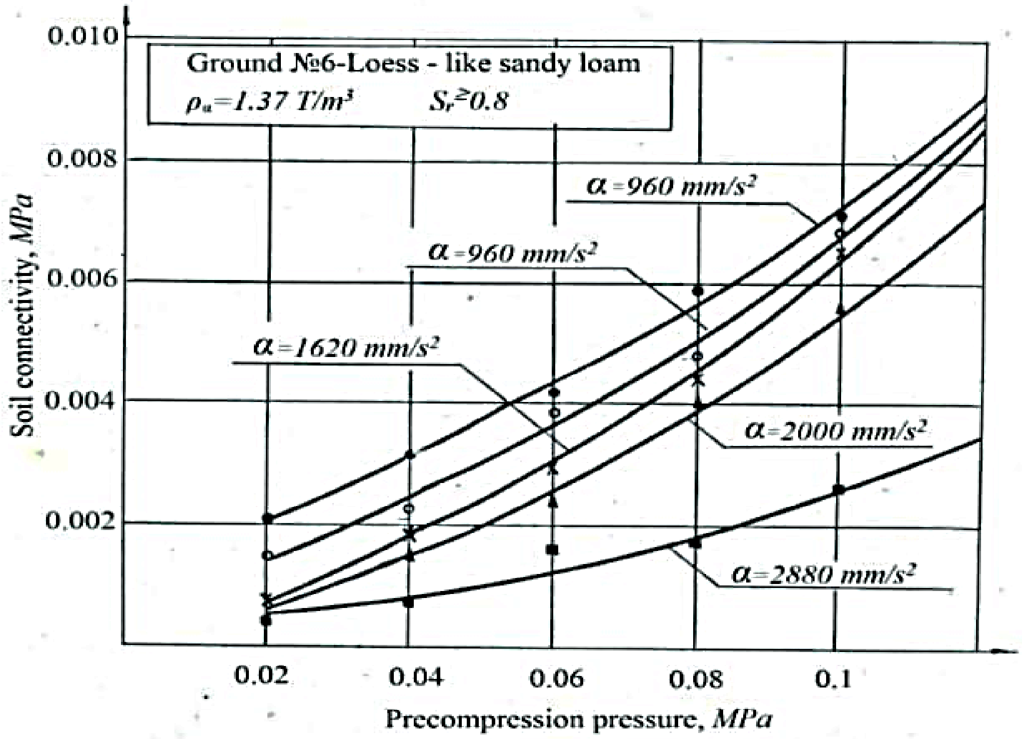

Figure 3. Change in cohesiveness of compacted loess soil depending on various vibration accelerations

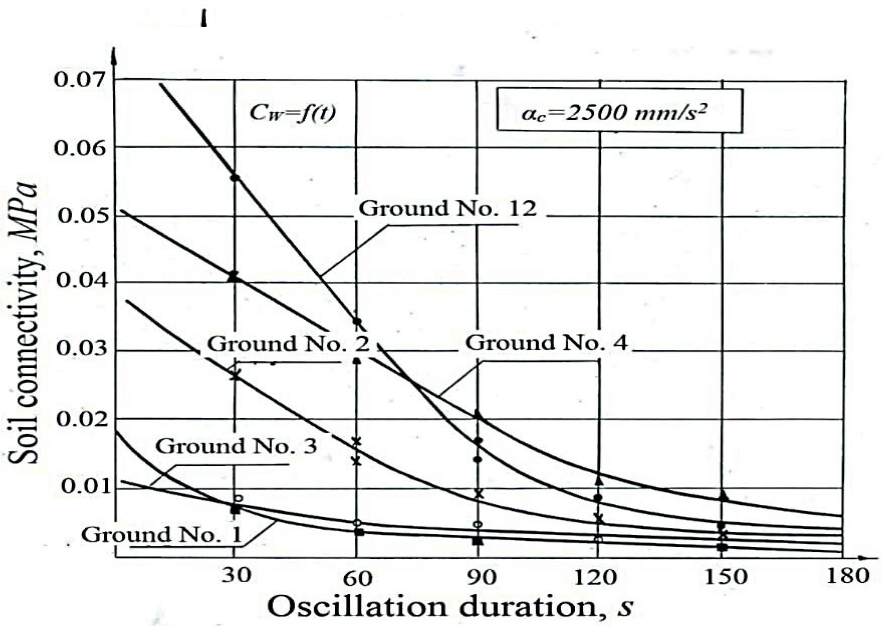

Figure 6. The nature of the change in the connectivity of loess-like soils in time during fluctuations.
The experiments were carried out at the degree of soil moisture

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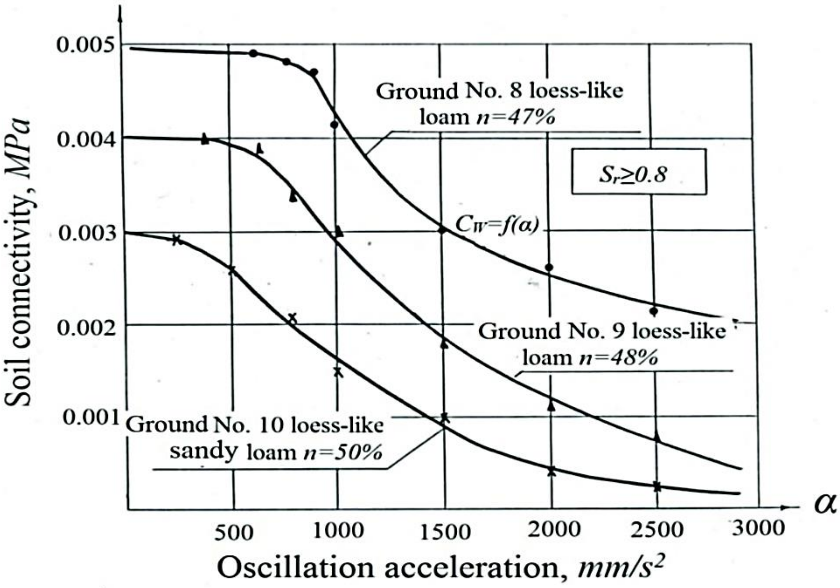

Figure 5. Change in the connectivity of loess-like soils from the acceleration of vibrations

Conclusions. Thus, it can be concluded that the change in the strength characteristics of moistened loess soils under dynamic conditions depends on their moisture content, density, as well as the intensity and duration of the dynamic impact.

The results of experimental studies carried out on moist loess soils showed:

- the possibility of reducing the value of critical acceleration with an increase in soil moisture and a decrease in the role of the load in the oscillation process;
- development of deformation of loess soil from the intensity of vibration. Moreover, high-frequency oscillations play a significant role in the process;
- the deformation of the loess soil also increases with the increase in the duration of the dynamic impact;
- decrease in the strength characteristics of loess soil (the angle of internal friction and the cohesion-cohesion force) during vibrations with acceleration exceeding the critical value. At the same time, the change in the strength of cohesion is especially noted, which is intense in the process of oscillations (as our experimental study showed, with 9-point earthquakes on the international scale MSK-64, the cohesion of a moist subsidence loess soil decreases by about 5-15 times).

The results obtained from studying the change in the strength characteristics of loess soils depending on humidity in static and dynamic conditions can be taken into account in the design and construction of buildings and structures on moist loess soils in seismic regions.

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