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DEPENDENCE OF THE SEISMIC SUBSIDENCE THRESHOLD ON SOIL STRENGH

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Abstract
The article is devoted to research on the relationship between the ability of soil to settle under seismic action and its strength. It is emphasized that the ability of soil to settle under seismic action depends on the amount of soft bonding strength between particles.

Introduction

It is known that the occurrence of seismic subsidence deformation due to the violation of the structural strength of the moistened loess layer under dynamic influence does not occur in all cases and with varying degrees of intensity. It can be assumed that the intensity of the dynamic influence plays a significant role in this process. On the other hand, the natural strength, which is determined by the density and moisture content of the fluctuating soil, may also be of importance. It is also indisputable that the degree of disturbance of the structure of moist loess soils during oscillation, and hence their seismic subsidence deformation, is determined by the effect of only a certain part of the dynamic (seismic) load applied to them. This is estimated by the magnitude of the maximum seismic acceleration associated with the resulting oscillation. (α_c).

Denoting the active part of the acceleration of oscillations by , α_p, we can write

$$\alpha_p = \alpha_c - \alpha_{\lim} \tag{1}$$

Where $\alpha_{\lim}$ - the seismoprosadnost threshold is a certain limiting acceleration that is absorbed within the soil mass by the forces of resistance acting within it, and primarily, as the analysis of the research results showed, by the forces of cohesion (c_w) and internal friction (φ_w).

Under these conditions, the seismic subsidence threshold can be considered as a criterion for soil stability during shaking, where the soil structure remains intact and the soil retains its static strength.

Therefore, all values of seismic accelerations less than $\alpha_{\lim}$, resistance (strength) the moisture content of loess soil is determined by the expression [1]:

$$S = \sigma_d \cdot tg\varphi_w + c_w , \tag{2}$$

Where σ_d - dynamic normal stress from the weight of the soil above the horizon in question and the weight of the structures;

φ_w - The angle of internal friction at humidity w;

c_w - General adhesion in case of soil moisture w.

Obviously, the higher the seismic subsidence threshold value is $\alpha_{\lim}$, the smaller the acceleration is α_p, it causes deformation of the soil layer. The seismic subsidence threshold is functionally related to the strength characteristics of soils in the form of:

$$\alpha_{\lim} = \xi(\sigma_d tg\varphi_w + c_w) \qquad (3)$$

Where ξ - a parameter related to the property and condition of the soil, as well as the nature of the dynamic mode.

According to expression (3), the value of the seismic subsidence threshold $\alpha_{\lim}$ during the oscillation process, the soil strength parameters, such as the angle of internal friction, may change partially or completely. (φ_w)and the clutch (c_w), as well as the normal stress (σ),acting on the horizon in question.

Thus, the disclosure of the nature of the structural strength violation of loess soils is reduced to the identification of parameters of resistance (strength) to their shear, changing in dynamic conditions.

Laboratory studies were performed on specially selected samples of loess rocks, which within the depth of 12m were characterized by a small spread of values of the main indicators of the physical state of the soil.

Seismic subsidence threshold $\alpha_{\lim}$ was determined on a vibrocompression device. The load range on the samples was taken within 0 to 30.0·105 Pa, and the acceleration of the oscillatory motion from 500 to 4000 mm/c2. According to expression (3), the value of the seismic subsidence threshold ($\alpha_{\lim}$)depends on the soil's strength characteristics (the angle of internal friction and cohesion), as well as the normal stress (both from the self-weight of the overlying layer and from the weight of the structure).

It should be noted that the unstable structure of loess soils is due to the weak cohesion of the structural elements that is characteristic of these soils. The strength of these soils depends on the composition and water resistance of the aggregating substance. The ability of the natural cementing substance to relax and break down during vibration, which creates cohesion between the soil particles, determines the nature of the bonds to a large extent. The nature of the cohesion in loess soils is determined by the physical and chemical properties of the bonds, their water resistance, and their mechanical strength.

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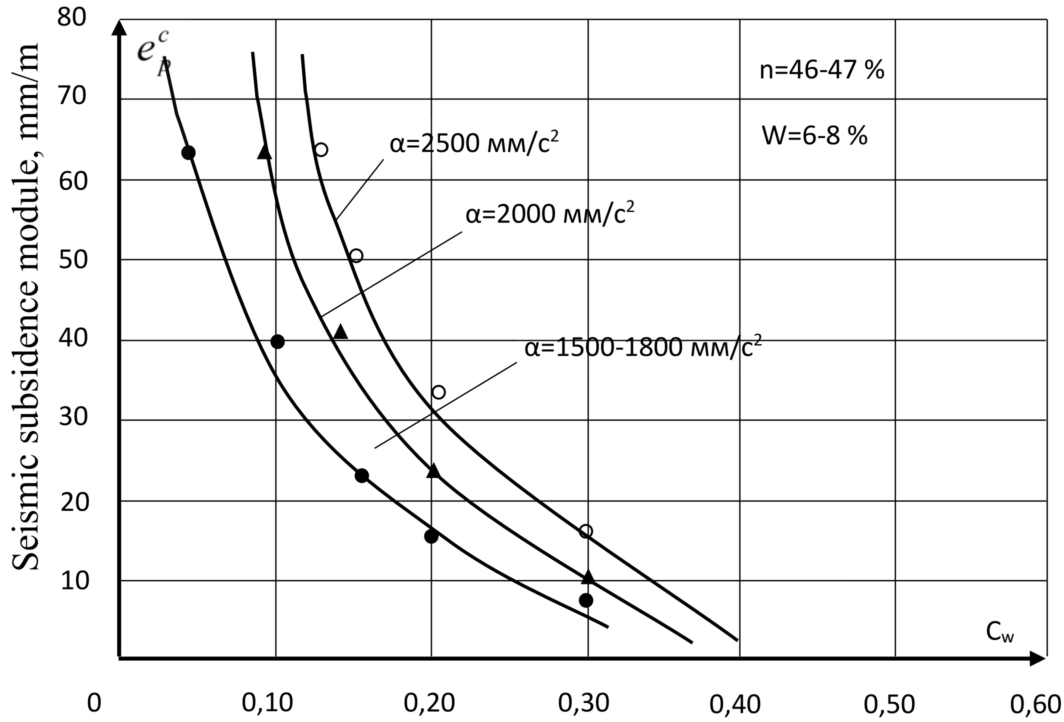
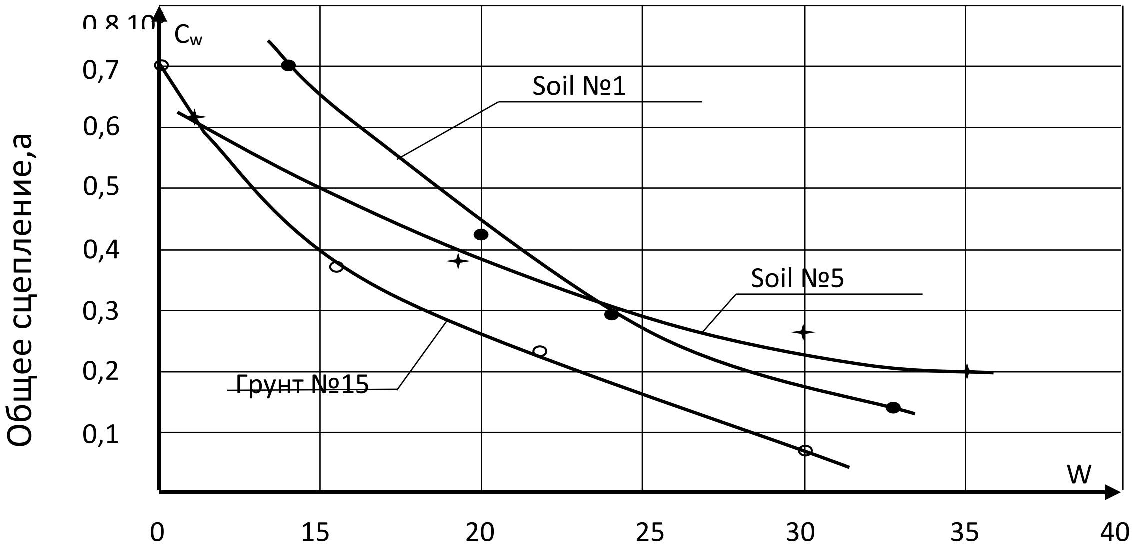


Soil cohesion, 10^5 Pa Pic. 1. Graph of the form $e_p^c = f(c_w)$ for moistened forests.

In nature, there may be cases where, in different zones of a soil mass, the forces of adhesion between particles are determined by cements of different strengths. In such cases, it is clear that the deformation of particles will be different in different places, and the structure of the soil will remain intact where the forces of adhesion are strongest and are determined by more rigid cements. Figure 1 shows the results of vibration tests on loess soil. The soil was pre-soaked for 3 to 8 days before the experiment, and it was in a similar condition before the experiment.

At the same time, the soil's cohesive force decreased to 0.5·105 Pa, and the porosity ranged from 49.0% to 44.4%. Subsequently, the samples were subjected to vibration with an acceleration of 2500 mm/s2. The results of such experiments allowed us to establish a significant dependence of the seismic subsidence deformation of loess soil on the magnitude of the cohesion force (Fig. 2).



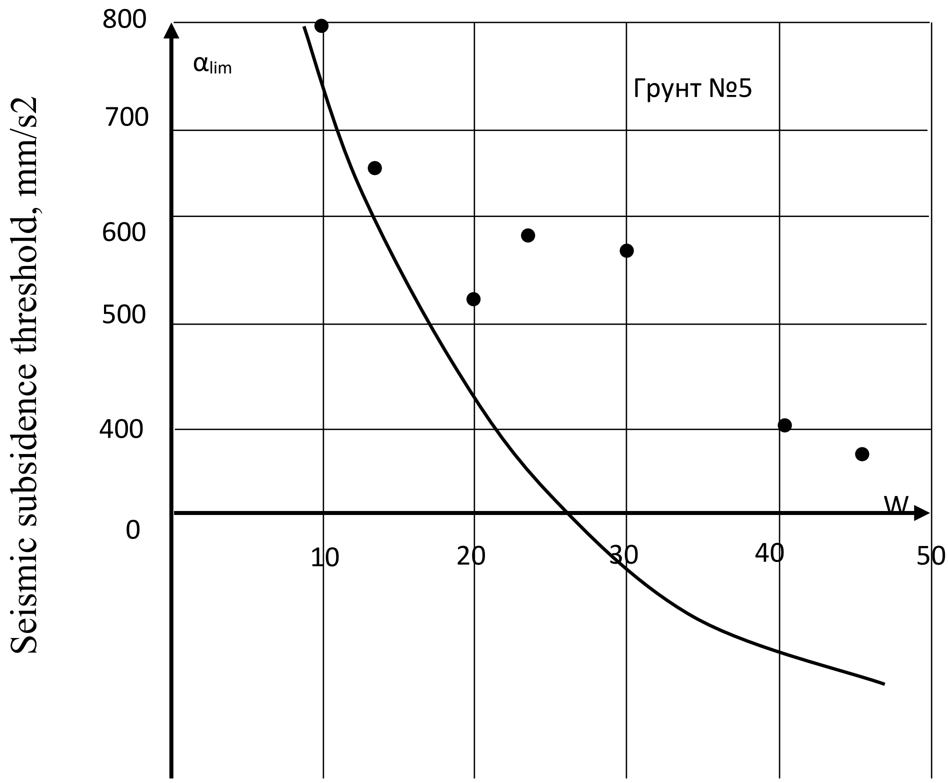
Soil moisture content, % Fig. 2. Decrease in cohesion of loess soils with increasing moisture content

This type of dependence is especially evident in the oscillation of highly moistened (water-saturated) forests, whose strength is determined only by the soft cohesive forces (c_w) that have a water-colloid character. In these types of forests, there are almost no internal friction forces. (φ_w), and rigid structural bonds (c_c).

Hence, the strength of plastic lasses is represented by:

$$S_{пл} = c_w \qquad (4)$$

According to research, these types of lesseps are capable of seismic subsidence under the slightest seismic impact, as they have low seismic subsidence thresholds. $\alpha_{\lim}$ (Fig.3).



Soil moisture content, % Fig. 3. The nature of the seismic subsidence threshold change for plastic loess soil.

Unlike plastic leses, their low-moisture varieties are characterized by the presence of internal friction (φ_w) and cohesion (c_c), and sometimes structural adhesion (c_c) in a very weak form.

Then their strength is represented as:

$$S_{pw}(t) = \sigma_{\partial u н} tg\varphi_w + c_w(t) + c_c \tag{5}$$

Subsidence, a slightly higher acceleration and longer duration of vibration are required due to their increased strength. However, in this case, the critical factors are the values of cohesion (c_w, c_c) and the intensity of dynamic impact. Additionally, the natural moisture content of the soil also plays a significant role, as an increase in moisture content always leads to a decrease in cohesion, resulting in a lower threshold for seismic subsidence in these soils. $\alpha_{\lim}$.

In conclusion, it should be noted that in the plan under consideration, the entire issue boils down to establishing the cohesion of the soil, the strength of which determines the threshold for seismic subsidence under all conditions. For this reason, many clay soils may be considered seismically stable if they possess sufficient cohesive forces. In such cases, the duration of one or more phases of an earthquake may not be sufficient to disrupt their bonds.

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