V.V. Gruzin, S.N. Nurakov, K.B. Yesbergenov

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AUTHORS
V. V. Gruzin
S. N. Nurakov
K. B. Yesbergenov
National University of Defence
Republic of Kazakhstan

MODELLING OF STRUCTURAL AND PHASE DEFORMABILITY OF SOIL FOR STRENGTHENING OF THE BASES OF PLACES OF STORAGE APPLIANCES

Storage of appliances on military facilities in peacetime makes to 70-90% of the general duration of their operation [1]. In this regard, as a result 35-40 years later there are problems on these objects related to:

– sag of foundations of buildings of storages;

– rise in level of ground waters in semi-underground storages because of emergence of natural reservoirs;

– salinization of the surface of soil;

– swelling of soil at foundations of semi-underground storages and their rise during the winter period.

Complex influence of the specified factors leads to change of physical and mechanical properties of the soil bases and, as a result, premature destruction of the bases of buildings and constructions where storage of military property is carried out.

On the basis of stated by the actual direction, a study of deformation properties of soil is conducted in order to carry out timely actions for strengthening of the bases and bases of buildings and military constructions.

After numerous research works performed, it was established that dependence between the enclosed tension and the deformations caused by them in soil has a nonlinear character. Therefore, for instance, A. A. Bartholomaei suggests recording it like [2]:

$$\varepsilon = \alpha_c \sigma_c + \alpha_n \cdot (\sigma_n - \sigma_c)^m , \qquad (1)$$

where α_c and α_n are coefficients, defined by practice;

σ_c – tension which isn't exceeding the structural durability of soil $\sigma_c \le P_{cmp}$;

σ_n – tension causing soil deformation – $\sigma = \sigma_n - \sigma_c$;

m – the nonlinearity parameter determined by practical consideration.

Coefficient α_c is inversely proportional to the module of elasticity:

$$\alpha_c = \frac{1}{E_y}, \tag{2}$$

Coefficient α_n is the function of the module of total deformation $E(z)$:

$$\alpha_n = \frac{k(\beta)}{E^r(z)}, \tag{3}$$

where $k(\beta)$ is a coefficient, which depends on Poissons coefficient;

r – parameter (≤1), which is defined by the practical way.

I. I. Cherkasov by means of stamps investigated in field and laboratory conditions of interaction of the three-phase disperse environment with the loading transferred to it by a rigid body (the base or a stamp for field tests) [3].

For the description of nonlinear dependence of relative deformation of soil on tension attached to it S. R. Meschyan offers three options of the approximating functions [4]:

$$\varepsilon = k_1 \cdot \left(1 - \exp(-k_2 \cdot \sigma)\right), \tag{4}$$

$$\varepsilon = k_3 \cdot \sigma^{k_4}, \tag{5}$$

$$\varepsilon = k_5 \cdot \sigma + k_6 \cdot \sigma^{k_7}, \tag{6}$$

where $k_1 ... k_7$ are coefficients, defined by practice.

In the course of development of more exact model of dynamic deformation of the soil environment of undisturbed structure in the form of an elasto-plastic half-space possibility of the description of dependence “tension – relative deformation” was investigated by function of a look (4).

Considering the structural durability of soil σ_{cmp}, dependence (4) for every $\sigma > \sigma_{cmp}$ is presented in the following form:

$$\varepsilon(\sigma) = k_1 \cdot \left(1 - e^{-k_2 \cdot (\sigma - \sigma_{cmp})}\right) \tag{7}$$

For specification of coefficients k_1 and k_2 known dependence of coefficient of porosity of soil e on the set size of the enclosed squeezing tension σ:

$$e(\sigma) = e_0 - \varepsilon(\sigma) \cdot (1 + e_0) \tag{8}$$

where e_0 is initial coefficient of porosity of soil.

During theoretical research by means of mathematical model the dependence option “tension – relative deformation” was received:

$$\varepsilon(\sigma) = k_1 \cdot \left(1 - e^{-k_2 \cdot (\sigma - \sigma_{cmp})}\right)^{k_3} \tag{9}$$

Research allowed defining coefficients k_1, k_2, k_3 [5] by earlier created mathematical model, having substituted their values, will be able to get:

$$\varepsilon(\sigma) = 0{,}2564 \cdot \left(1 - e^{-2{,}03 \cdot 10^{-7} \cdot (\sigma - \sigma_{cmp})}\right)^{1{,}4} \qquad (10)$$

For the analysis of adequacy to the developed model comparative research of the theoretical and available practical results received for loams of various consistence was conducted. The comparative analysis of experimental and analytical data allows drawing a conclusion on applicability of the equation (10) for the description of dependence "tension – relative deformation loam of undisturbed structure with plasticity number $0 \le I_P \le 0{,}5$ in the working range of loadings when modeling pulse impact of working body on soil of undisturbed structure.

As initial characteristics of soil standard values of specific coupling were used c, corner of internal friction φ, and also porosity coefficient e_0 of soil [4, 5, 6].

For comparison reasons there are provided in the table theoretical and experimental data of research of time of pulse impact of t the worker of body on an elasto-plastic half-space (soil).

Table 1.

The table of the comparative analysis of results of the carried-out research

i, Pa·s	Time of pulse influence, c		
	Model (10) (theor.)	Kharkuta N. Y. (exp.)	Tarasov V. N. (theor.)
5 000	0,0150	0,015	0,016
10 000	0,0196	0,020	0,023
15 000	0,0254	0,025	0,029
20 000	0,0310	0,030	0,034
25 000	0,0360	0,035	0,038

As a result of carrying out research there were received:

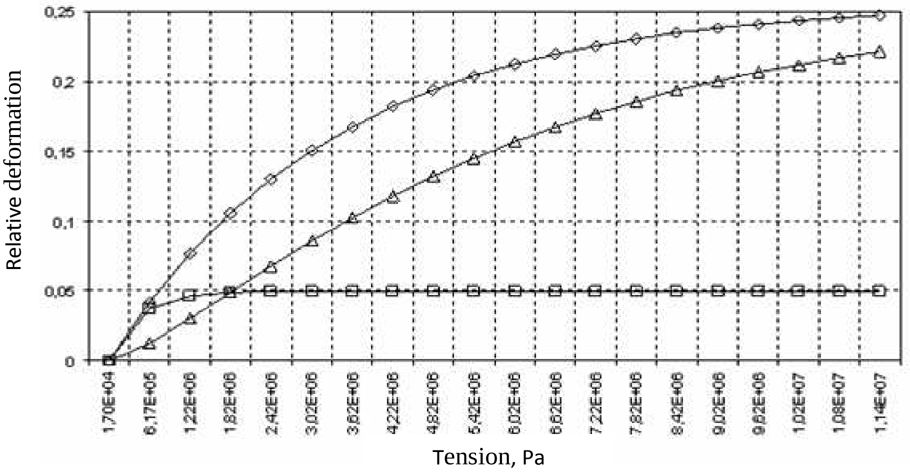
– dependence of density of loam on its porosity $\rho = f(e_0)$:

$$\rho = \frac{2700}{e_0 + 1} + 260 \qquad (11)$$

– dependence of structural durability of loam on its porosity $\sigma_{cmp} = f(e_0)$:

$$\sigma_{cmp}^{I_L} = \sigma_{cmp}^{0}\left[k_4 \cdot (0{,}95 - e_0) + 1\right] \qquad (12)$$

The application of mathematical model taking into account expressions (10) allowed receiving graphic dependences of time of influence for loams of various consistence taking into account the module of deformation and size of the pressing impulse (see the drawing).



Drawing of dependence of relative deformation of soil on tension in the range from 0,02 MPa to 12,02 MPas for various approximating functions.

By results of theoretical research, the error of mathematical model was calculated of the application of loading for loams of various consistence whose size does not exceed 19,1% that is quite accepted for similar calculations. The possible reason of a divergence of theoretical and experimental data is the absence of data describing dependence of structural durability on a consistence and porosity of soil.

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