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T. Olevskaya, E. Kolunaev

CHANGE DURABILITY OF NATURAL MATERIALS IN THE CONDITIONS OF VARIABLE NORMAL LOADINGS

A change durability of natural materials is investigated in the conditions of complete cycle of unloading-loading. It is shown, that durability of natural materials is not a constant magnitude. A change durability of natural materials takes place in time and is determined by the operating loadings.

Problem statement

Durability of natural materials is not a constant magnitude. A change durability of natural materials arises because of change of the tense state, that is determined by the application of external normal loading or unloading in the conditions of absence of possibility of lateral expansion. The change of physics-mechanical properties of natural materials, composing an array, can be accompanied deformations of array and loss of stability of buildings. Solving the problems, related to the quantitative estimation of stability degree of an array, it is necessary to forecast the changes of properties of the examined natural material in the range of affecting him loads.

The purpose of the article consists in description of results of experimental researches concerning change durability of natural material in the conditions of the variable normal loadings. In this publication Eocene clays are considered as natural material.

Analytical method and experimental results

Researches of change durability of Eocene clays were conducted in natural and laboratory condition based on the standards of different height of natural and broken addition on the methods of unconsolidated - undrained and consolidate – undrained cut which foresees pre-treatment of standards by their untightening or compression to the set values.

In the course of unloading there is a change of a natural tension therefore considered clay become recondensed in relation to a new mode of loading and start to be loosened. Process of clay untightening proceeds phasic: at the first stage occurs preliminary untightening by means of realization of elastic restoration forces and partially via swelling in the conditions of sharp decrease in normal loading and possibility of additional humidifying; at the second stage clay untightening is realized in the course of free swelling with change of physicomechanical properties under condition of preservation of natural addition. At the third stage process of untightening is accompanied by infringement of natural addition clay and sharp change of their physicomechanical properties.

Character of swelling of Eocene clays of natural addition corresponds the character of swelling of breeds, possessing tripping work-hardenings, in which the splitter effect of water thin-films is substantially low-spirited and untightening takes place due to resilient deformations of skeleton, pore water and connections in the contact points of mineral particles. Swelling quantity of carbonaceous clays on-loading, changes in time and can be described by empiric dependence:

$$E = E_0 \cdot \sqrt[n]{t}\,,$$

where: E – is a size of the relative swelling

$$E_0 = \frac{h' - h}{h},$$

t – is time,

n – an index of weakening degree, characterizing the terms of breed work in nature;

h – is an initial height of standard, sm;

h' – eventual height of standard, sm.

The size of weakening degree depends on the degree of unloading of breed which is expressed through the index of swelling:

$$П_Н = 1 - \frac{\sigma_i}{\sigma_Н},$$

where: σ_i – it is the operating loading, MPa;

$\sigma_Н$ – it is pressure of swelling of the probed soil, MPa.

The values of indexes of swelled change in an interval from 0 to 1. At a zero index value of swelled clay does not yet begin to swell, at the size of index of swelled to equal unit clay is fully disburdened and swelling will be maximally possible. In the process of swelling humidity is increased and durability of clays goes down. An increase of humidity of Eocene clays in the conditions of the free swelling at the maintainance of natural addition was only 2%, that is explained by presence in clays of the structural tripping. The results of researches concerning change durability of clays in the process of their unloading and subsequent swelling under the different normal loadings are presented as family of curves on the fig. 1.

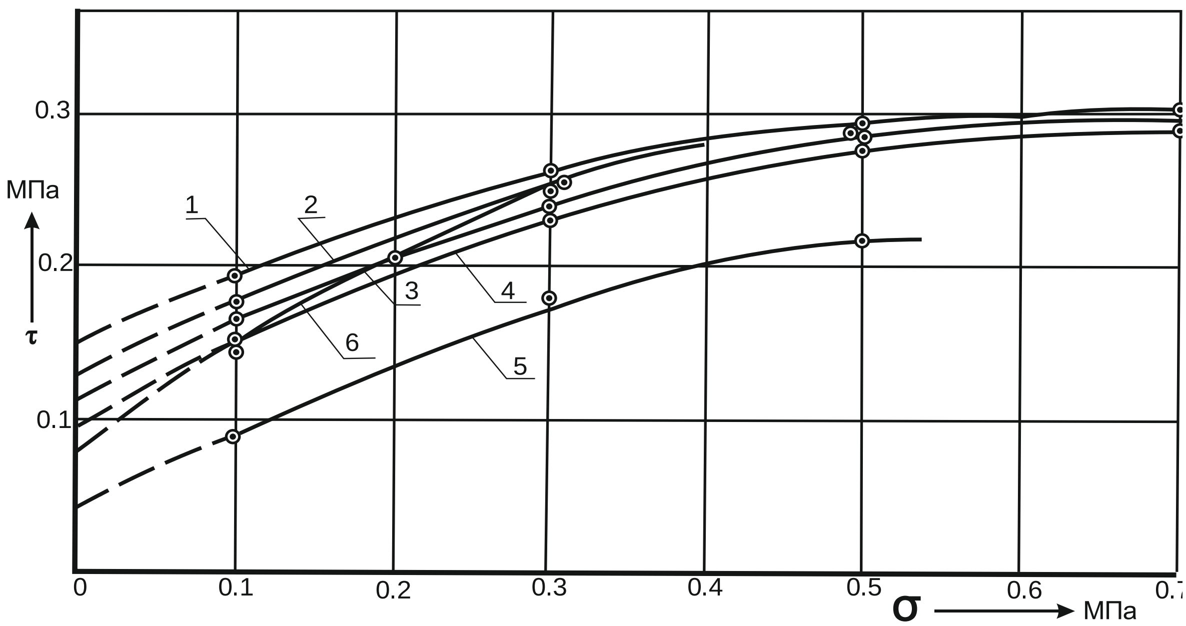

Fig. 1. Schedule of shear resistance of Buchatskiy carbonaceous clays, decompressed under different normal loads

1 – same household, 2 – 0,3MPa, 3 – 0,2 MPa, 4 – 0,1 MPa, 5 – zero

Curve 1, obtained as a result of clays test on the chart of unconsolidated-undrained change characterizes durability of clays in the conditions of natural closeness – humidity at loadings, exceeding pressure of swelling, curve 5, characterizes durability of those clays after completion of the free swelling process;

curve 6 characterizes durability of clays, preliminary dropsically under those normal loadings, at which a change was produced, as a swelling process is possible only at loadings less then swelling pressures, curve 6 partly coincides with a curve 1. Curve 6 is the geometrical mestome of points, lying on family of curves. Each of which corresponds durability of the examined clays in the certain state of closeness-humidity and degree of breed swelling.

As the conducted experiments rotined, the decline of clays durability because of diminishing of the normal loading on condition of maintenance of natural addition takes place due to diminishing of tripping at practically unchanging coal of internal friction. In the interval of the normal loadings from a zero to the size, equal to pressure of swelling, the change of tripping with sufficient for practical aims exactness is approximated by the empiric dependence got in the process of researches:

$$C_i = C_0 \cdot E^{\Pi í}$$

C_i – size of the remaining tripping, MPa

C_0 – is a value of quantity of clay tripping at a natural closeness – humidity, MPa;

Π_H – is an index of swelled.

Researches of change durability of the disburdened clays in the conditions of the alternate moistening – dryings showed that s a result one-multiple torrefactions humidity of standards goes down by 4-5%, here is by volume shrinkage and opening of thin cracks on-the-spot standards. Test on the change of hard-baked standards displayed the increase of durability due to sharp, increase in two times of internal friction. At the subsequent moistening there is a decline of standards durability both due to diminishing of tripping size after the first cycle of drying-moistening and due to the angle declination of internal friction from 220 to 30. Humidity is increased here as compared to natural by 5%. After the triple reiteration of drying moistening cycle clay becomes deformed as a plastic body. The study of change durability of the water-logged clays in the process of their consolidation was produced by shear tests. As a feedstock in experiments on consolidation clays of the broken addition were used at humidity, exceeding humidity yield-point. Time of compression of standards in seals was accordingly for every party of standards: 30 min, 1 h, 1 d., 3 d., 10 d., and 1 m., 3 m. Experiments were held in the conditions of one-sided outflow of water that designs the terms of consolidation of the water-saturated rocks on a conditional aquiclude. More compact loading was accepted equal 0,2 MPa in the size of swelling pressure of the probed clays. The use of dependence of lauter consolidation theory for description of compression of the water-logged clays of the broken addition at the first stage of their ladening is legitimate, as in the initial state the probed breeds are the ground mass without structural connections due to a presence in the breeds of free, hydraulically continuous water and strongly developed water-colloid shells, eliminating possibility of direct contact between particles. At consideration of process of compression of the water-logged carbonaceous clays, it is possible to be limited to the decision of task of consolidation of the ground mass for the terms of unidimensional compression under an action external the instantly attached equipartition loading:

$$C\frac{d^2 pz}{dz^2} = \frac{dpz}{dt},$$

where pz – is pressure in the skeleton of soil of MPa;

t – is time;

C – is a coefficient of soil consolidation.

$$C = \frac{k}{\alpha_0 \gamma_{\hat{a}}}$$

where k – is a coefficient of filtration, m/s;

α_0 – is a coefficient of compressibility, reflecting the change of volume of soil;

γ_0 – is a density of water, t/m^3.

Curves, illustrating the conduct of the probed clays under constant sealing loads, are illustrated on a fig. 2.

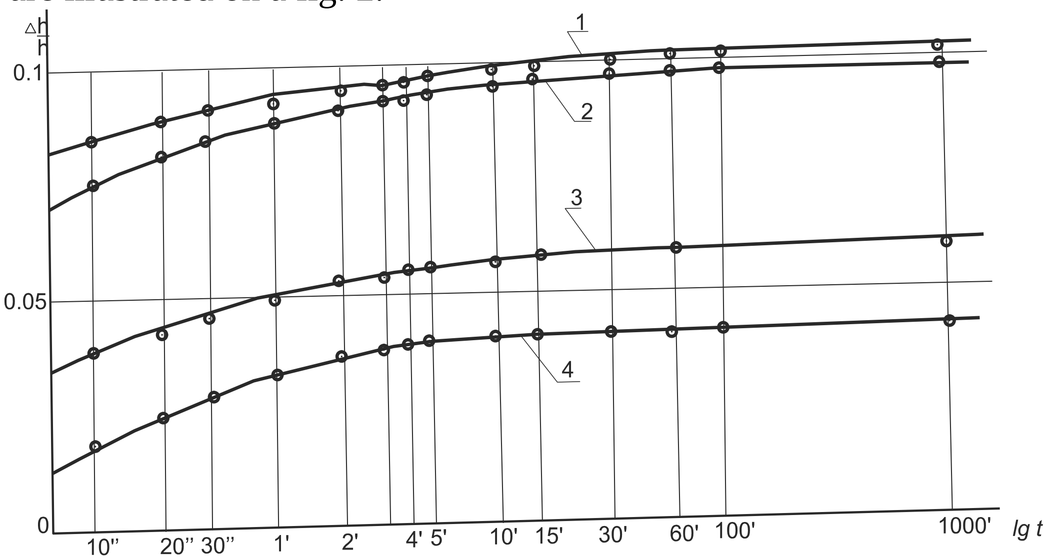

Fig. 2. Sealing of wetland Buchatskiy carbonaceous clays under a constant load. Sealing load is accordingly:

1 – 0,3 MPa, 2 – 0,2 MPa, 3 – 0,1 MPa, 4 – 0, 05 MPa

It presents from the given scheme, that the unidimensional compression of clays under the action of quiescent load takes place in two stages and consists of lauter consolidation and deformation of creep. The moment of completion of primary or lauter consolidation is determined by inflectionpoints charts of compression dependence. In the period of lauter consolidation the process of compression of clays, regardless the size of the attached normal loading, flows considerably more intensive, than in the period of the second consolidation. Deformation of compression of lauter consolidation is 85% to general deformation of compression. Does the coefficient of filtration of investigational clays according to laboratory data average 1,3 x10-7 sm/s, that supposes possibility of pore pressure in soil. According to the theory of lauter consolidation durability of clay breeds is the function of operating normal tension and changes within the limits of change in degree of pore pressure:

$$\tau = \left(\sigma - p_w\right)\mathrm{tg}\varphi + C$$

where τ – it is a rate of sharing resistance, MPa;

σ – the normal loading, MPa;

p_w – is a size of pore pressure, MPa.

Work-hardening of clays in the process of their consolidation shows up in the simultaneous increase of tripping and recreation internal friction. The increase of sharing resistance corresponds diminishing of humidity of standards.

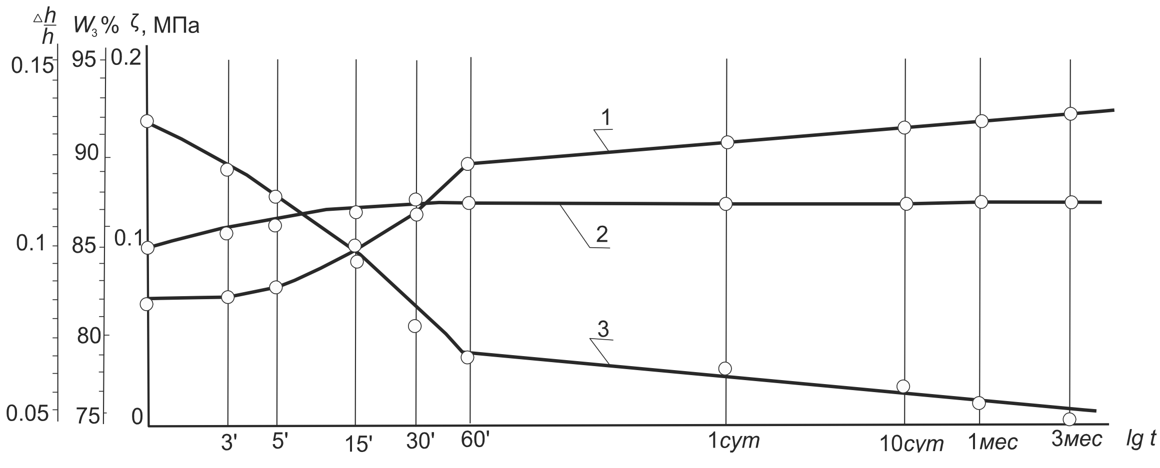

Fig. 3. Changing the physical and mechanical properties decompressed wetland carbonaceous shale in time under a constant load
1 – curve of strength changes over time, 2 – precipitation curve,
3 – curve of humidity changes over time

Comparison of curves of change humidity and durability in time with a compression curve (fig. 3) shows that an inflectionpoint curves of changes humidity and durability in time coincides with the moment of completion of lauter consolidation of the probed carbonaceous clay breeds. Thereby sharing resistance in an inflectionpoint the crooked dependence of change durability in time characterizes durability of breed, corresponding the state of closeness – humidity, attained by the probed soil in times of its lauter consolidation under the given loading. Consequently, the process of lauter consolidation in clays is expressed in the change of three associate descriptions: closenesses; humidity; durability, reflecting changes taking place in a breed.

Conclusions

From the given results of researches of natural materials, executed on the example of Eocene clays, it follows that durability of natural materials is not permanent in size and depends on the following factors: time, initial state of closeness-humidity of material, sizes and mode of load application, presence of additional factors of influence on natural materials, such as conditions of the additional moistening, temperature condition of environment, geodynamic phenomena et cetera.

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