Simulation of Stress-Strain State of The Reinforced Soil Foundation for Structures

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Abstract: Therein there is formation of algorithms database of stress-strain state of reinforced soil foundations and optimizing the main parameters of the computer model. The analysis of the results of calculations for the foundation strip, slab and columar type on homogeneous and layered the basis.

Keywords: soil foundation, foundation, distortion, stress, stratification, modeling

1.Introduction

Pressure injection techniques [1] and electrochemical fixing [2] of weak saturated soils are very promising in underground, surface and hydraulic engineering. Processes in the area of consolidation, are very complex, they are dedicated to the study of a number of works. Until now the aspect of the interaction geo-mechanical fixed zone adjoining its natural array and structural elements is poorly studied. This paper [2] attempts to make analytical solution of problems in the elastic and elastic-plastic formulation. The results can be used in practice with sufficient accuracy only under ideal conditions, such as a homogeneous medium, winze circular section shell of equal thickness.

To solve the applied and practical problems of the issue under consideration, it's reasonable to use numerical methods, while application of Alterra, included into the software package Geosoft is promising. The main advantages of this program are as follows: the possibility of solving both two - and three-dimensional problems; implementation of nonlinear (elastic, plastic and elastic-plastic using Mises criterion) and rheological models; possibility of accounting for heterogeneity of the environment (geological structure, geometry and properties of the docking region, structural elements).

This paper [3] reviews main methodological aspects of modeling of geo-mechanical processes in the grounds of the post footing, strip, slab and pile foundations.

As part of the concept developed in this paper we present algorithms for data bank, detailing the parameters of the computer model and some simulation results.

2.Work description

The object of study is the state of the soil mass surface mining structures having structural changes upon application of loads in the form of various types of foundations. For an analysis of its stress-strain state a database of state parameters array (normal and shear stress σ_x, σ_z, τ_{xz}, deformations vertical and horizontal displacement u and v) was formed according to the enlargement algorithm (Fig.1). In the framework the effect of different soil deformation parameters before and after fixing (modules of deformation E and E_y, Poisson's ratio ν и ν_y, and the cohesion C и C_y, angle of internal friction φ and φ_y respectively), the size and location of zones ECP, geological structure and parameters of the foundations are reviewed.

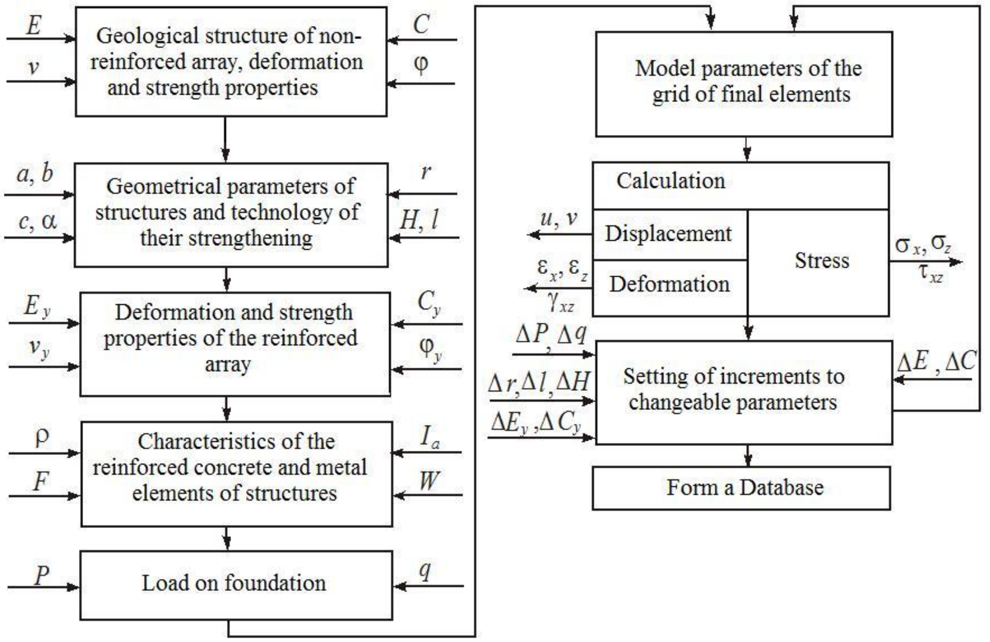
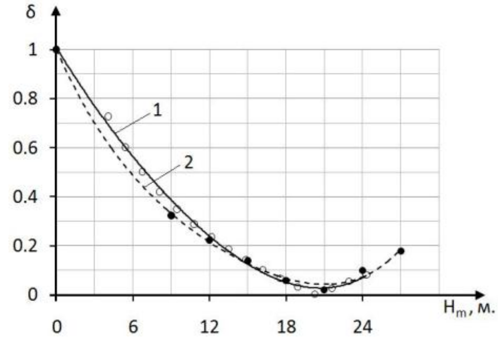


Fig. 1: Enlarged algorithm of formation of the source database:
a, b - width and height of foundation; c - depth of foundation; α - angle of cut slope; H - radius and height of docking zone, respectively; l - distance between fixing zones; P, q - concentrated and distributed load along the edges of foundation; ρ - density of material for foundation; F, I_a, W - parameters of sole foundation

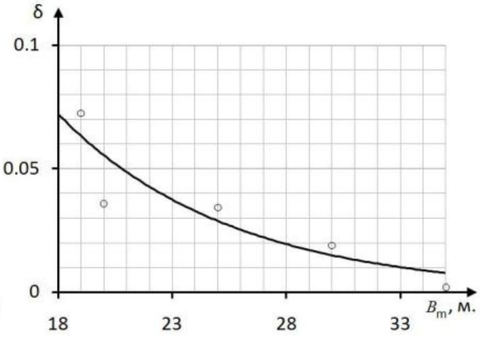
At the initial stage of computing geo-mechanical research study, an important aspect is the substantiation of initial parameters of the basic model, which must comply with the maximum calculation and can be determined based on the primary software calculations estimate areas by establishing of the basic parameters of the model as follows: width B_m, height H_m and number of elements N.

The main criterion for selecting of the model parameters is the error δ, defined as the relative difference of simulation results and theoretical reference values determined by classical methods of calculation of the foundations [4, 5]. For the analysis we used etalon foundation (stamp) under the most adverse ground conditions.

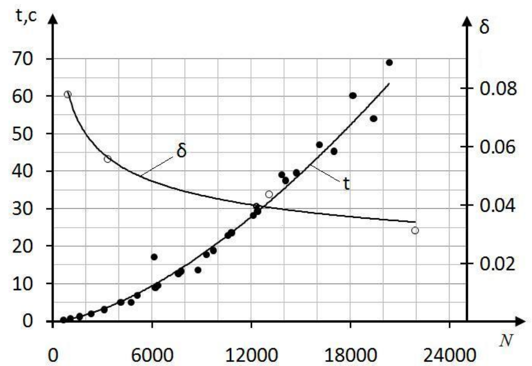
Fig.2 shows the obtained results of calculations of the dependence of error δ from the model parameters B_m, H_m, N, so we can determine the field of rational foundation model. In particular, the analysis of the graphs shows that changes of δ occurs by polynomial or logarithmic dependence, and setting the value of the maximum error on the level $\delta = 5\%$, you can define the minimum values of the above parameters.



(a)



(b)



(c)

Fig.2: Dependence of δ from H_m (*a*) δ from B_m (*b*) N from δ and time *t* (*c*)

1 - at a ratio of $H_m / B_m = 4:3$; 2 - at $B_m = 20м = const$

The algorithm for determining of the main parameters of the calculation of the signal model is shown on Fig.3.As part of the formation of the analytical database modeling results are obtained in the form of contour of the principal stresses σ_x, σ_z, τ_{xz} strain ε_x, ε_z, γ_{xz}, and displacements u and v.

Some results of the calculation for the main types of foundations are shown on Fig. 4.The stress-strain state of the strip foundation was studied in more detail, as this foundation has a distinctive element - the sole, and the conditions of its modeling as close as possible to the conditions of the plane problem. The primary analysis showed that within the linearly deformed base there is a proportional dependence between the stress and strain that is the criterion validity of the results. Stress distribution σ_x, σ_z, τ_{xz} in the soil body is uniform with the formation of the zone of maximum stress under the foundation.

The interest is geo-mechanical state of the layered base for different deformation properties of layers and angle of inclination β of its border.

The dependency graphs of vertical deformation ε_z on Fig.5, show that the inhomogeneous strain ε_z distribution is characterized by displacement $\Delta\varepsilon_z$ at the boundary layers having different values E, and ranges of changes ε_z of both layers and $\Delta\varepsilon_z$ is dependent on the ratio E_1/E_2 and the angle of inclination of the boundaries of layers β.

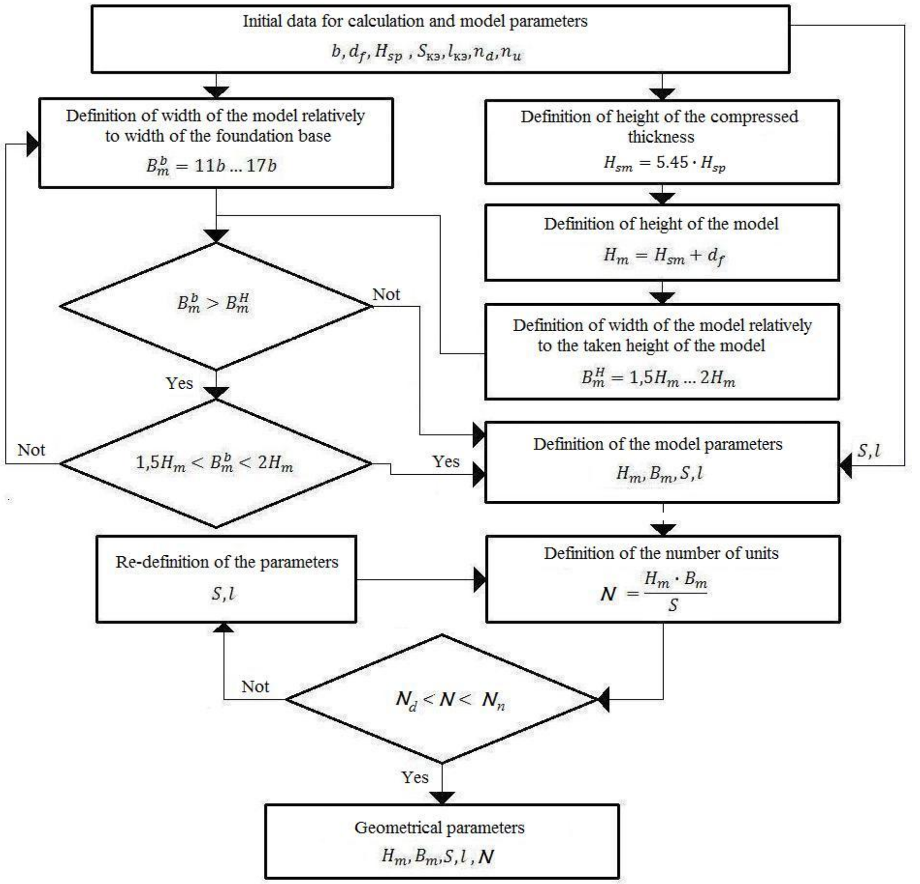
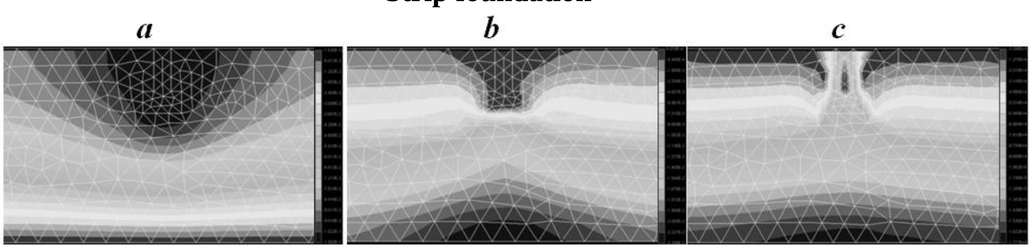
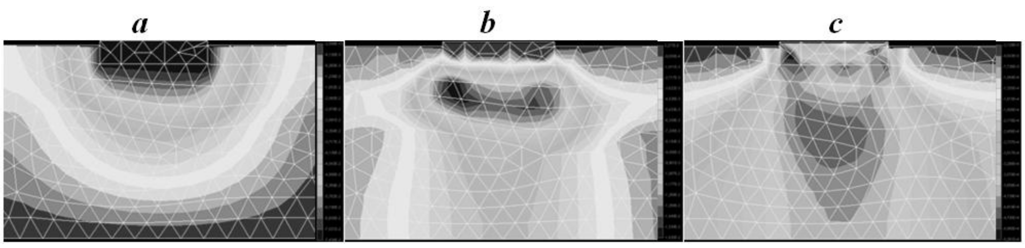


Fig. 3: Algorithm to determine geometric parameters of the model:
d_f - depth of foundation; H_{sp} - theoretical value of height of the compressible strata adopted regarding the load; S, l - area and length of elements; N_d, N_u - lower and upper limit of the number of elements

Strip foundation



Slab foundation



Post Footing

a *b* *c*

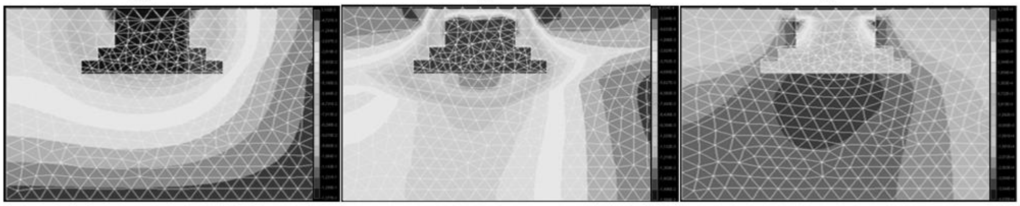
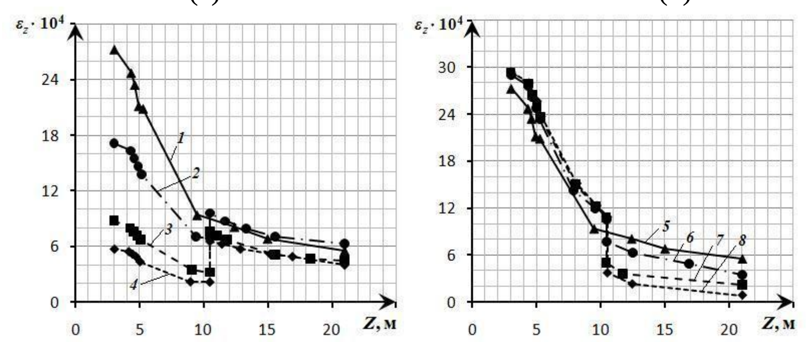


Fig. 4: Results of calculation of vertical displacements u (*a*), strain ε_z (*b*); stress σ_z (*c*) for the main types of foundations

Angel of deposition layers $\beta = 0^{\circ}$

(a) (b)



$\beta = 18^{\circ}$

(a) (b)

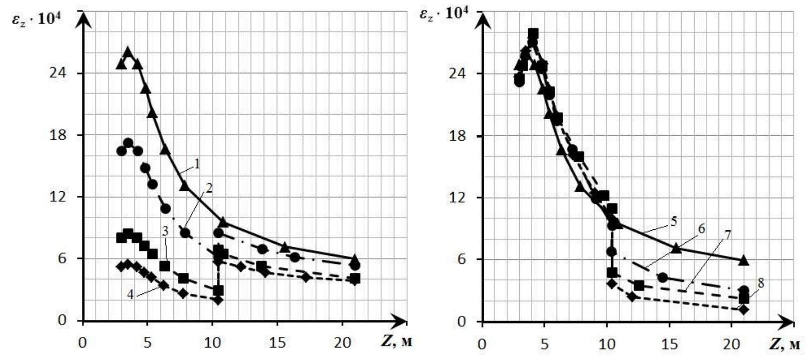


Fig. 5. Dependencies of vertical deformation ε_z of the coordinate Z at low bottom (*a*), top (*b*) layer depending on the ratio of the deformation modulus E_1/E_2 :

1 – 1,0; 2 – 1,5; 3 – 3,0; 4 –4,6; 5 – 1,0; 6 –0,67; 7 – 0,33; 8 – 0,22

Dependencies $\Delta\varepsilon_z\,(E_1/E_2)$ (Fig.6) are complex, it is necessary to take into account when justifying the foundations of rational parameters.

The main practical use of the database obtained as a result of simulations is as follows: the establishment of regularities of the formation of the stress-strain state of structures at the base in the most typical cross-sections; establish dependencies major technological and structural parameters of the foundations of the variable parameters of the model;

recommendations on specific technological and design parameters for the design of foundations, construction and repair work.

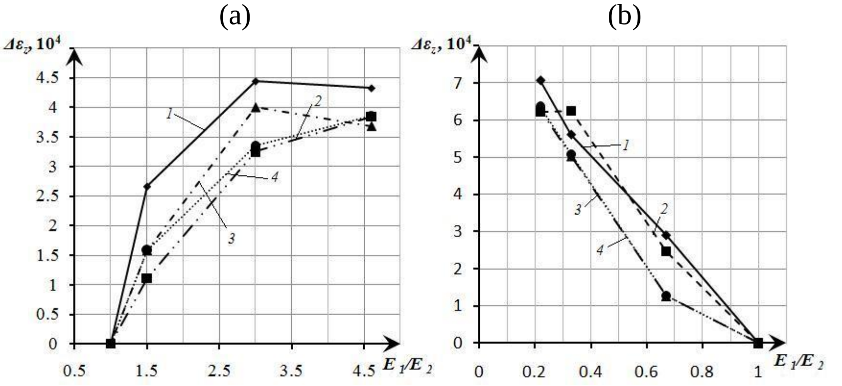


Fig. 6. Dependence of the value of displacement of the vertical deformations $\Delta\varepsilon_z$ from strain modules ratio E_1/E_2 at weak bottom (*a*), top (*b*) layer and an inclination of layers β : 1 – 0 °; 2 – 6 °; 3 – 12 °; 4 –18 °

3.Conclusion

Generalizations of these results allow making the following conclusions:

1. Purpose of computer modeling stress-strain-state groundwater strengthened by ground structures is the formation of a database of displacements, strains and stresses, in this case as a priori information using geo-technical soil characteristics, geometrical and physical-mechanical parameters of the docking zones, and reinforced concrete structures.
2. While modeling it’s necessary to take rational computer model parameter ranges: width, height, number of elements, using as a criterion for calculating the error and the length of the computing.
3. One of the major factors influencing the stress-strain state of subgrade is its bedding, since the boundary layer has abrupt changes of strain and stress, depending on the ratio of moduli of deformation and inclination of the border.

4.References

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