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Dredging Modelling at Construction of Underground Constructions

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Abstract **-** The finite-element calculation procedure of strain of the soil cooperating with elastic structures located in it is constructed. For modeling interaction between deformable structures and soil continuums the special "contact" finite element is used, allowing to consider all cases of interaction of contacting continuums, including shift with slipping and detachment. As an example the problem of stage-by-stage excavation from a foundation ditch with concrete walls is solved. Necessity of the decision of a contact problem for modeling interaction concrete constructions and a soil is shown.

Keywords**:** Method of finite elements, Contact problems, Finite strains, Soils.

1. Introduction

In the course of modeling of stage-by-stage construction of difficult elements of designs, industrial and transport constructions by drawing up power and settlement schemes for identification of being formed fields of tension, deformations and movements it is required introductions of concept of being transformed designs (mechanical systems) which at separate stages of technological process of construction pass from one class to another as previously shown by Boroday et al. (2003), Berezhnoi et al. (2005). Mathematical modeling of process of formation of fields of tension, deformations and movements in elements of this mechanical system also demands a problem definition of mechanics of a being transformed design. In the mechanical system described above transformation of the settlement scheme happens discretely upon transition from one stage of construction on another. On each step of transformation necessary calculations should be carried out taking into account a field of tension, movements and the deformations collecting in system on the previous steps.

When modeling interaction of elements of designs with soil in some cases for an adequate assessment of nature of deformation various techniques of contact interaction of elements of designs among themselves and with soil, as previously shown by Berezhnoi et al. (2010a, b), are used. Not the accounting of contact can lead to essentially other result to some extent even contradicting common sense.

The calculations have been performed with physical and geometrical nonlinearity Berezhnoi et al. (2010c, 2011), (Golovanov et al. (2005a, 2005b 2008), Davydov et al. (2013)). Some aspects of the proposed algorithm of calculation are proposed in Berezhnoi et al. (2010c, 2011).

2. Modeling of Mechanical Contact

The interaction mechanism between constructions and soil can be illustrated figure 1 where one of options of deformation of the contact layer for descriptive reasons formed by two slips is represented.

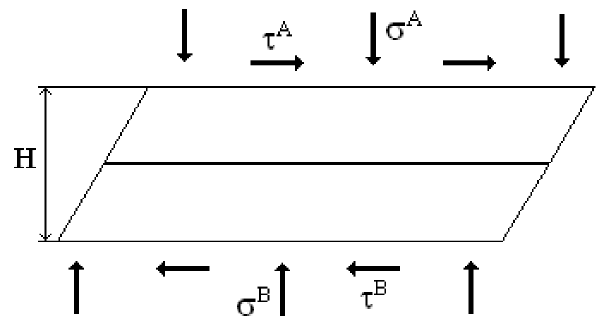

Fig. 1. Modeling of a contact layer.

All options of contact interaction can be моделированы within mechanics of the continuous environment, i.e. at representation of two slips in the form of the uniform material possessing specific properties.

The received task is nonlinear and demands application of special techniques for its decision. Characteristic of this nonlinearity is that for normal tension takes restriction place on deformation, and for tangent tension - on their limit values defining possibility of slipping.

The general allowing equation registers in a variation form proceeding from the principle of virtual movements. For realization of the described mathematical model of interaction of slips within MKE it is convenient to define a so-called contact element. As initial information for it radiuses - vectors of the points defining the bottom and top surfaces, and initial thickness which can be a constant on an element are defined, and can vary (in it cases are set their nodal values). Approximations of front surfaces are entered, the tangent planes of these surfaces are defined. In the course of deformation originally parallel front surfaces stop being those, and extent of their relative turns in the course of deformation can reach big size. Therefore all geometrical, kinematic and power characteristics are defined on both front surfaces independently. In other words, intense the deformed state is defined independently in each slip that will allow to model more truly them a state when slipping from each other.

Definition of tangent deformations and tension (for an assessment of friction forces) demands introduction of local systems of the coordinates focused along arts for each of front surfaces. Blocks of a matrix of rigidity are calculated in the form of integrals, to calculate which in an analytical look it is impossible. Therefore formulas of numerical integration on Gauss-Legendre's formula of the third and fifth orders on each coordinate are for this purpose used.

The database about the mechanism of possible interaction between slips in each quadrature point of each contact FE is thus formed and is constantly updated. It represents values of deformations of sinking and shift, and also tangent tension and sinking tension for both front surfaces and on each iteration is analyzed and it is calculated again.

3. Modeling of Stage-by-stage Dredging from a Ditch

For an example calculation intense the deformed condition of retaining walls of a ditch of station of the subway is given at stage-by-stage work.

As the ditch has a parallelepiped form, its length is great in comparison with its width, for detection of the main regularities of deformation calculation can be carried out in two-dimensional statement, in the conditions of flat deformation. Mechanical characteristics of discretely located objects when carrying out calculations were recalculated to average sizes.

Soil in a ditch is supposed uniform (sand small water-saturated) with the following characteristics: the module of elasticity of 33 MPa, Poisson's 0.3 coefficient, specific weight is 2040 kg/m^3. For concrete the module of elasticity of 30000 MPa, Poisson's 0.2 coefficient, specific weight is 2500 kg/m^3, thickness of retaining walls is 1 m, length – 15 m, distance between them 10 m, the maximum depth of a ditch – 10 m. Calculation is carried out for a case of flat deformation.

Lateral and the lower bound of area are set by straight lines, and on them conditions of lack of shift of points in the direction, perpendicular to rectilinear borders are set. Distances from retaining walls to borders of area get out of a condition of a smallness of influence of retaining walls in the field of movements and intense the deformed condition of soil (computing experiment showed that is enough that this distance was not less than ten distances between ditch walls). Sampling is carried out by square final elements of the continuous environment, for the basic size of the party of an element thickness of a concrete wall gets out. At calculations at the first stage the body weight of settlement area was put. Further, step by step and equal portions dredging is carried out. Computing experiment showed that in this task it is enough to carry out dredging of all soil for ten stages.

Two series of calculations were carried out. In the first case the contact problem wasn't solved, in the second case between soil and concrete walls the contact element was entered and the separation and slipping between walls of a ditch and soil was allowed. In figure 2 distribution of tension is given in retaining walls and in soil for the first settlement case (without contact), in figure 3 – for the second settlement case (with contact).

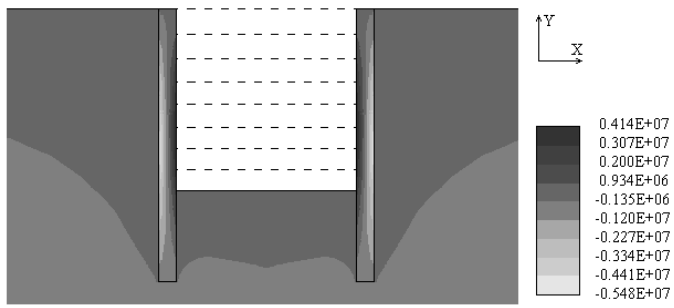

Fig. 2. Flexural tension in concrete walls (without contact).

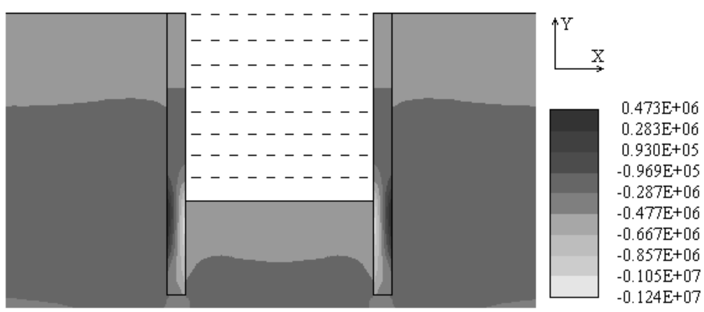

Fig. 3. Flexural tension in concrete walls (with contact).

The analysis of results shows that these options of calculation essentially differ. In the first case of a wall disperse in the parties and the maximum flexural (stretching) tension arises on an internal surface of retaining walls. This results from the fact that after dredging between walls, which (in the absence of contact) as though pulled together a wall, the soil located behind retaining walls, starts moving apart them. It doesn't occur in case of the accounting of contact between walls and soil, and in this case after dredging by gravity soil behind walls they start being bent in a ditch. Besides, tension level in this case is much lower.

4. Conclusion

The offered method of the solution of problems of mechanics with concrete appendices belongs to modern technology of scientific maintenance, design and building of difficult objects. Its use allows to track change intense the deformed state and a field of movements of structurally changing settlement area from beginning to end of construction. It allows more precisely and to make technically competently design decisions for various stages of construction works.

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