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Analysis of the Influence of Various Models of the Soil Foundation on the Stress-Strain State of the Foundation of the Building

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Abstract

The article analyzes the influence of various models of the soil found on the stress-strain state (SSS) of the foundation of a multi-storey building, the results of which show a significant difference in the SSS of the foundation and the need to take it into account in real design**.**

Keywords: Ground foundation, foundation, linearly deformable medium, model, stress-strain state, inhomogeneity of ground foundations, Gegenbauer polynomial.

Introduction

In modern soil mechanics, the choice of a computational model of the soil foundation with which a construction object interacts is one of the main tasks of modelling and calculating the interaction of the "foundation-foundation-structure" system, since the determination of contact stresses along the sole of foundations allows to identify the stress-strain state not only of the foundation structure itself but also of other elements of the structure. However, in order to obtain reliable calculation results, it is necessary to adopt a base model that is close to the real ground environment according to two criteria: distribution capacity and precipitation of the structure.

Subsequently, more advanced multiparameter and combined models were developed, including discrete models capable of describing various properties of soil bases, which were mainly developed for engineering calculations of structures interacting with the soil base.

At the design stage of the construction process, multiple models are used: physical, mechanical, corrosion, mathematical, technological, etc. At the same time, many models have been developed for soil bases. Therefore, depending on the models used, the design results differ significantly from each other. The existing variety of combined models takes into account the real properties of various soils to a greater extent. Therefore, the choice of models and design schemes is one of the most important stages in the design process, which is sometimes little paid due attention.

Currently, mechanical models of the soil base are used in engineering practice: the Fuss-Winkler model, elastic half-space models [1], elastic layer model of finite thickness, combined models, etc. Each model has its advantages and disadvantages. For example, the widespread Winkler model does not always give correct calculation results, since it does not take into account the distribution capacity of the soil base and the value of the bed coefficient depends on the size of the stamp being tested. The elastic half-space model, on the contrary, exaggerates the distribution capacity and leads to the appearance of physically unrealistic infinite pressures under the edges of the beam and plate.

In order to bring the calculation results closer to reality, the elastic half-space models were improved in the direction of to reduce their distributional capacity, a model of an elastic layer of finite thickness [2]; a two-parameter model describing the base using two-bed coefficients depending on compression and shear [3]; a model with a deformation modulus increasing in depth [4]; removal of edge infinities - a combined model (Winkler layer on an elastic half-space [5].

The choice of an elastic base model depends on the intuition of the design engineer and is a rather difficult task. The elastic base model is proposed in the formulation of the problem and is physically justified during the calculation. SNB 5.01.01-99 recommends that "deviations of calculated models from real conditions should be taken into account by coefficients of working conditions. These coefficients are established based on theoretical and experimental data on the actual operation of soils and foundation materials under the conditions of exposure and operation of buildings and structures.

Therefore, due to the natural features of soils as continuous inhomogeneous media, when calculating structures placed on an elastic base, the primary issue is the choice of such a base model that accurately described the stress-strain state of this base and brought it closer to real conditions.

The article proposes modelling of the "building-foundation-foundation" system using a foundation structure on a non-uniform ground base. Here, the heterogeneity of the soil base is taken into account through the modulus of soil deformation, which changes with depth according to a power law, which allows taking into account complex soil bases. The Poisson's ratio (v0) is assumed to be constant since its effect on the characteristic of the deformation properties of the soil is less significant.

Literature revive

Currently, the issues of various options for calculating structures on an elastic base have been significantly worked out in the works of N.P. Puzyrevsky, N.K. Snitko, N.M. Gersevanov, Z.G. Ter-Martirosyan, V.A. Barvashov, E.3. Boltyansky, V.I. Solomin, Yu.Yu. Chinilin, V.Z. Vlasov, N.N. Leontiev, P.L. Pasternak, K.G., B.N. Zhemochkin, A.P. Sinitsin, I.A. Simvulidi, G.K. Kleina, M.M. Gorbunova-Posadova, Yu.K.Zaretsky and also the works of scientists of Uzbekistan G.A.Mavlyanov, N.I.Kazakbayev, T.Sh. Shirinkulov, T.R.Rashidov, S.M. Kasymov, H.Z. Rasulov, G.H.Khozhmetov, E.V. Mavlyanov, A.M. are devoted. Khudaibergenova, K.S.Abdurashidova, A.A. Ishankhodzhayeva, H.Sh: Turayeva, E.S.Pesikova, G.Z.Chakhvadze, S.M.Makhmudova, Z.S. Sirozhidtsinova, F.A.Ikramova, G.I.Seidalikhodzhayeva, H.H. Khudainazarova, Ya.S. Sadikova A.M., Mirzayeva, K.M. Dzhumaeva, M.M. Honkeldieva, S.R., Mukhammadaminova, et al. The assessment of the influence of the heterogeneity of the foundation on the "building-foundation-foundation" system in their works is carried out by T. Sh.Shirinkulov, S.M. Makhmudov [7, 10]. In the methods of calculating structures on an elastic base, modern calculation complexes are used, which allow taking into account the joint work of "building-foundation-foundation". However, there are no engineering methods for evaluating and verifying the results of calculations.

Materials and methods

The purpose of this work is to study the stress-strain state, taking into account the joint work of building structures and foundations that interact with a non-uniform soil base, the modulus of soil deformations is used, which varies with the depth of the bases according to a power law, which allows for complex soil bases to be taken into account in a simple form. Taking into account the joint work of the foundation, foundation and aboveground structures of a building in accordance with the requirements of current regulations are one of the basic principles of designing buildings and structures. At the same time, it is recommended to take into account geometric and physical nonlinearity, heterogeneity, layering and rheological properties of building construction materials and foundation soils in regulatory documents.

The advantage of this approach is the possibility of obtaining forces in the aboveground and foundation structures of the building associated with the development of uneven deformations of the base. However, in most cases, the result of such calculations is the determination of the final deformations of the base corresponding to the stage of sediment stabilization. The requirement to take into account rheological properties and heterogeneity of soils associated with the development of deformation of the base over time is often not taken into account in practical calculations. As is known from field observations, precipitation of buildings on clay soils can develop over a fairly long period (several decades). Under such conditions, joint calculations based on the consideration of the deformation stabilization stage do not estimate the intermediate and sufficiently long period of development of these deformations. As a result, the solution of some tasks becomes incorrect or almost impossible at all. A typical example is the assessment of the mutual influence of buildings during phased construction. In this case, to calculate the mutual influence of two neighbouring buildings, it is necessary to estimate the proportion of deformation of the base of the first building before the construction of the second. Such an assessment implies the need to calculate the deformations of the foundation over time, the accuracy of which will fundamentally depend on the magnitude of stresses in the structures of buildings associated with mutual influence. Thus, the development of a methodology for calculating the deformation of the base in time is relevant, first of all, for the correct assessment of efforts in structures, taking into account the actual timing and sequence of construction of structures. Statistical material for comparing the observed final precipitation of the building with the calculated values of precipitation is insufficient. The analysis of the deformations of the foundation over time allows us to assess the trends in the development of sediment, manifested at the initial stage of construction and operation of the building, and compare the calculated and measured values of sediment for different periods of time. Thus, the development of a methodology for calculating the deformations of the base in time is relevant for performing a statistical assessment of the reliability of geotechnical calculations in comparison with the data of field observations. Analysis of the deformations of the foundation overtime at the design stage allows you to predict the dynamics of the development of precipitation and forces in building structures, and use this forecast for interactive geotechnical monitoring. As a result, it becomes possible to assess the correctness of the performed forecast already at the initial stages of observation. Such a comparison is relevant for making decisions about the degree of danger of certain phenomena observed on the construction site. The development and improvement of methods for calculating foundation structures are one of the urgent tasks of construction science since the foundation is an integral part of every building and structure. The cost of foundation construction, according to various estimates, is 30 per cent of the total construction cost of the facility [11,12]. Recently, in connection with the development of the construction of high-rise and unique buildings, beam and slab foundation structures have become increasingly widespread. Their peculiarity is the joint work with the ground base and rigid over the foundation structure, which makes it necessary to take these factors into account when calculating the foundation structures. Despite the increasing use of electronic computers in the practice of designing and calculating building structures, there is still a certain shortage of software. This often forces design organizations to use tables or software complexes that are not designed for collaboration and calculation of the "building-foundation-foundation" system when calculating foundation structures. Meanwhile, to solve this problem, specialized programs are needed, in which the main attention would be paid to the foundation structure and its interaction with the base. At the same time, in order to minimize the dimensionality of the problem, it is necessary, without introducing large errors, to simplify the part of it that reflects the influence of the upper structure on the foundation structures.

Results and discussion

Mathematical models and programs have been developed to determine the precipitation of the foundation, taking into account the real ground conditions, the joint work of foundations with a heterogeneous ground base and above the foundation structure.

In these models and methods for calculating foundations, special Gegenbauer polynomials are used to approximate the reactive pressures of the foundation soil and the displacements of the foundation, which has a high degree of convergence of the approximation process, which in most cases is sufficient to be limited to only two or three decomposition terms. These studies are based on hypotheses of contact problems of elasticity theory. The problems under consideration are reduced to solving integrodifferential equations and Volterra-type integral equations under certain boundary conditions. These equations, based on power series with a highlighted feature, are reduced to equivalent infinite systems of linear equations, which are implemented on the LIRA 9.6 program at various parameters and external loads.

Studies conducted by scientists in the field of soil mechanics, foundations and foundations show that when deforming soils, 90-95% of deformations are residual. To represent the soil environment as elastic means to idealize it. It is proved that it is most effective to design structures according to the maximum permissible precipitation, with a check of the load-bearing capacity if necessary. This is because emergencies most often occur due to uneven precipitation within the building. Designing buildings according to the maximum permissible precipitation allows the most efficient use of materials, which is important with their ever-increasing cost. However, this approach requires the use of mathematical models of soil in calculations, taking into account the complex relationships between stresses and deformations.

Forecasting changes in the properties of the soil environment during the construction of buildings and structures is difficult, but quite a solvable task. The durability of the structure will depend on how well the mutual influence of the "building-foundation-foundation" continuum is taken into account during construction and operation.

To date, no method has been developed for predicting the precipitation of structures, taking into account the prehistory of the loading of the soil mass, its new object, and so, excavation of the soil, subsequent nonlinear deformation in time, as well as joint work "building-foundation-foundation" taking into account the increase in the rigidity of the building during its construction. Such a method is necessary at the design stage of buildings and structures in complex engineering and geological conditions (with heterogeneous stratification of soils, rugged terrain, on the slopes of the terrain), with close urban development [12-14].

Until now, emergency situations arise during the construction of new residential and industrial buildings located next to existing buildings. It is not possible to fully take into account all the stages of construction, the results of this influence on nearby buildings, those from the pit in conditions of close urban development, the device of foundations violate the existing tense state of the surrounding soil mass. This causes deformations of the base and, as a consequence, uneven precipitation of nearby buildings, stresses in structural elements, cracks, bends, and distortions.

Therefore, the development of a method that allows you to predict the precipitation of buildings and structures, taking into account the history of the loading of the foundation, the joint work "building-foundation-foundation", increasing the rigidity of the building and structure during construction, the mutual influence of the erected structure (building) and existing engineering facilities in time in complex engineering and geological conditions, including on the slopes of the terrain, is a solution to an urgent problem of important scientific, practical and economic importance.

The use of this method will reduce the consumption of reinforced concrete when installing slab foundations for heavy structures, taking into account the joint work of the "building-foundation-foundation" system; design pile foundations according to the maximum permissible precipitation, taking into account the nonlinear deformability of soils over time, eliminate emergencies at the design stage.

The article proposes modelling of the "building-foundation-foundation" system using a foundation structure on a non-uniform ground base.

The class of nonlinear problems to be solved can be significantly expanded if we use the method proposed by T.S. Shirinkulov [7] for calculating foundations and foundations. In this case, special Gegenbauer polynomials are used to approximate the reactive pressures of the bases and the displacements of the foundation.

Conclusions

1. Due to the natural features of soils as continuous inhomogeneous media, when calculating structures placed on an elastic base, the primary issue is the choice of such a base model that accurately described the stress-strain state of this base and brought it closer to real conditions.

2. Overview of approaches modelling of the "building-foundation-foundation" system using a foundation structure on a non-uniform ground base.

3. Mathematical models and programs have been developed to determine the precipitation of the foundation, taking into account the real ground conditions, the joint work of foundations with a heterogeneous ground base and above the foundation structure.

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