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ASPECTS OF THE INFLUENCE ASSESSMENT OF THE NEW CONSTRUCTION DURING THE RECONSTRUCTION OF URBAN TERRITORY AREAS IN THE DENSE BUILDING CONDITIONS

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Abstract. *The scientific substantiation concept has been considered for the urban development and territorial planning reconstruction principles of the urban area sections with dense building and difficult engineering-geological conditions for scientific and technical support of all reconstruction processes and recommendations elaboration for a safe and balanced development of built-up territories and more efficient use of housing estates in the present social and economic conditions.*

Keywords: influence of new construction; preservation of existing buildings; reconstruction of urban areas.

1. Introduction

At present the construction in large cities is carried out in the dense building conditions, that affects the stability of the surrounding areas, changes its equilibrium and causes significant changes in the stress strain state of buildings and structures adjacent building.

The civil engineering in a dense building conditions, creates in each case, the set of additional risks that should be considered in planning reconstruction of the urban area, the development of design and design-engineering documentation, organization of new construction, safe operation of new facilities and the surrounding buildings.

For the adjacent objects of the existing building a new construction can cause a risk of injury, disruption of the normal exploitation structural deformation and sometimes crashes as a result of soil bases infringement during the digging works implementation on the deep excavation development; the soil compaction and moving in the basis active zone; as a result of additional loadings from the new building, dynamic loads on the basis from the fencing structures implementation with the use of sheet piling, piles and anchors; vibration or dynamic effects from the work of construction equipment; and also disruption of normal insolation and ventilation conditions, engineering maintenance, objects improvement of existing buildings.

2. Statement of the problem

The construction in a dense building conditions in the populated areas is due to one of a major issues – the preservation of the existing adjacent buildings located in the zone of influence of new construction or renovation.

One of the most important factors determining the qualitative state of industrial and civil engineering, is strength and the absence of cracks and local damage in buildings and structures on the entire period of operation.

During the reconstruction of the urban territories sections in a dense building conditions with the need to use underground space and a unavoidable breach of its equilibrium, there is activation of additional processes in the basis and foundations of existing buildings and structures.

Need to predict the consequences of this activation became an urgent problem of designing and construction of new facilities in the reconstruction of sections of urban areas. The solution to this problem is related to strength maintenance of buildings and structures that depends on the strength characteristics of soil foundation and the complex causes and factors that can influence their change.

Soils usually are complex disperse systems, physical and mechanical characteristics can be modified by various causes and factors.

One of the determining factors that influence the fencing constructions scheme are the deformations in the basis soils near the buildings foundations. At present there are several effective models for calculating the combined semispace, but to ensure the uniqueness of the solution of this problem is not possible.

Therefore, in each particular case it is necessary to carry scientific and technical support out, with the relevant numerical investigation and subsequent observations the behavior of buildings and structures located on the territory under consideration in the process of reconstruction.

Analyzing the degree of impact of new construction on state grounds adjacent existing buildings and structures in order to obtain reliable results, is associated with the need to solve complex scientific problems of continuum mechanics in a comprehensive approach.

The solution of this problem issue is connected with the development of a specific methodology that is based on generalized dependences of nonlinear soil mechanics, nonlinear theory of elasticity and plasticity, due the nonlinear programming apparatus, considering the deformable solids and heterogeneous soil massifs interaction, to obtain patterns that allow more reasonably determine the magnitudes of the stress strain state of fencing constructions, bases and foundations of surrounding building.

In this connection, the main problem is creating the methodology for the areas stability analyzing during the urban territory reconstruction in a dense building conditions are considered for the possibility of its influence areas research implementation to obtain more valid results of numerous investigations, to analyze the measures to strengthen soil masses, to design the fencing protecting structures, and to carry out the urban territory safe reconstruction in the dense building conditions, based on the laws of the nonlinear soil mechanics, nonlinear elasticity and plasticity, connecting apparatus of nonlinear programming and interaction deformable solids with heterogeneous soil massives, based on the existing mathematical soil model improvement, being in conjunction with the adjacent building structures, according to their different physical and mechanical properties and spatial structures that significantly affect on the stress-strain state of the soil masses structures strengthening, of the surrounding buildings bases and foundations, also in the preservation of the existing buildings located nearby, as well as prediction of the potential implications that at present is the actual problem of modern urban development and territorial planning.

3. Analysis of the latest research, publications, regulatory documents

Analysis of the practical and scientific developments experience on the complex problem of the existing residential buildings reconstruction allows to note the her major and growing relevance and national economic significance especially in large cities.

Since the processes of urban areas modernization concern many historical, social, economic, environmental, architectural and urban planning aspects, which does not always consistent with each other, there is necessary to search the optimal solutions for each time and specific urban conditions making.

Despite the urgency, has not yet been developed the scientific foundations and practical guidelines that impose into a unified system the whole complex of theoretical, organizational, technical, socio-economic, financial and other issues that determine a solution of the problem.

As part of developing and updating the Master Plan of the city of Kyiv on the period up to 2025 envisages the development of relevant concepts of sustainable urban development, that has been proposed a balanced development of all the main city components – residential districts, industrial areas, transport, green spaces, with maximum preservation of the natural environment – in the long term on the principle of "inside of the existing city boundaries".

Thus, the urban substantiation of shelter location has been provided by until 2025 in areas with dense urban building, and in the city development concept in the existing boundaries has been envisaged nearly double the amount of housing fund, that in conjunction with the social and physical infrastructure lead to significantly higher the building density, since considerable part of construction is expected due to consolidation and renovation of existing buildings.

In a modern regulatory management of urban development activity in Ukraine today there is still the trend of construction regulations development based primarily on economic and technological factors [The State…2002; The State…2008].

Despite some existing regulatory framework to regulate urban district reconstruction in a dense conditions, issues of need to consolidate a comprehensive analysis of new construction possibility in areas with existing buildings has been remained unresolved, as well as the impact on adjacent buildings and structures, in order to prevent disorders the current situation and the required scientific and technical support of the research, design, construction and subsequent operation of the new and existing facilities of the urban environment.

Analysis of engineering geological conditions of different areas to assess their impact on the design solutions for the dense urban districts reconstruction

when it is necessary to apply a variety of special activities for the strengthening measures and territories protection.

At present the analysis of these systems can be made by means of numerical simulation only, that requires the use of appropriate mathematical methods.

The difficulty of solving the relevant problem tasks is not only in the creation or use of an appropriate software package, but first of all in making an substantiated physical and mathematical model, that most correctly describes the non-linear processes of deformation of the material environment including the soil material, and in the choice of design models and the implementation of special computation algorithms, that ensure the accuracy of the calculation results.

This situation is compounded by the fact that at present there is no universal methods and models that can be applied to any material and in different environments.

Analysis of recent researches on the scientific and practical solution to this problem, gives grounds for assuming that the strength of buildings depends on the strength characteristics of soil bases and complex of causes and factors that can influence on their change.

Complexity and a significant number of factors that occur in the natural basis for the construction of fortifications and their changes over time, etc. are not considered by the calculations enough. Deformations of fencing constructions change the soil structure and reduce its mechanical strength, lead to seepage deformation and surface deformation, and are one of the main factors that cause the accidental destruction of buildings and structures.

In this regard the problem of the study and design of soil masses strengthening structures for the urban district safe reconstruction in the dense building conditions is relevant, and its solution is possible through improvements the existing mathematical soil model considering its layered structure, that significantly affects on the stress strain state of strengthening fencing constructions as well as the adjacent buildings foundations.

Analysis of regulatory documents and scientific papers of national and foreign scientists, who published in related sectors of civil engineering, shows the presence of a large number of methods and techniques for determining the structures stress-strain state.

But the application of any particular method or work can not account the soil structure complexity considering the presence of weak layers, development in the soil bases of the various phenomena, their effect on the stress-strain state of the fencing structures, soil masses strengthening constructions, and also bases, foundations and structures of existing buildings and structures [The State…2006; The State…2009].

For the relevant calculations there is no regulatory base, there are practically no method investigation of the stress-strain state of the surrounding buildings with discrete modeling of soil foundation. Moreover, some of the existing technologies of civil engineering, for example, the piles implementation without excavation are new and have not yet found a place in the standard documents.

The methods application due to existing standards and empirical correlations in assessing the impact of new construction to the surrounding buildings generate unnecessary strenght reserve, or contrary lead to the destruction of the surrounding structures, and ensuring the reliability of buildings and structures, reducing the financial and material costs, is an urgent problem of modern urban planning.

The purpose of the work is to elaborate the scientific substantiation concept of the urban development and territorial planning principles for the reconstruction implementation of the urban districts with dense building and complicated engineering-geological conditions for the further scientific and technical support of all reconstruction processes, and also recommendations generation for a safe and balanced development of built-up areas and more efficient using of housing estates in the present social-economic conditions.

4. Concept of the investigation methodology of the new construction influence during the reconstruction of the urban districts

The methodology of the interaction research of new objects construction with surrounding buildings structures has been develop in view of interactivity of fencing and protective structures with soil semispace in the ultimate state considering the geometric and physical nonlinearity in the problem statement in the realization of the complicated loading evolution including active and passive load and the effect of soil bases unloading.

The methodology has been designed based on the theory of nonlinear soil mechanics, nonlinear theory of elasticity and plasticity, nonlinear programming methods and the finite element method. New modified models of the heterogeneity accounting and the influence of the anisotropic properties of multilayer soil space have been proposed in the absence of friction between the layers.

The work is based on the idea of generalized dependence of soil mechanics, that allows more reasonably to determine the value of the stress-strain state of the building structures which are in interaction with complicated soil bases [Bazhenov et al. 2000].

Theoretical foundations of the proposed methodology for stability analysis of the urban territory sites consist in relations formation for stress-strain state of the computational range from the mechanics of deformable solids standpoint, with the use of algorithms for solving problems of the elasticity, plasticity, and creep theories, with the construction of universal design models for soil masses, that are being in conjunction with the fencing constructions elements, with structures of surrounding building, and the subsequent efficient numerical methods for their computer realization [Kislookyy et al. 2012].

In the computational scheme of the problem is assumed a discrete modeling of a flat of soil heterogeneous multilayer semispace with the presence of cavities (excavation new buildings underground premises of existing buildings) and inclusions (elements of fencing constructions, protective structures, foundations of the surrounding buildings and structures).

The solution of the strongly nonlinear problem has been constructed using equations in increments, based on the first principle of virtual work for static three-dimensional problem of nonlinear deformable body. The variational equations describe the equilibrium of the volume element of arbitrary continuum in accordance with the energy method approach to solving problems, regardless of its physical properties adequately to such stress state when a small additional effect may disturb this equilibrium. This stress state is characterized also by the fact the shear strength in elementary area is defined in the limit state for this type of soil with the significant development of shear strains in the array. In the proposed method for solution stability of the soil mass the criterion of soil stability or soil fluidity in a single homogeneous isotropic elementary area (finite element) is described in the universal form – in the form of invariants of the stress state, on the basis of the Mises extended flow criterion, using the load surface by the Mohr-Coulomb criterion, considering not only the second but the third invariant of stress function tensor-deviator through the Lode-Nadai invariant [Prusov 2009; Prusov, Badakh 2010].

The described methods for the elastic semispace calculating is based on the finite element method in the relations of moment scheme in the formulation of the plane problem of nonlinear deformable solid including geometrical and physical nonlinearity. In soil space modeling has been provided essential heterogeneity of soil layers and inclusions. The semispace stress state assessment has provided the numerical results comparison with the ultimate deformations and displacements, that make it possible to consider the local instability areas and the plastic deformations development.

The research methodology of soil half using nonlinear elasticity theory using the nonlinear elasticity theory has provided reliable results of the soil mechanics plane problem solutions considering the given semispace heterogeneity, the presence of layers with different physical and mechanical characteristics, different boundary conditions, arbitrary external influences. The application of this methodology provides a quite accurate description of the deformation mode of soil semispace in interaction with structures of municipal facilities and research the soil stress-strain state carrying out with purposes to solve the real problems for strengthening structures calculating in complicated engineering-geological conditions.

The main content of scientific substantiation is the following:

– the mathematical models development of the inhomogeneous soil semispace stability in interaction with the surrounding buildings and strengthening structures;

– the basic equations development of complex systems state and equilibrium considering the geometric and physical nonlinearity in the problem statement;

– the special algorithm elaboration for solving systems of nonlinear equations;

– the numerical investigations carrying out in order to validate the results reliability;

– the deformation modification regularities detection in the soil bases, foundations and constructions of buildings and structures.

Investigation of the interaction of soil bases with objects existing buildings during the district reconstruction processes is related to the definition of the stress-strain state and stability of the soil mass, and with the definition of deformability and strength of fencing structures.

The resulting influence dependence of the inhomogeneous soil bases on the municipal objects state during its reconstruction have a completely qualified practical importance, and the influence estimation of heterogeneous soils inclusions with different physical and mechanical properties in the bases, and also the dependence establishing of the deformed state definition of the existing buildings and other municipal objects on these soil bases is relevant and important objective of the civil engineering industry [Tsyhanovskyy, Prusov 2004; Tsyhanovskyy, Prusov 2009].

The developed methodology application for the soil bases stability modeling and for the complicated conditions impact assessing on the stress-strain state of the existing building during the municipal objects reconstruction has provided the refined calculation of the strengthening structures elements in the evolutionary technologies implementation of external impact on soil bases space, and in the context of extreme plastic deformation development. The methodology of the stability numerical investigation of soil bases toward the surrounding buildings objects considering the soil space limit equilibrium.

In results of numerical research have been obtained the optimal design solving for urban objects reconstruction in the dense building condition, with given complicated engineering and geological conditions, using a variety of discrete models and soil types.

This is evidence of the universality of the proposed research methodology and on the basis of the analysis numerical investigations of the soil stress state and bases stability assessment by generalized design parameters have been developed the principles for the urban district objects reconstruction in order to predict the possible consequences, defense of territories, and preservation of existing buildings.

5. Conclusions

The methodology has been developed for modeling the soil bases stability and estimating the difficult conditions impact on the stress-strain state of the existing buildings during the municipal districts reconstruction and has been provided the refined calculation of fencing structures elements implementing the evolutionary technologies of external influence on the underground space in terms of limiting plastic deformation.

During numerical investigations of the soil bases stability in the interaction with the surrounding buildings objects it is possible to consider the limit equilibrium state of soil semispace and its anisotropy field influence.

On the basis of the methodology created has been developed the stability mathematical model, and also algorithms for nonlinear equations systems solving using a combination of the method by disturbance parameter continuation and the method by plastic deformation development.

Organization of the urban environment reconstruction could be structured in the following directions:

- the compliance to the regulatory legislation and its subsequent reformation;
- the engineering and geological surveying and analysis of multi-layered soil foundation;
- the state assessment of soil bases, foundations and constructions of buildings and structures located in the influence zone;
- the possibility of underground space using;
- the modeling of the new construction effects, a deep excavation arranging, interaction with soil masses strengthening structures;
- risk analysis and the conservation of existing buildings protection areas;
- guidelines for planning and carrying out the reconstruction of the urban territory sections in a dense building conditions.

At the construction projects design in a dense building conditions it is required a set of measures to ensure the construction safety, with subsequent monitoring that has provide natural observations of the construction technical condition, of the adjacent building, engineering geology and environmental situation in the neighborhood, and a stabilization period of operation of the object.

The specified set of activities provides engineering investigations of the construction site for the design solutions development and methods of the object construction, ensuring the preservation operational qualities of nearby objects and the satisfaction of technological security.

In the construction design in a dense building conditions it is necessary to choose the space-planning and design solutions with the influence of embedded structure on existing buildings, to provide the fencing structures for excavation walls strengthening, and construction of the new object foundations sould be designed in accordance with their effect on the stress state on existing objects and to enable their independent settlement.

The research results of the stress-strain state modeling of the fencing structures in conjunction with the soil semispace have been adopted for use in calculating of retaining walls during the reconstruction design of the real objects.

The purpose has been to clarify the behavior of filler constructions in interaction with heterogeneous soil half-space, and to analyze of the stress-strain state of fencing constructions of this object considering the real difficult complex engineering geological conditions and identify potential hazards.

Implementation results of this research has been allowed in some measure to reduce the possibility of soil mass displacement, to reduce the risk of destruction of structures strengthening, and to improve the reliability of the further exploitation of the constructioning objects, and existing buildings and structures nearby in a dense building conditions during and after reconstruction.

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Д.Е. Прусов. Вплив нового будівництва та реконструкції ділянок на стійкість території в умовах щільної забудови
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Показано, як будівництво у великих містах в умовах щільної забудови впливає на стійкість прилеглих територій, змінює їх рівновагу і викликає значні зміни в напружено-деформованому стані будівель і споруд прилеглої забудови. Розглянуто аспекти створення методології аналізу стійкості ділянок міської території при реконструкції в умовах щільної забудови для досліджень зони її впливу, отримання обґрунтованих результатів досліджень, укріплення ґрунтових масивів, проектування огороджувальних конструкцій, проведення безпечної реконструкції територій на основі законів нелінійної механіки ґрунтів, нелінійної теорії пружності та пластичності, з підключенням апарату нелінійного програмування та взаємодії твердих деформівних тіл з неоднорідними ґрунтовими масивами, на основі вдосконалення існуючої математичної моделі ґрунтових масивів, що знаходяться у взаємодії зі спорудами прилеглої забудови, з урахуванням їх різних фізико-механічних характеристик і просторових структур, які суттєво впливають на напружено-деформований стан як конструкцій зміцнення ґрунтових масивів, основ і фундаментів прилеглих будівель та споруд, так і на збереження існуючої прилеглої забудови в цілому. Особливу увагу приділено прогнозуванню можливих наслідків, що є актуальною проблемою сучасного містобудування та територіального планування.
Ключові слова: вплив нового будівництва; збереження існуючої забудови; реконструкція міських територій.

Д.Э. Прусов. Влияние нового строительства и реконструкции участков на устойчивость территории в условиях плотной застройки
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Показано, как в условиях плотной застройки строительство в крупных городах влияет на устойчивость прилегающих территорий, изменяет их равновесие и вызывает значительные изменения в напряженно-деформированном состоянии зданий и сооружений прилегающей застройки. Рассмотрены аспекты создания методологии анализа устойчивости участков городской территории при реконструкции в условиях плотной застройки для исследований зоны ее влияния, получения обоснованных результатов исследований, укрепления грунтовых массивов, проектирования ограждающих конструкций, проведения безопасной реконструкции территорий на основе законов нелинейной механики грунтов, нелинейной теории упругости и пластичности, с подключением аппарата нелинейного программирования и взаимодействия твердых деформируемых тел с неоднородными грунтовыми массивами, на основе совершенствования существующей математической модели грунтовых массивов, находящихся во взаимодействии с сооружениями прилегающей застройки, с учетом их различных физико-механических характеристик и пространственных структур, которые существенно влияют на напряженно-деформированное состояние как конструкций укрепления грунтовых массивов, оснований и фундаментов прилегающих зданий и сооружений, так и на сохранение существующей прилегающей застройки в целом. Особое внимание уделено прогнозированию возможных последствий, что является актуальной проблемой современного градостроительства и территориального планирования.
Ключевые слова: влияние нового строительства; реконструкция городских территорий; сохранение существующей застройки.

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