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КОНСТРУКЦІЇ ІЗ ЗМІННИМИ ПАРАМЕТРАМИ І ПРИСТРІЙ ДЛЯ РЕГУЛЮВАННЯ КРЕНУ БУДІВЕЛЬ

О. О. Петраков, К. О. Брижата, М. С. Масло
Донбаська національна академія будівництва і архітектури,
2, вул. Державіна, м. Макіївка, 86123.
E-mail: kate88.88@bk.ru

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Анотація. У статті розглянута технологія вдосконалення пристрою регульованих фундаментів. Наведено схему розробленого пристрою регулювання вертикального положення у просторі. Розроблена кінцево-елементна модель багатоповерхового каркасного будинку на плитному фундаменті у програмному комплексі SAP2000. Дослідження включає в себе розробку кінцево-елементної моделі будівлі і аналіз отриманих результатів на трьох етапах: перший етап: модель багатоповерхового будинку має непорушене вертикальне положення в просторі, другий етап: модель багатоповерхового будинку отримала крен 30 см, третій етап: з допомогою розробленого пристрою (а саме регулювання довжини стрижня, який моделює роботу пристрою), будівля має вірне вертикальне положення в просторі, крен плити залишився незмінним. Отримано дані про напружено-деформований стан елементів каркасного будинку на плитному фундаменті при регулюванні вертикального положення у просторі.

Ключові слова: регульований фундамент, каркасний будинок, крен, кінцево-елементна модель, SAP2000, напружено-деформований стан, плитний фундамент, вертикальне положення будівлі в просторі.

КОНСТРУКЦИИ С ИЗМЕНЯЕМЫМИ ПАРАМЕТРАМИ И УСТРОЙСТВО ДЛЯ РЕГУЛИРОВАНИЯ КРЕНА ЗДАНИЙ

А. А. Петраков, Е. О. Брыжатая, Н. С. Масло
Донбасская национальная академия строительства и архитектуры,
2, ул. Державина, г. Макеевка, 86123.
E-mail: kate88.88@bk.ru

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Аннотация. В статье рассмотрена технология совершенствования технологий устройства регулируемых фундаментов. Приведена схема разработанного устройства по регулированию вертикального положения в пространстве. Разработана конечно-элементная модель многоэтажного каркасного здания на плитном фундаменте в программном комплексе SAP2000. Исследование включает в себя разработку конечно-элементных моделей здания и анализ полученных результатов на трех этапах: первый этап: модель многоэтажного здания имеет ненарушенное вертикальное положение в пространстве, второй этап: модель многоэтажного здания получила крен 30 см, третий этап: с помощью разработанного устройства (а именно регулирования длины стержня, который моделирует работу устройства), здание имеет верное вертикальное положение в пространстве, крен плиты остался неизменным. Получены данные о напряженно-деформированном состоянии элементов каркасного здания на плитном фундаменте при регулировании вертикального положения в пространстве.

Ключевые слова: регулируемый фундамент, каркасное здание, крен, конечно-элементная модель, SAP2000, напряженно-деформируемое состояние, плитный фундамент, вертикальное положение здания в пространстве.

CONSTRUCTIONS WITH VARIABLE PARAMETERS AND THE DEVICE FOR CORRECT THE TILT OF THE BUILDINGS

Oleksandr Petrakov, Kateryna Bryzhata, Nikolay Maslo
Donbas National Academy of Civil Engineering and Architecture,
2, Derzhavina Str., Makiyivka, 86123.
E-mail: kate88.88@bk.ru

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Abstract. The article considers the technology improved technology device controlled foundations. The scheme developed device to regulate the vertical position extension. Finite-element model of multi-storey frame building on a slab foundation in the software package SAP2000 was developed. The study includes the development of finite-element model building and analysis of the results obtained in three stages: the first stage: a model of multi-storey building has an unbroken vertical position in extension, the second stage: the model of multi-storey buildings had tilt of 30 cm, the third step: using the developed device (namely the length of the bar control that simulates the operation of the device), the building has the correct vertical position in extension, the tilt of the slab foundation remained unchanged. The data on the stress-strain state of the elements of the frame in the building on the slab foundation in the process of regulation the vertical position in extension.

Keywords: adjustable foundation, frame building, tilt, finite-element model, SAP2000, strain-stress state, slab foundation, the vertical position of the building in extension.

Introduction

The territory of Ukraine is characterized by complicated engineering-geological and mining-geological conditions. Donbass – the country's oldest coal-mining field which occupies the first place in the industrial importance and size of coal. In the 1720s it opened the Donetsk coal basin and industrial development began in the late XIX century. The area is about 60 thousand square kilometres. The total reserves to a depth of 1 800 m – 140.8 billion tons. The Donetsk city is located at the centre of a mining district. Mining subsidence involves horizontal and vertical displacements of the ground surface as a consequence of the excavation or the failure of mining galleries. This type of subsidence has occurred since last time in the residential zone of Donetsk, probably as the result of the collapse of abandoned underground mining labours [1–3].

The wide cost of land plots in large cities of the world suppose active use of underground space and dispose increasing the number of stories within a densely urban setting. There are a lot high-rise buildings in Donetsk. Many of this constructions have non-uniform settlement that exceed permissible levels. In the centre of the city located multi-storey apartment building which has tilt more than provided by building regulation. Such buildings is dangerous in use because of the violation of their serviceability. On the one side the building is supported by a auxiliary girder, which hinders further settlement of the building. Such cases are not uncommon in the cities located on Anthropogenic Soils [3, 4].

Two methods of levelling buildings are currently employed: 1) sinking of a portion of the building opposite the tilt; 2) raising the undersized section of the building and levelling it.

The first method (slightly controllable) is accomplished by either drilling-out soil from beneath the lower surface of the foundation, or local wetting of the bed, which is simultaneously subjected to a pressure increase [5].

Method suppose providing geodesic levelling of the building, assign angle and direction equal to foundation slope, after this determining needless bank yard under foundation from the side which characterized by lesser settlement, which prevents elimination of the tilt.

The second method is employed with use of various designs of jacks, and is controlled. Method to balance monolithic reinforced concrete structures includes cutting jack holes, installation of a monolithic reinforced concrete distribution belt, installation of jack units in jack openings and systems for lifting and balancing, supply of pressure into jack units, monolithing of gaps between the lifted and the support part of the structure, formed after building lift.

In this paper a different procedure is presented. Numerical model of the building shows influence of use of developed device. First of all, object of study – administrative building is the same construction with out-of-service building that situated in the centre of Donetsk city. The space-planning decision of the building include general building in terms of size 22×22 m. The building is skeleton-type, made of braced frame structural design, building is 24 stories with a grid of columns 3×3 and 2×2 m. Typical floor height is 3 m. The frame of the building is made of precast concrete. Columns used prefabricated concrete rectangular cross-section with a size of 400×400 mm. The foundation adopted in the form of a monolithic reinforced concrete slab thickness of 0.5 m (fig. 1). Second, the experiment study shows the use of the developed device with a load of the building.

Discription of the tilt correction procedure

This device is set in at the construction phase of the building, and relates to the field of construction. After ground work and establishment of monolithic foundation slab. Developed device set on the underground technical story under every column and mate with foundation slab. During construction and after it the settlement is occurs. This process should be evenly and gradually stop. If settlement is relative can arise various strains, including building tilt. High-rise buildings can be deformed due to wind or non-uniform heating of the sunshine of walls.

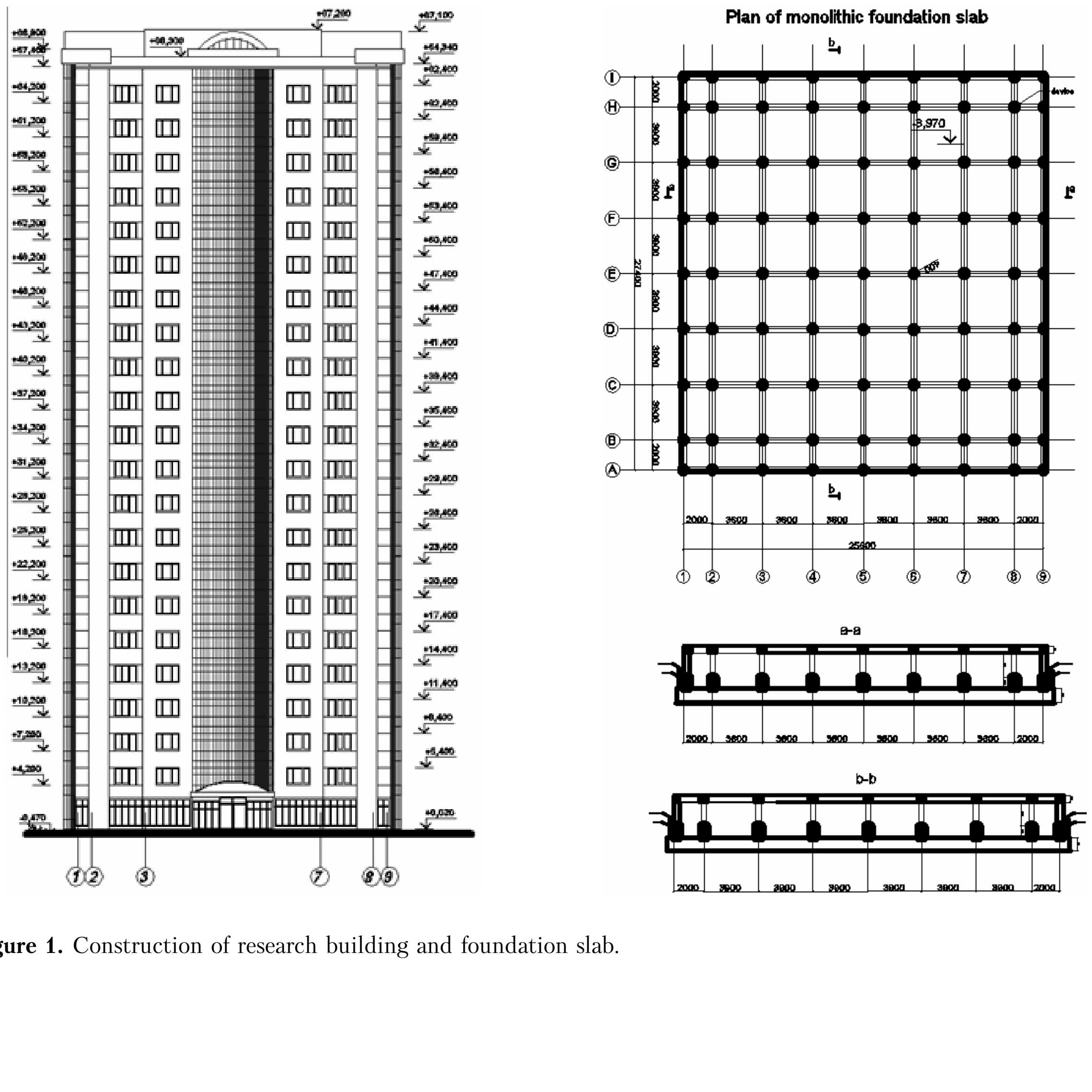

Figure 1. Construction of research building and foundation slab.

In buildings with more than 20 stages the centre of inertia is situated high enough, and the area of base is relatively small. It contributes to propagation of tilt of the buildings and structures. Control of these processes is very important in the study of use of a building.

The idea of the device usage is next. In the first phase construction has normal vertical position after commissioning, but, after non-uniform settlement which could occur by the several reasons such as: due to mining, soil liquefaction, earthquake, ground motions, blast induced ground excitations etc., the building has wrong vertical position that is dangerous for people inside. To correct this position and levelling the construction it's necessary to use the developed device (fig. 2).

Numerical analisys

It is useful to build up a 3-D full scale finite element model in order to accurately monitoring the structural behaviours of the high-rise building of differential settlement. With help of finite-element model can analyze the bending moments and how they will change in phase of experiment.

In the software package SAP 2000 has been design finite element model of the twenty-four story building. Columns and beams made of reinforced concrete with a cross section of 40×40 cm. The device was placed between the columns of the ground floor and foundation slab. The device is a steel pipe and from economic considerations, it was laid diameter of 24.5 cm. With a diameter of greater virulence device was placed in the center of the building. In order to clearly depict the behavior of a building during its non-uniform settlement and further adjustments in the software package has been developed 3 stages. In the first phase the building was under permanent and temporary load (fig. 3a). In the second phase the building received the tilt with a maximum value of 30 cm (fig. 3b). The verticality of the building was disrupted. In the third phase, to simulate the behavior of device, in the opposite direction of the tilt is applied load for bias the joint in the right direction. Foundation plate remained tilted, but the building is levelling and serviceable (fig. 3c).

Diagrams of bending moments in software package SAP2000 in all phase of experiment are shown in fig. 4.

The results are tabulated and are made according to these findings (table).

Devices proposed. Experimental results

The invention relates to the construction, namely to the devices that minimize the effects of non-uniform settlement of the underlying foundation soils and buildings.

Between the foundation and the superstructure is placed system of cross-beams and underneath them

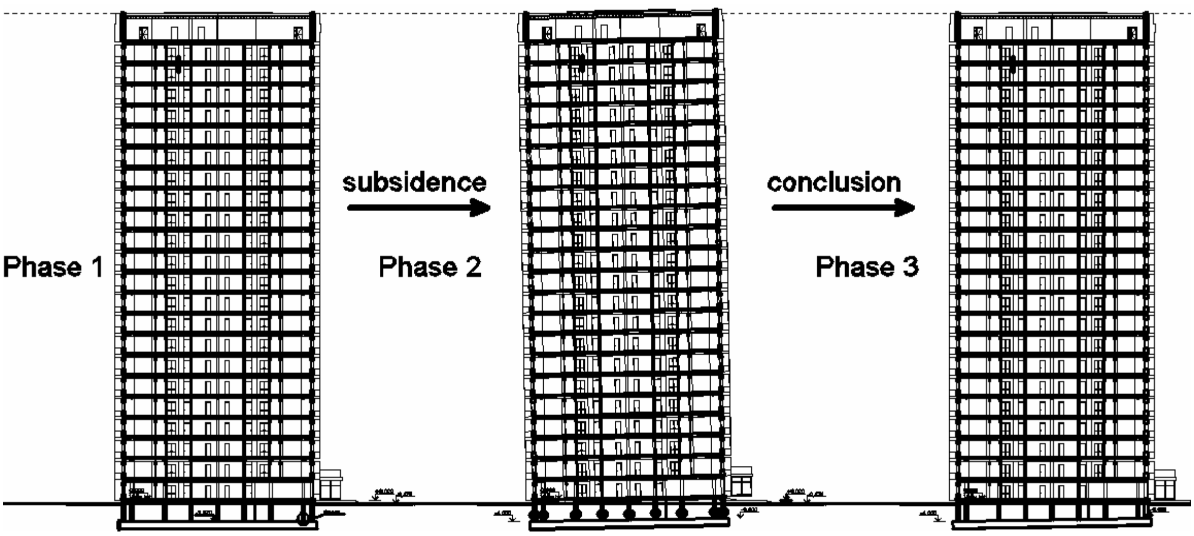

Figure 2. Phase of experiment.

satisfied recess for placing a device which consists of two metal tubes (internal and external) (shown on fig. 5). The interior and exterior tubes have a oblique bottoms. There is a sand in the exterior tube. If the building receives non-uniform settlement(tilt) (shown on fig. 3b) and it necessary adjustment the position of the building construction is carried out by the release of the bulk material through the hole of the interior tube. After the release of the required amount of sand, the interior pipe is lowered into place, thereby blocking the release of the bulk material and measure the sediment associated with the release of sand. Application of the device to adjust the position of a building or structure at the base of differential settlement allows the possibility of adjusting the position of the building or structure in use.

According to the results of experimental studies it was determined sequence of axial load and displacement of sand in the device (fig. 6).

a) b) c)

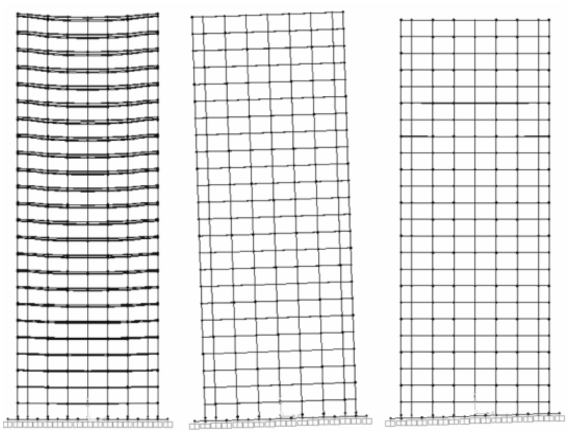

Figure 3. Load and the boundary condition of the numerical model in SAP2000: a) normal vertical position; b) building has a tilt; c) levelling the tilt.

Conclusions

Thus, the comparative analysis efforts multistorey building frame elements showed the following results on a slab foundation: The average force values in the frame elements at the second stage forces exceed the first stage of 50 %; force values are reduced in the third phase of the study compared to the second stage of the study and reaches values of effort in the first stage with a difference of 5–10 %.

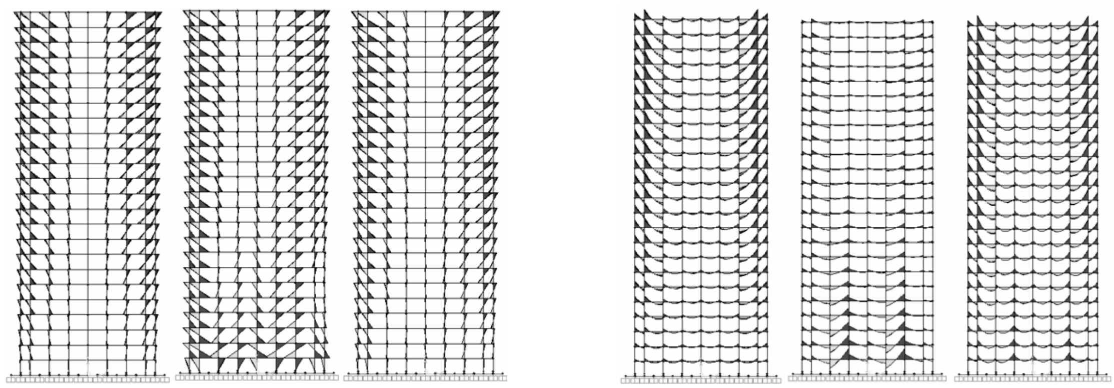

Figure 4. Bending moment M_z and Bending moment M_y.

Table. Bending moments M_z and M_y received by software package SAP2000

		M_z max, kN·m	M_z min, kN·m	M_y max, kN·m	M_y min, kN·m
Frame 1	Stage 1	26.240 (100 %)	–23.040 (100 %)	19.40 (100 %)	–23.66 (100 %)
	Stage 2	38.530 (147 %)	–38.330 (166 %)	27.92 (144 %)	–35.26 (149 %)
	Stage 3	31.160 (118 %)	–29.460 (127 %)	21.39 (110 %)	–25.81 (109 %)
Frame 2	Stage 1	0.008 (100 %)	–0.004 (100 %)	23.59 (100 %)	–30.45 (100 %)
	Stage 2	27.050 (338 125 %)	–33.560 (839 000 %)	29.69 (125 %)	–41.77 (137 %)
	Stage 3	0.074 (925 %)	–0.980 (24 500 %)	25.89 (109 %)	–36.53 (119 %)

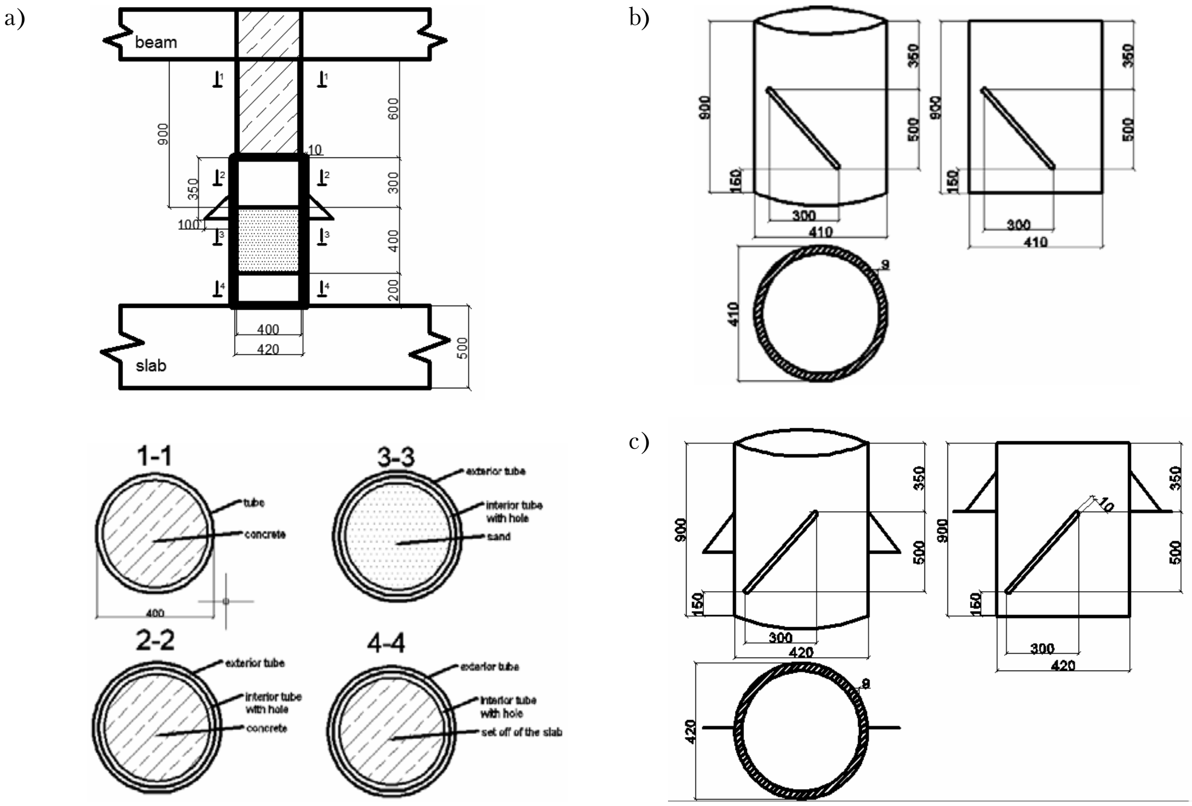

Figure 5. Construction of device: a) general form of the device; b) interior tube; c) exterior tube.

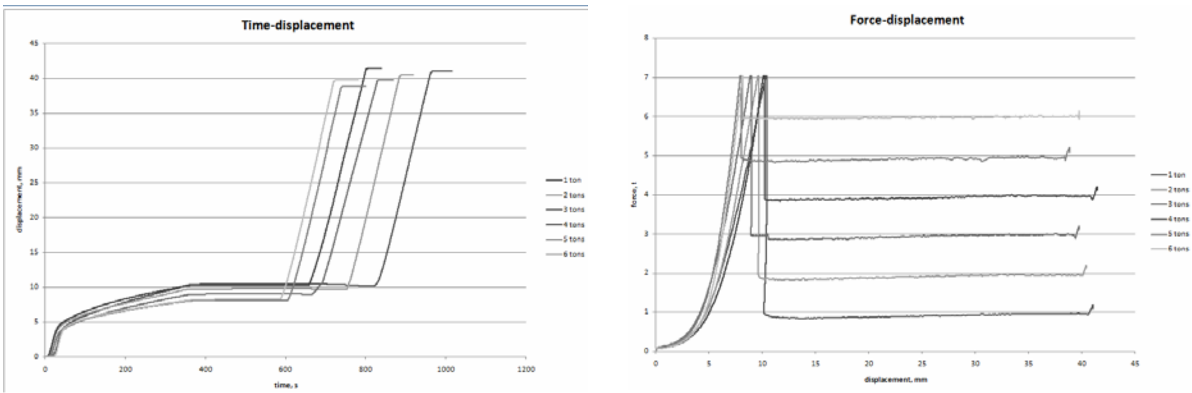

Figure 6. Dependency diagrams of time-displacement and force-displacement.

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Петраков Олександр Олександрович – доктор технічних наук, професор кафедри основ, фундаментів та підземних споруд Донбаської національної академії будівництва і архітектури. Наукові інтереси: теорія взаємодії споруд з деформованою підосновою, у тому числі на підроблюваних територіях і просідаючих грунтах; розробка і дослідження фундаментів підвищеної несучої спроможності і методів їх розрахунку на основі гіпотез нелінійної геомеханіки та теорії будівельних конструкцій.

Брижата Катерина Олегівна – аспірант кафедри основ, фундаментів та підземних споруд Донбаської національної академії будівництва і архітектури. Наукові інтереси: конструкції із змінними параметрами для виправлення кренів споруд.

Масло Микола Сергійович – асистент кафедри основ, фундаментів та підземних споруд Донбаської національної академії будівництва і архітектури. Наукові інтереси: конструкції підпірних стін. Особливості визначення навантажень на підпірні стіни.

Петраков Александр Александрович – доктор технических наук, профессор кафедры оснований, фундаментов и подземных сооружений Донбасской национальной академии строительства и архитектуры. Научные интересы: теория взаимодействия сооружений с деформирующимся основанием, в том числе на подрабатываемых территориях и просадочных грунтах; разработка и исследование фундаментов повышенной несущей способности и методов их расчета на основе гипотез нелинейной геомеханики и теории строительных конструкций.

Брыжатая Екатерина Олеговна – аспирант кафедры оснований, фундаментов и подземных сооружений Донбасской национальной академии строительства и архитектуры. Научные интересы: конструкции с изменяемыми параметрами для исправления кренов сооружений.

Масло Николай Сергеевич – ассистент кафедры оснований, фундаментов и подземных сооружений Донбасской национальной академии строительства и архитектуры. Научные интересы: конструкции подпорных стен, особенности определения нагрузок на подпорные стены.

Petrakov Oleksandr – D.Sc. (Engineering), Professor; Basements, Foundations and Underground Structures Department, Donbas National Academy of Civil Engineering and Architecture. Scientific interests: theory of interaction with deformable structures base, including undermined territories and subsiding soils; development and research foundations increased carrying capacity and methods of their calculation on the basis of hypotheses and theories of nonlinear geomechanics constructions.

Bryzhata Kateryna – postgraduate student; Basements, Foundations and Underground Structures Department, Donbas National Academy of Civil Engineering and Architecture. Scientific interests: Constructions with variable parameters to correct the lists in buildings.

Maslo Nikolay – Assistant; Basements, Foundations and Underground Structures Department, Donbas National Academy of Civil Engineering and Architecture. Scientific interests: Construction of retaining walls. Specifics of determining loads on the retaining walls.