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ТРАНСПОРТНЕ БУДІВНИЦТВО

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IMPROVEMENT THE CALCULATION OF THE STABILITY OF BUILDING LOCATED NEAR THE SLOPES FOR STRUCTURAL UNSTABLE SOILS

Purpose. This article is devoted to research of soil in complex engineering and geological conditions, as well as ways to improve the stability of the stacked bases structurally unstable soils. The relevance of this work lies in the solution of grounds stability problem interacting with foundations established on structurally unstable soils. In accordance with the researches results compiled recommendations aimed to the improvement of the base stability folded by structurally unstable soils is supposed. **Methodology**. The aim of the work is to improve the reliability of the strength characteristics obtained by the method of mathematical modeling of the expected processes. The objective was the enhancements the existing testing methods and technologies in order to determine the relative value of safety factor and reliability assessment of the bearing capacity of the base folded structurally unstable soils. **Findings**. This system was designed to ensure the automated measurement of deformation parameters on the on-line with followed mathematical processing and presentation of data in an accessible form. Thus, the obtained results allow drawing the conclusions about the patterns of structure strain state, as well as predicting its future behavior. It all depended on well-formed mathematical algorithm, which is adjusted by tests conducted in natural conditions in selected regions of the Donbass region. **Originality**. One of the most effective ways to start and register a timely activation of deformation processes in plant cells from the damaging effects is the use of automated systems with high reliability which receive signals from the deformable objects. The main tool used to solve the problem, was the method of mathematical modeling in ACS reproducing receptive model processes in the soil with a program «HRUNT» and «MONOMAKH». And modeling the three-dimensional base of the building on the joint work of the soil mass and building by the finite element method (FEM-calculation) in the PC-LIRA system. **Practical value**. The problem of increasing the sustainability of slope, the prognosis of deformations and their strengthening, remains urgent. This is due to the increasing shortage of available land area and the location of facilities in cramped conditions, near the slopes composed of the non-uniform grounds.

Keywords: soil; subsidence; part; investigation; methods of testing; cramped conditions

Introduction

The problem of increasing sustainability of escarpment him prognosis, deformations and their strengthening, remains urgent.This is due to the increasing shortage of available land area and the location of facilities in cramped conditions, near of escarpment stacked up from heterogeneous soils. It is important to know, too, whether the possibility of reduced resistance of materials and structures under from any from factors. For example, a very

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important factors can be as flammability, and accordingly flame resistance, and stability of constructs interacting the base ground surface, which loses structural strength at 500 ° C. Particularly acute, this problem with respect to the stability of slopes, their phenomena occurring on the territory of Ukraine . Contribute to this, first, strongly dissected relief, secondly, complex engineering-geological conditions that endanger the lives of people [4-9, 11-16].

These circumstances make it necessary to improve the methods of calculation on the stability of soil masses, particularly by escarpment.

Purpose

The purpose, all the work is to improve the reliability of the strength characteristics obtained by the method of mathematical modeling of the expected processes.

The objective was to enhancements the existing testing methods and technologies in order to determine the relative value of safety factor and reliability assessment of the bearing capacity of the base folded structurally unstable soils.

Methodology

Object is achieved empirically by study sites Donbass region and in the laboratory using real groundwater characteristics. Unlike the previously known methods for calculating estimates for the stability of the array is the mathematical modeling of real basis to the settings through a comprehensive program for calculating algorithm specified.

Basic option would be the use of results from prior continuous testing, maintaining the current load in the study in the field [4, 9].

New variant provides modeling, which should be carried out through an integrated computer-based program (EBM), using actual ground conditions. It is contemplated the load transmitted from the simulation modeled structures located near the slope by scaling in real-time by mathematical apparatus containing the complex calculation programs that allow to forecast occurring processes.

To determine necessary to carry out the relevant calculations that will compare traditional evaluation methods for calculating the stability array folded structurally unstable soil under them with the proposed load.

The task is complicated by the investigations in parts establish limit relative values safety factor and reliability assessment of the bearing capacity of the base folded structurally unstable soils for buildings located in cramped conditions.

In Parts creating recommendations, for incorporating parameters affecting the calculation to determine the resilience of buildings increased fire combustion mode, depending on the cramped conditions.

Unlike the previously known methods for calculating estimates for the stability of the array folded structurally unstable soils under the action of the load transmitted from facilities located near the slope in cramped conditions, is the mathematical modeling of real base unit with the specified parameters and process control test using a computer, using complex programs (EBM).

In improving the method of calculation and increase the accuracy of the recommendations of parameters affecting the bearing capacity of the foundation, in particular, to recommend the most secure location facilities from the edge of slope.

In the account of the parameters affecting the calculation to determine the resilience of buildings increased combustion fire regime. From the analysis of works of reference materials on the grounds and foundations are values in the stability factor K_y for strengthening slopes by conventional anti-landslide measures, but these measures are not always acceptable.

There is a statement that to improve the accuracy of the calculations and the use of more efficient anti-landslide measures in order to limit degradability structures required value of the stability coefficient should decline only very small values of K_y in excess of unity. That is enough to wonder at the K_y values from 1.05 to 1.1. This assumption is controversial and requires clarification by obtaining the most reliable data.

Known variational calculation methods, the proposed A.D. Girgidovym, M.N. Goldstein, A.G. Dorfman, W.H. Magdeeva etc. The complexity of the known methods is enclosed in a large volume of calculations, the possibility of a human error, and complexity of calculations in such methods is not justified by any refinement results [1-3, 9-16].

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The main disadvantages of the currently existing numerical methods are: the absence of a rigorous analysis of the soil mass the VAT; slope stability calculation is carried out using only the vertical component of stress and excluding such important characteristics of soils, as the coefficient of lateral thrust and elastic modulus.

These shortcomings in many cases do not allow sufficiently accurately and reliably determine their stability. This requires further study and improvement of methods of calculation for the stability of slopes composed of heterogeneous, with which one could establish the impact of all factors on the overall stability. Therefore, the issues of the problem solved, to improve the sustainability of action bases foundations sensing load of the entire structure, are the first and quite relevant. The urgency of this problem increases also due to the ever-increasing shortage of available land area continues to be significant, especially when assessing the bearing capacity of foundation for structures located in cramped conditions, taking into account the influence of the degree of their increased resistance to fire the combustion mode of information directly in the literature.

Essence of the method lies in the implementation of the calculation of the total stability of the slope along the most probable or known surface displacement by summing the values of private K_y received well-known formula, (1):

$$K_y \sum_{i=1}^{i=n} \tau_i \Big/ \sum_{i=1}^{i=n} \tau_i \, , \qquad (1)$$

where: K_y – the stability factor; n – number of attracted in the calculation private values; τ_i – private values of shear stresses

If the relative value of the stability factor K_y <1.10 – this means an unstable state of the wedge. The reason is explained by the fact that the wedge differ between a shape and dimensions that make up the segment, the clipped area and rolling in the overall wedge (Fig. 1, 2).The experiment was carried out to verify the conditions for the most safe distance for the location of the building near the slope, by mathematical modeling using integrated programs and the introduction of real soil conditions.

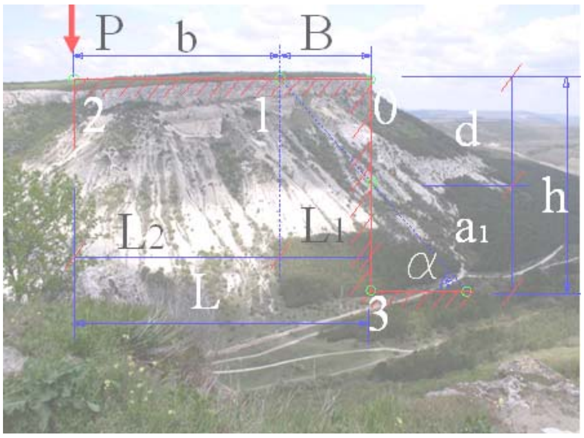

Fig. 1. General view of a portion of the slope planned for construction

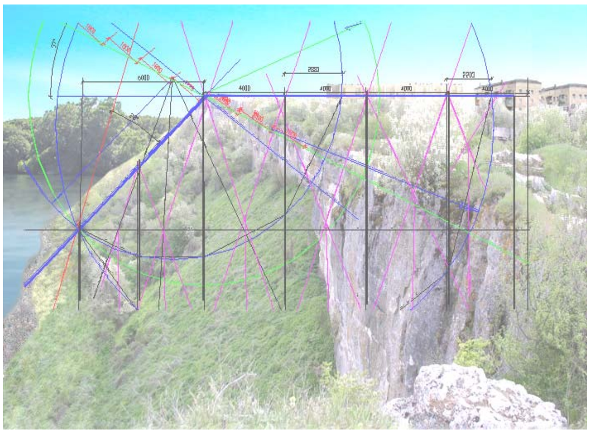

Fig. 2. Calculation scheme for the definition of stability base and a safe distance required for location of the building near the slope.

Required recalculation and empirically confirm that the planned location of facilities performed within a convenient distance. Preliminary calculations were obtained, as well field points and interpolated data points stability factor K_y, which allowed us to estimate these values and to reflect them in the form of contouring at K_y = const, which allowed for further experiments:- Objectively select the position of the surface likely Slope failure corresponding to the cut-off line stability, with chalky soil masses Donbass region (Fig. 2, 4) and on the slope near the undermined areas (Fig. 2).

Assess the overall slope stability along the surface displacement in the form factor of safety or stability $K_y = K_3$ and found in rock mass slope zone of potential instability, where: $K_y \langle 1$;

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-To quantify the degree of influence of various geotechnical factors (Surcharging, anti-destroying activities, decreased strength of rocks, hydrostatic and hydrodynamic pressure) on the overall stability; -construct a graph particular values along the selected stability factor or known surface displacement (Fig. 3).

Further studies showed that a more reliable determination of the required values of the coefficient of stability base folded structurally unstable soils K_{TP} strength (the first limit state) should be determined by the expression:

$$K_{TP} = \frac{K_n \cdot n_c \cdot n_0}{m_0}, \qquad (2)$$

K_n – safety factor for purpose facilities; n_c - factor load combinations; $n_c = 1$; n_0 – load factor; n_0 = 1,1, n_0 = 1,2; then coefficient of working conditions; m_0 = 0,9 – for salty clay soils in a stabilized condition, m_0 = 0,85 – in unsterilized condition [10-16].

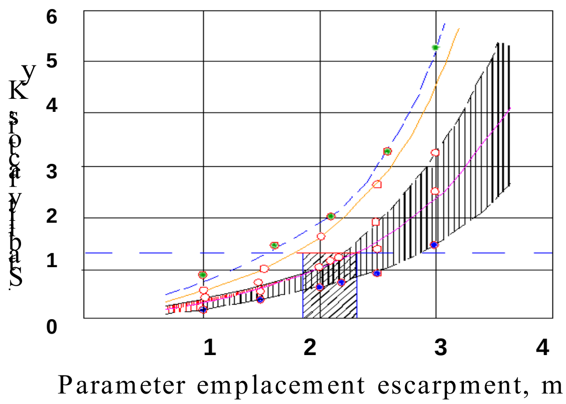

Fig. 3. Nomograms to determine the stability factor in ddepending on the strength characteristics.

Important value has factors that affect the overall stability of structures interconnected with the base is not enough and not always taken into account in the design of foundations – the quantities fire resistance, flammability which require further study, particularly in the wall conditions.

Us in the study of factors such as the impact on the fire set the earth's surface and the material of construction of the structure [9]. Setting its value showed that the base loses structural strength at 500 ° C. It is therefore not necessary to plant at the location in cramped conditions and near slopes, increasing the distance between the buildings is not less than 30% see Table 1.

Table 1

Values of temperature capable materials resist fire.

material	ρ_o, kg/m^3	T_{bm} ^0C	T_{em} ^0C
sand	1.76	100	500
clay	1.78	100	510
sandstone	2.20	150	400
metal steel	2.70	150	400
concrete	2.20		
reinforced concrete	2.40		

To elucidate the effect of the strength characteristics of the material from which the construction is made on the general stability at ignition and to determine the fracture resistance value of the interval of time were examined various materials constituting an idea of interacting with the base construction [4, 8-9].

Research was marked difference in the readings, temperature softer emosti times. For example, some materials when heated to certain temperatures (below the melting point) are transformed into a plastic state is softened (e.g., by heating the glass to 750-900°C; asphalt than 50°C).

Some materials softened after cooling accept previous structural condition. Further study of factors affecting the overall stability of the structures necessary to take account of mathematical modeling showed that some of the material ductility increases with heat and decreases with decreasing temperature (steel, bitumen, some plastics). Relaxation occurs, ie, other owls voltage drop in the material at a constant initial strain. Relaxation is detected in the material due to the gradual transition to a plastic deformation of an elastic, particularly enhanced at elevated temperatures. Therefore, the material structures must have a higher resistance at high temperatures than the test samples

In mathematical modeling and drafting calculation algorithm were introduced by the studied parameters: Mo 1 700-2 000 °C,

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2 200-2 500 °C tungsten, niobium, 1 900-2 300 °C, and others [1, 3].

Dependence an algorithm provided by the saturated vapor pressure and temperature to calculate the ignition point t_y, °C, substances composed of atoms of C, H, O and N, and to record, based on the known formula ,(3):

$$t_v = \frac{453}{P_v \cdot D_0 \cdot \beta}, \qquad (3)$$

where P_v — partial vapor pressure of flammable liquid at a temperature flash kPa; D_0 – the vapor diffusion coefficient in air, cm²/s; β – the stoichiometric coefficient of oxygen in the combustion reaction

For the calculation of the ignition temperature of the substances in the molecules which contain structural group recommended Table 1, wherein the algorithm is calculated according to the formula, (4), ° C:

$$t_v = -47,79 + 0,882 \cdot t_k + \sum_{j=2}^{q} a_j l_j, \qquad (4)$$

Where t_k – the boiling temperature of the liquid at 101 kPa, ° C; l_j – the number of structural groups of j-th species in the molecule; a_j – empirical coefficients, which values are shown in Table 1.

All these factors were taken into account and the algorithm used to determine the deformability of the mass soil and Forecasting processes.

Findings

One of the main factors affecting the quality assessment base for the design of foundations, is the lack of reliable features are included in the calculation formulas. Ambiguous conclusions obtained by engineering surveys are fraught with consequences. This particularly applies to the buildings on the grounds designed stacked structurally unstable soils, where the slightest deviations result in significant costs to strengthen the foundations and crumbling foundation interacting with the construction. Or leads to the suspension of construction works or their complete cessation.

The object of the study are presented with the aim of designing buildings on their sites undermined mine yard Torez, Donetsk region and near slopes (Figure 4 *a,b*) composed of chalky soil masses Donbass region (Figure1).

– *a*

– *b*

Fig. 4. General view of a building under construction and a portion of the modeled area near the slope

In the period 2012-2014 we have studied and investigated soil conditions plots for the design of structures, in order to improve methods of calculation using the potential of mathematical modeling in the laboratory and comprehensive calculation programs, by definition, the stability of the soil mass and prediction of deformation properties [3, 9].

One of the most effective ways to start and register a timely activation of deformation processes in plant cells from the damaging effects is the use of automated systems with high reliability which receive signals from the deformable objects. Came to help computer technology, enabled the massive processing, with the probability of making a possible exception error from the influence of the human factor in the removal of the information and further processing

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of payment indicators included in the calculation formulas [2].

And, also, allowed to confirm the accuracy of the results processed by tables, graphs, monograms, when compared with the full-scale tests, the results of which were published previously in other studies [1, 3].

This system was designed to ensure the automated measurement of deformation parameters on the on-line, followed by mathematical processing and presentation of data in an accessible form. So that the results obtained allow to draw conclusions about the patterns of strain state of the structure, as well as predicting its future behavior, and it all depended on well-formed mathematical algorithm, which is adjusted by tests conducted in natural conditions in selected regions of the Donbass region.

Originality and practical value

The main tool used to solve our problem, was the method of mathematical modeling in ACU reproducing receptive model processes in the soil with a program «PRIMER» MONOMAH and modeling three-dimensional base of the building on the joint work of the soil mass and building the finite element method (FEM-calculation) in the PC-LIRA.

The solution to this problem and the reliability of these decisions is a direct function of how accurately and fully adopted calculation scheme corresponds to the real conditions of collaboration considered structures and subgrade.

Studies have shown that not every design scheme adopted model can fully describe the processes occurring in the soil and the array so far not been adequately studied. Calculation scheme model should reflect the main features of the process of interaction with the engineering structure subgrade – this requirement allows for a simplified mathematical model of a good enough reason to get the convergence of predicted values with the experimental data.

From our point of view the study object is the subject of today's discussion and an example to find the most practical activities that do not allow the destruction of structures during construction and further operation of the building. As reported above, research has focused on the search patterns of change in the properties of construction site of a ground layer, which is in a dangerous state of emergency. And also do not need to confirm the emergence of strains of assumptions drawdown respectively banks and as a result, disorders compounds, followed by confirmation of the reliability of the results applied in determining the adequacy of the bearing capacity of the underlying layer under the foundation.

To date, many publications in which they treat them with two points of view. Geologists who study these processes, based on the method of field observations and methods for using the experience accumulated over the centuries.

The direct use of techniques without specific conditions in many cases leads to serious errors: the reason for this – a variety of natural conditions and soil types, conditions of their occurrence, and hydrogeological conditions. The most promising solution to this problem is to study the stress-strain state of the soil mass the VAT using the finite element method. Therefore, improving the methods of research and calculation slope stability analysis based on VAT is relevant task in mechanics soils and rocks [14-16].

However, many questions have not been studied, and in the formulation and solution of problems of escarpment stability has a number of drawbacks.

The main disadvantages of the currently existing numerical methods are: the absence of a rigorous analysis of the soil mass the VAT. Calculation of slope stability is carried out using only the vertical component of stress and excluding such important characteristics of soils, as the coefficient of lateral thrust and elastic modulus. These shortcomings in many cases do not allow sufficiently accurately and reliably determine their stability.

Conclusions

In conclusion we can say this improved method will:

1. Estimate the magnitude of creep strain for a period equal to the beginning of changes in the structural strength of the subgrade and the beginning of recovery to improve the strength properties of soils measures applied in those cases where когда $K_n \langle 1$, а $K_{oy} \geq 1$.

2. Know the amount of space stability factor, we can predict compiled by nomograms (Fig. 2, 3)

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for the load and, what distance from the edge the slope must have structure, so as not collapsed, or make provision precluding change the structural strength of the subgrade with to restore and improve the strength properties of soils.

3. To detect probable zone of plastic deformation and fracture $(K=1)$ helps to organize and purposefully mining and drilling operations, selection and testing of samples, and apply measures aimed at improving the sustainability of the base, folded structurally unstable soils (eg soils with folded subsidence properties Cretaceous origin or undermined arrays).

4. To take into account factors that affects the strength properties of the material of construction of the structure.

5. Get interval fire resistance values over time, according to the classification of the material, to take into account when designing their appointment and use the material for construction, which will reduce accidents.

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УДОСКОНАЛЕННЯ РОЗРАХУНКУ СТІЙКОСТІ БУДІВЛІ, РОЗТАШОВАНОЇ ПОБЛИЗУ УКОСІВ НА СТРУКТУРНО-НЕСТІЙКИХ ГРУНТАХ

Мета. Ця стаття присвячена дослідженню ґрунтів у складних інженерно-геологічних умовах, а також пошуку шляхів підвищення стійкості основ, складених із структурно-нестійких ґрунтів. Актуальність даної роботи полягає у вирішенні проблем стійкості основ, взаємодіючих із фундаментами, встановленими на структурно-нестійких ґрунтах. За результатами досліджень необхідно викласти рекомендації, що спрямовані на підвищення стійкості основ, складених структурно-нестійкими ґрунтами. **Методика**. Суть всієї роботи полягає у підвищенні достовірності міцнісних характеристик, що одержуються методом математичного моделювання передбачуваних процесів. Задача досліджень полягала в удосконаленні існуючих методів та технологій випробувань для визначення відносної величини коефіцієнта запасу надійності та оцінки несучої здатності основ, складених структурно-нестійкими ґрунтами. **Результати**. Ця система спрямована на забезпечення автоматизованого вимірювання деформаційних параметрів у режимі on-line із подальшою математичною обробкою та представленням даних у доступному вигляді. Так, отримані результати дозволили зробити висновок про закономірності деформаційного стану споруди, а також спрогнозувати його подальшу поведінку. Все це залежить від правильно складеного математичного алгоритму, який коректувався випробуваннями, проведеними в натурних умовах на обраних ділянках Донбаського регіону. **Наукова новизна**. Одним із найефективніших способів, що дозволяє своєчасно зареєструвати початок й активізацію деформаційних процесів у елементах споруд від руйнівного впливу, є використання автоматизованих систем, які з високою вірогідністю сприймають сигнали від об’єктів, що деформуються. Основним інструментом, використаним для вирішення нашої задачі, був метод математичного моделювання в системі АСУ, що відтворює та сприймає моделі процесів у ґрунті за допомогою програм «ГРУНТ» та «МОНОМАХ». Використано також моделювання тривимірної основи будівлі з урахуванням спільної роботи ґрунтового масиву та будівлі методом кінцевих елементів (МКЕ-розрахунок) у системі ПК-ЛІРА. **Практична значимість**. Проблема підвищення стійкості укосів, прогноз деформацій та їх зміцнення продовжує залишатися актуальною. Це пов’язано зі збільшенням дефіциту вільних земельних площ та розташуванням споруд в обмежених умовах, поблизу укосів, складених неоднорідними ґрунтами.

Ключові слова: ґрунти; просадочність; підробіток; дослідження; методи випробування; обмежені умови

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ТРАНСПОРТНЕ БУДІВНИЦТВО

УСОВЕРШЕНСТВОВАНИЕ РАСЧЕТА УСТОЙЧИВОСТИ ЗДАНИЯ, РАСПОЛОЖЕННОГО ВБЛИЗИ ОТКОСА НА СТРУКТУРНО-НЕУСТОЙЧИВЫХ ГРУНТАХ

Цель. Эта статья посвящена исследованию грунтов в сложных инженерно-геологических условиях, а также поиску путей повышения устойчивости оснований, сложенных из структурно-неустойчивых грунтов. Актуальность данной работы заключена в решении проблемы устойчивости оснований, взаимодействующих с фундаментами, установленными на структурно-неустойчивых грунтах. По результатам исследований предполагается составление рекомендаций, направленных на повышение устойчивости основания, сложенного структурно-неустойчивыми грунтами. **Методика.** Суть всей работы состоит в повышении достоверности прочностных характеристик, получаемых методом математического моделирования предполагаемых процессов. Задача исследований состояла в усовершенствовании существующих методов и технологий испытаний для определения относительной величины коэффициента запаса надежности и оценки несущей способности основания, сложенного структурно-неустойчивыми грунтами. **Результаты.** Эта система была направлена на обеспечение автоматизированного измерения деформационных параметров в режиме on-line с последующей математической обработкой и представлением данных в доступном виде. Так, полученные результаты позволили сделать заключение о закономерностях деформационного состояния сооружения, а также спрогнозировать его дальнейшее поведение. Все это зависело от правильно составленного математического алгоритма, который корректировался испытаниями, проведенными в натурных условиях на выбранных участках Донбасского региона. **Научная новизна.** Одним из самых эффективных способов, позволяющих своевременно зарегистрировать начало и активизацию деформационных процессов в элементах сооружений от разрушающего воздействия, является использование автоматизированных систем, которые с высокой достоверностью воспринимают сигналы от деформирующихся объектов. Основным инструментом, используемым для решения нашей задачи, был метод математического моделирования в системе АСУ, воспроизводящего и воспринимающего модель процессов в грунте с помощью программ «ГРУНТ» и «МОНОМАХ». Использовано также моделирование трёхмерного основания здания с учётом совместной работы грунтового массива и здания методом конечных элементов (МКЭ-расчёт) в системе ПК-ЛИРА. **Практическая значимость.** Проблема повышения устойчивости откосов, прогноз деформаций и их укрепление продолжает оставаться актуальной. Это связано с увеличивающимся дефицитом свободных земельных площадей и расположением сооружений в стесненных условиях, вблизи откосов, сложенных неоднородными грунтами.

Ключевые слова: грунты; просадочность; подработка; исследования; методы испытания; стесненные условия

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