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Flexible oneanchor retaining building models calculation results comparing with experimental data

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Based on the previously described mathematical model implemented in software complex PLASTICA, nonlinear calculation of one anchor sheet pile wall together with surrounding soil medium has been performed. To assess the results reliability with experimental data tests Lazebnik G.E., calculations in PLAXIS 2D and classic Coulomb method are compared. The basis of a mathematical model incorporated the theory of plastic flow with hardening, which is based on the principle of maximum Mises. In general, it can be assumed that the calculations results in the software package PLASTICA using the proposed nonlinear models showed satisfactory agreement as compared with the experimental data

Keywords:mathematical design, retaining wall, theory of plastic flow, experiment, mathematical pressure of soil, sensors, indicators of deformations, tensoresistors, epure of flexion moments

Порівняння результатів розрахунку моделей гнучкої одноанкерної підпірної споруди з експериментальними даними

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На підставі математичної моделі, яка реалізована в програмному комплексі PLASTICA, виконано нелінійний розрахунок шпунтової одноанкерної стінки спільно з оточуючим її ґрунтовим середовищем. Для оцінювання достовірності отриманих результатів їх порівняно з даними експериментальних випробувань Г.Є. Лазебника, розрахунками в PLAXIS 2D та з класичним методом Кулона. В основу математичної моделі закладено теорію пластичної течії зі зміцненням, яка базується на принципі максимуму Мізеса, що дозволяє врахувати процес складного навантаження і реальні властивості матеріалів конструкції та ґрунтів. Випробування здійснено в лабораторному лотку. Як засипку використано річковий кварцовий пісок. Тиск ґрунту на шпунтову підпірну стінку встановлено за допомогою датчиків для вимірювання малих тисків. Для визначення згинальних моментів застосовано індикатори деформацій і тензорезистори, встановлені на шпунтині-вимірнику. За результатами порівняння відзначено, що найбільші відхилення в епюрах пасивного тиску між експериментальними і розрахунковими в PLASTICA даними спостерігаються в нижній частині стінки, приблизно в два рази. Подібна різниця в епюрах активного тиску в області кріплення анкера склала 20%, в епюрах моментів – 23,5% в середній частині стінки. Показано, що результати розрахунку в програмному комплексі PLAXIS вийшли дещо завищеними порівняно з експериментальними даними. Доведено, що найбільші відмінності спостерігаються при порівнянні з результатами, отриманими за класичною теорією Кулона, особливо в епюрі пасивного тиску піску на стіну. У цілому, можна вважати, що результати розрахунку в програмному комплексі PLASTICA з використанням пропонованої нелінійної моделі показали задовільний збіг порівняно з експериментальними даними. Це дозволило зробити висновок про можливість використання запропонованої моделі в практиці проектування розглянутих споруд.

Ключові слова: математичне моделювання, підпірна стінка, теорія пластичної течії, експеримент, тиск ґрунту, датчики, індикатори деформацій, тензорезистори, епюра згинальних моментів

Introduction. Currently, there are a large number and variety of soil environment models, which continues to grow. Is is due to a variety of soil types and their work characteristics in a variety of conditions. Thus, any model describing phenomena characteristic subgrades should [1]: 1) to provide the laws and principles of solid mechanics deformable body; 2) reflect soil type characteristics, manifested by its behavior in various conditions; 3) determine the relationship among stress and strain.

For the design it is very important from the variety of existing models to make the most suiltable correct choice. It is known that the best proof of this selection correctness is to compare in each case the calculation results with natural or experimental data. This article is dedicated to this problem solution.

Analysis of recent research and publications of sources. Laboratory and field tests of retaining structures were made, for example, in [2 – 8]. The book [9] provides a detailed analysis and classification of the soil existing models, as well as references to work where they are described in detail. At [10] is described a mathematical model, which is embedded in the software complex PLASTICA used here, however in this work material exposure is lowered.

Isolation of previously unsolved aspects of the problem. In the article [11] a comparison calculation of the joint rigid retaining wall and its surrounding soil mass at software package PLASTICA have been already performed with experimental data obtained Z.V. Tsagareli by testing its towing model. In this paper, this comparison results example reliability for flexible oneanchor study wall is continued.

Purpose of the work. The aim of this study is to estimate the reliability of implemented in the software package PLASTICA mathematical modeling results of flexible retaining structures oneanchor by comparison with experimental data obtained by G.E. Lazebnik [5, 6] and a software package PLAXIS 2D and classic Coulomb method.

Main material and results. The basis of the mathematical model incorporated the theory of plastic flow with hardening, which is based on the principle of maximum Mises. It enables to consider the complex process of loading and the soils and construction materials real properties such as elasticity, plasticity and viscosity.

The algorithm incorporated in the software package PLASTICA uses numerical methods, which implement two problems: 1) sampling the area occupied by the model and the original equation; 2) the construction of an iterative process to determine the desired functions characterizing the stress-strain state model with preassigned accuracy.

The solution to the first problem enables to represent the problem in algebraic form, i.e. move from an infinite number of freedom model degrees to their finite number. It can be implemented using various projection methods, for example method of weighted residuals. The solution to the second problem enables to produce the original linearization of non-linear equations. In this case, the operation for adjusting their coefficients can be performed at each iteration solutions (method variables elastic parameters, the method of tangential inflexibility) or only on the first iteration or through their predetermined amount (modification of the method Newton -Kantarovich, which include, for example, the method of elastic and making initial stress method). Reviews of these methods, solutions have been found in many studies, for example, [12].

For discretization equations and the body region the finite element method (FEM) was used. Its advantages and drawbacks are detailed, for example, in [13]. One major advantage of this method is that it enables to use functions that approximate generalized solution, with domain within each finite element and enables to obtain the stiffness matrix symmetric and tape that makes the method very efficient. It is not superior to classical holds Bubnov-Galerkin and variational. FEM enables relatively easy to approximate the boundary conditions that cause serious difficulties in the finite-difference and variational-difference methods. Other benefits of FEM include its simplicity, versatility and clear physical interpretation.

The model of a flexible towing oneanchor retaining wall has been considered. Experiments were carried out on it in the tray size 5×2,5 m in plan and height 1,65 m using backfill river quartz sand of average particle size density ρ = 1,82 g/cm^3, and the internal friction angle φ = 36,5^o. Model sheet pile wall had a height of 1,6 m. It consisted of 10 individual sheet pile profiled section having a groove and a ridge. The model is made from an aluminum alloy durable D16 having a yield strength of 80 MPa and a moment of wall inertia of 54 cm^4. The tray was filled with sand up to the top wall.

Fig. 1 shows the towing pattern sheet pile after pile in subsoil and installs the anchor rods, a distribution of the beam.

To measure soil pressure on retaining sheet pile wall it was equipped with sensors for measuring low pressures. Their diagrammatic diametric section is shown in Fig. 2. Sensor at various stages of assembly is shown in Fig. 3.

Fig. 4 are schematic longitudinal sections of sheet piles models applied with established sensors. Also shown are the installation location indicators and strain gages on the sheet piling-meter bending moment. The mutual arrangement of piles models with sensors in the walls of the model is shown in Fig. 5.

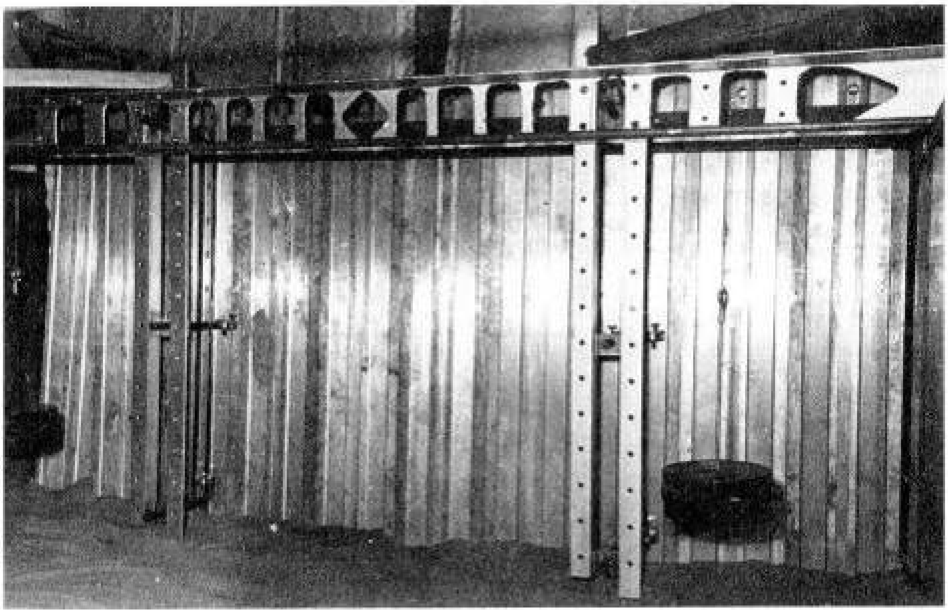

Figure 1 – Model of the sheet wall in the tray

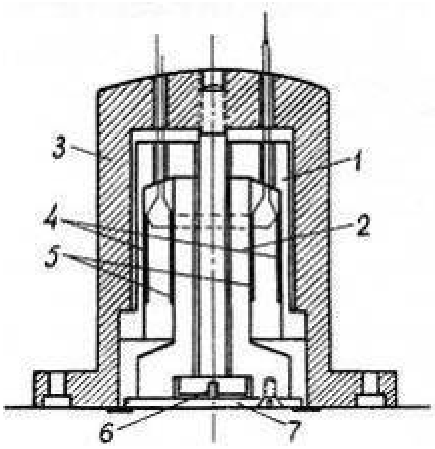

Figure 2 – A schematic diametrical sectional view
of the sensor for measuring small ground pressure:
1 and 2 – the outer and inner cups, respectively; 3 – a steel housing;
4 and 5 – strain gauges glued on the outer and inner cups; 6 – a tension screw;
7 – a steel lid that serves as a contact pad

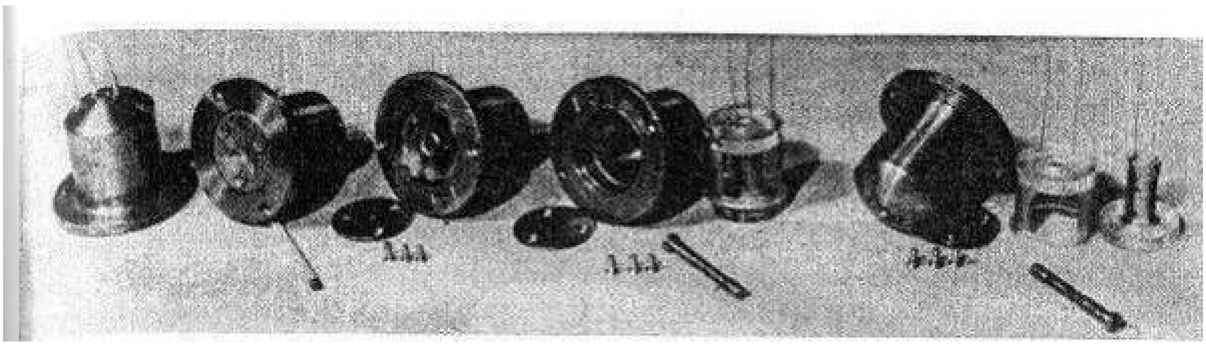

Figure 3 – Sensors for measuring low pressures at various stages of assembly

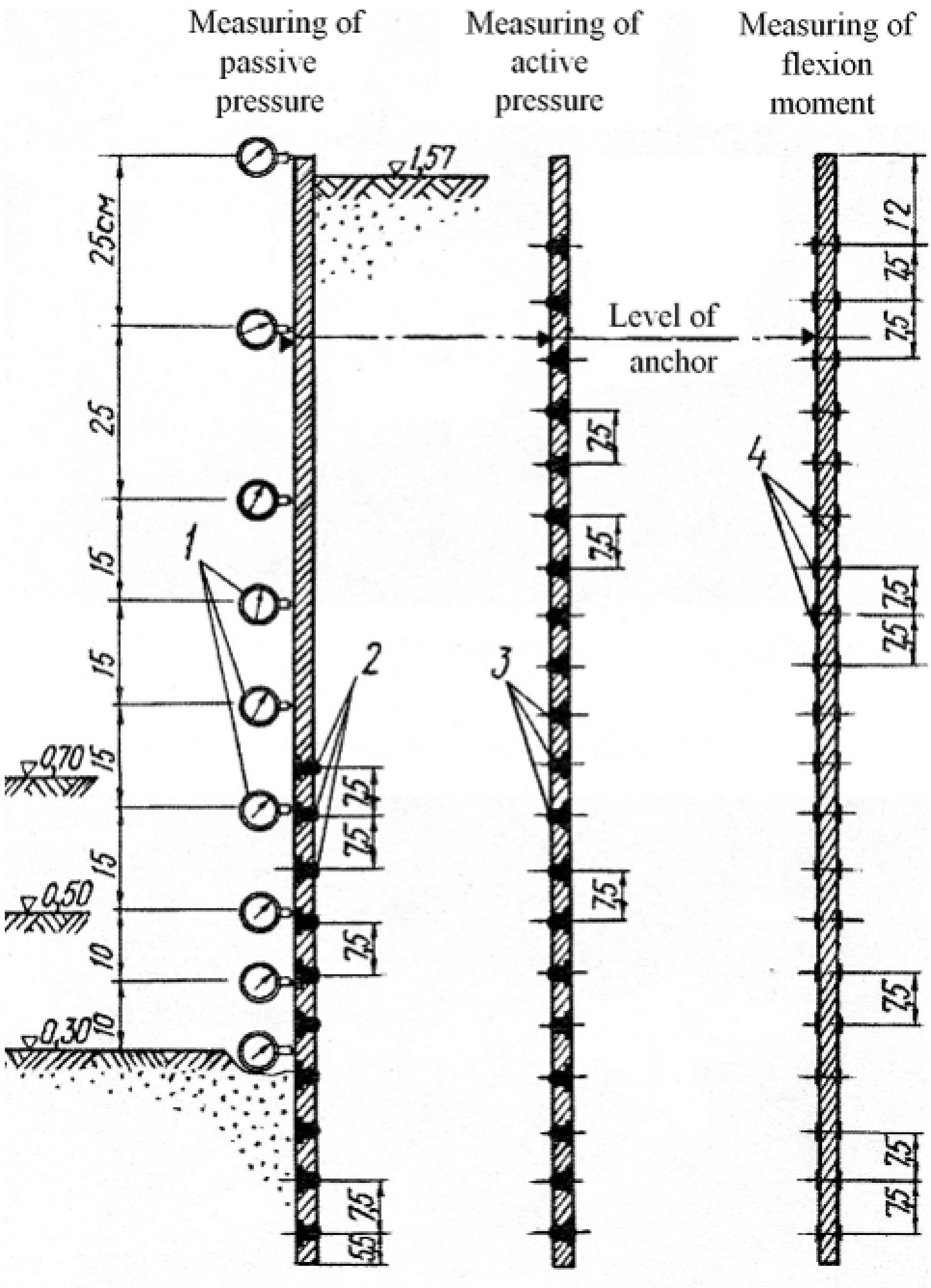

Figure 4 – Schematic longitudinal sections of sheet piles models with sensing devices
1 – strain indicators; 2 and 3 – active and passive sensors of pressure, respectively;
4 – strain gauges

Fig. 6, the solid line also shows the experimental data. Under the designation P shows diagrams of active and passive filling pressure on the wall and under the designation M bending moment arising in the wall. It can be seen that the greatest deflection in the Diagrams passive pressure between the experimental and calculated data in PLASTICA observed in the bottom wall and are 100% i.e. twice, and above – 9% (these places are shown in the figure by crosses). Such a difference in the Diagrams active pressure in the anchor mounting is 20%. At this moment diagram difference of 23,5% in the middle of the wall. Results of calculation in software PLAXIS complex turned somewhat exaggerated in comparison with experimental data. The greatest differences were observed when compared with the results obtained by the classical theory of Coulomb, especially in passive pressure sand diagram on the wall.

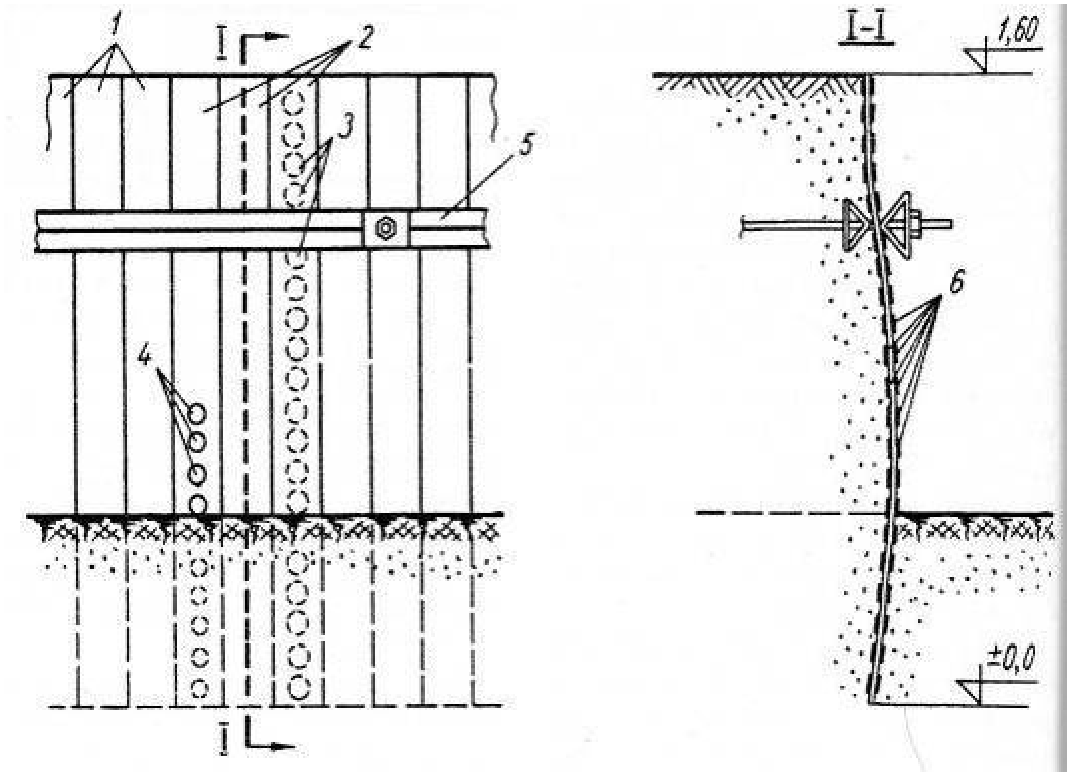

Figure 5 – The relative position of model piles, equipped with sensors

1 and 2 – respectively, are not equipped with sensors and equipped sheet piling;
3 – active pressure sensors; 4 – passive pressure sensors;
5 – distribution anchor beam; 6 – strain gauges

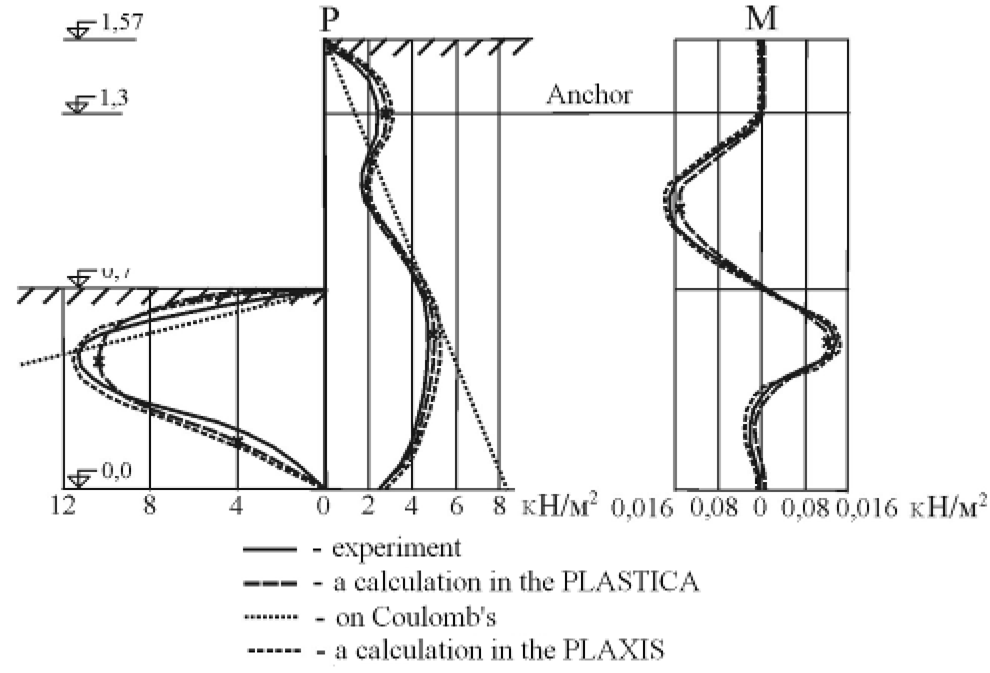

Figure 6 – Normal pressure diagrams sand on a flexible vertical wall and bending moment, resulting in the wall

Conclusions. According to the results of the comparison it can be noted that the calculations results in the software package PLASTICA using the proposed nonlinear models have shown satisfactory agreement as compared with the experimental data. It suggests the possibility of using this model in the practice of engineering structures under consideration.

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