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Method of Calculation of a Weakly Clay Base Strengthened By Sand from a Circuit with a Curvilinear Cushion

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Abstract: ***The article presents a method for calculating a sandy cushion reinforced along a contour with a curved sole arranged in weak clay soils under strip foundations.***

Index Terms: ***Foundation, weak clay soil, sand pad, reinforcing material.***

I. INTRODUCTION

One of the directions of studying the stress distribution in granular soils is the model of discrete media. The difference in the model of a discrete medium is the consideration of individual elements of its structure as mechanically interacting bodies. Elements of the structure are grains of bulk material. As a result of considering the distribution of pressure in a granular medium as a probabilistic process, I.I. Kandaurov [1] in 1959 for the first time introduced formulas (1) for the average stress values for the plane deformation problem.

$$\sigma_z = -F\sqrt{\frac{\alpha}{2\pi z}}\,e^{\left(-\frac{\alpha}{2z}x^2\right)} \qquad (1)$$

where F is the linear vertical load (kN / m); α is the medium structure ratio (1 / m); z - coordinate along the vertical axis (m); x - coordinate along the horizontal axis (m).

II. SUBJECTS AND METHOD

In this paper, we propose an experimental method for determining the coefficient of structure α, taking into account the curvilinear support surface of the sandy pillow and its contour reinforcement with geosynthetic material.

To calculate the stress-strain state of a sandy cushion reinforced along a contour with a curvilinear sole, a layer of a unit length in the longitudinal direction of a sandy cushion is mentally distinguished. The Cartesian XZ coordinate system is introduced into the selected layer with the beginning in the upper part of the sand reinforced pillow along the axis of symmetry (Fig. 1).

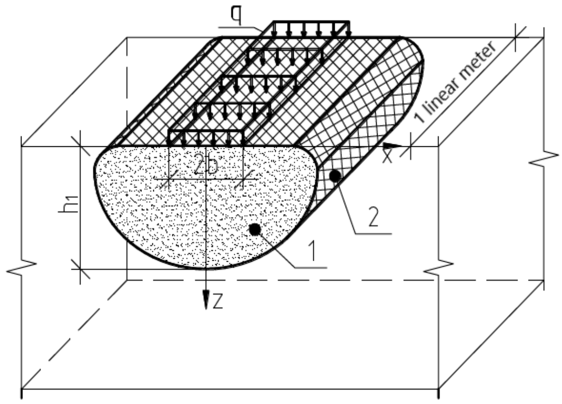

Fig. 1. An element of a unit length of a sand reinforced pillow with a curved sole.

This design scheme has the following designations: 1 - sandy soil massif with a curvilinear sole; 2 - geosynthetic reinforcing material; 2b is the width of the load action; - height of the sand reinforced pillow (along the axis of symmetry); q - uniformly distributed load.

In accordance with solution (1), we present the calculation scheme of a sandy contour-reinforced cushion with a curved sole under the action of a linear vertical load (Fig. 2).

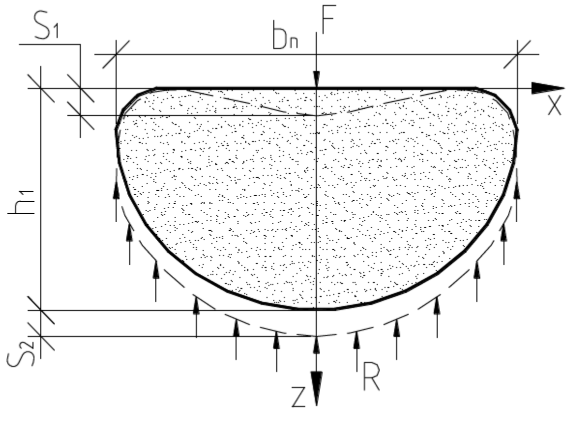

Fig. 2. The design scheme of sand reinforced along the contour of the cushion with a curved sole.

This design scheme has the following designations: - the width of the sand pillow (on top); - height of the sand reinforced pillow (along the axis of symmetry); F - linear vertical load; - the vertical component of the reaction of soil resistance; - vertical deformation of the sand reinforced cushion at the place of application of the load; - vertical deformation of a weak clay base without taking into account the deformation of the sandy massif.

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Apply solution (1) to the case of a distributed load of width 2b. To do this, it is necessary to integrate solution (1) within the limits of the load:

$$-F\sqrt{\frac{\alpha}{2\pi z}}\int_{-b}^{b} e^{\left(-\frac{\alpha}{2z}x^2\right)}\,dx \qquad (2)$$

Since the integral of (2) is non-contractible as an analytic function, let's execute the approximation of the function, replacing it with the function (k is the coefficient of approximation of the function).

Consider a part of the symmetric function and select the approximation coefficient k from the condition of maximum divergence between the areas of the figures limited by these functions 5-10%.

After carrying out the approximation of the function, we obtain the general solution:

$$\sigma_z = -F\sqrt{\frac{\alpha}{2\pi z}}\,e^{\left(-\frac{0{,}9061\alpha}{2z}\right)} \qquad (3)$$

Integrating the general solution (3) ranging from + b to -b, we obtain a particular solution for a uniformly distributed load:

$$\sigma_z = -\left(\frac{0{,}9061\cdot F\cdot\alpha}{z}\right)\sqrt{\frac{\alpha}{2\pi z}}\left[e^{\left(-0{,}9061(x-b)\frac{\alpha}{2z}\right)} - e^{\left(-0{,}9061(x)\frac{\alpha}{2z}\right)}\right] \qquad (4)$$

To find the structure coefficient α, let us specify the condition of coincidence of average experimental values of vertical stresses obtained in experimental studies [2] in sandbag planes fixed in height with theoretical values of average stresses according to the general solution (3):

$$\sigma_z^{\text{teor}} = \sigma_z^{\text{eksp}} \qquad (5)$$

In order to obtain the average value of the structure coefficient over the depth of the cushion, we integrate both sides of the expression:

$$\int_0^x \sigma_z^{\text{teor}}\,dx = \int_0^x \sigma_z^{\text{eksp}}\,dx \qquad (6)$$

where x is the variable limit of integration, equal for a fixed depth z to the horizontal size of the sand pillow. The total sediment of the loaded base reinforced with a sandy reinforced pillow will consist of the sediment from the compression deformation of the sandy pillow itself (S_1) and the sediment of the weak clay base (S_2):

$$S = S_1 + S_2 \qquad (7)$$

The deformation of the sand reinforced pillow of limited power from the linear load is determined by the expression:

$$S_1 = \frac{1}{E}\cdot\int_0^{h_1}\sigma_z\,dz \qquad (8)$$

where E is the reduced deformation modulus of a sandy reinforced cushion along the contour;

- height of the sand pillow along the axis of symmetry.

Integrating expression (8) with x = 0, we obtain the dependence on the vertical displacement (draft) of the array along the load line:

$$S_1 = \frac{2F}{E}\cdot\sqrt{\frac{\alpha\cdot h_1}{2\pi}} \qquad (9)$$

It is proposed to determine the deformation of the clay base by layer-by-layer summation with the width of the conventional base equal to the width of the sand reinforced pillow over the upper part, based on the condition of equality of the average values of vertical stresses at the border of the "sand reinforced cushion - weak soil" and the conventional foundation (Figure 3).

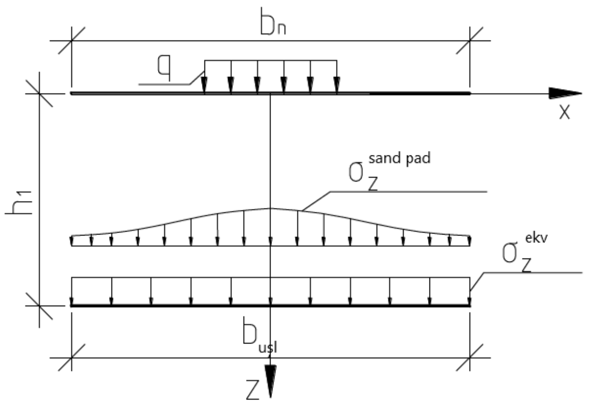

Fig. 3. Calculation scheme for determining the precipitation of a weak base

To do this, we equalize the average stress values under the curved sole of the sand reinforced pillow to the equivalent stresses of the conventional foundation:

$$\int_{-b_{\text{usl}}/2}^{b_{\text{usl}}/2}\sigma_z^{\text{sand pad}}\,dx = \int_{-b_{\text{usl}}/2}^{b_{\text{usl}}/2}\sigma_z^{\text{ekv.f.}}\,dx$$

According to the proposed method of calculation, the forecast was carried out for the foundation settlement on a weak clay base, reinforced with a sandy cushion reinforced along a contour with a curved base, and the calculation results were compared with the experimental values of the sediment obtained during field tests [3].

Calculation of precipitation was carried out for 6 loading steps with a pressure step of 40 kPa, which fully corresponds to the loading steps when conducting a full-scale experiment.

III. RESULTS

The results of the calculation are shown in the "settlement - pressure" graph (Figure 4).

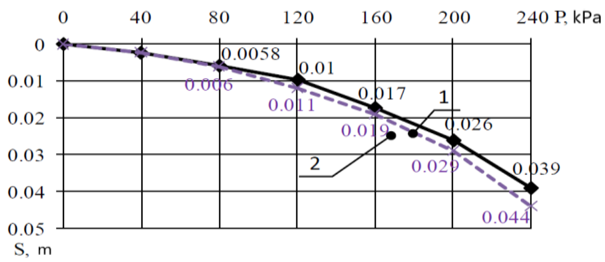

Fig. 4. Comparison of the results of the calculation of the precipitation of the foundation on a weak clay base, reinforced with a sandy pillow reinforced along the contour, with a curvilinear sole with experimental data of field experiment: 1- experiment; 2 - theory.

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IV. CONCLUSION

Analyzing the obtained “settlement - pressure” graphs, it can be seen that the discrepancy between the results of the analytical calculation and the results of the field experiment does not exceed 15%. This fact indicates the possibility of using the proposed method of calculation using the coefficient of the distribution capacity of the medium α, determined experimentally, for calculating sandy reinforced along the contour of pillows with a curvilinear sole.

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