EXPERIMENTAL STUDIES OF THE DEFORMATION OF SOIL BEDS REINFORCED WITH ROD ELEMENTS

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A procedure for and results of experimental investigation of the effect of the reinforcement of a soil bed by rigid rod structures on its deformation properties are cited. A conclusion is drawn concerning the strengthening of a soil where the ratio of the area of reinforcing elements to the loaded surface is 1:80 and higher. It is demonstrated that the reinforcement of soil is associated primarily with the constraint of plastic deformations and does not affect the properties of the soil mass being deformed.

INTRODUCTION

Various methods of strengthening soil beds are used in the construction of public and industrial projects. This applies especially to construction on weak soils, where, as a rule, irreversible foundation settlements develop or loss of soil stability occurs. All methods of strengthening soil beds are methodically divided into two groups. Construction methods that improve bed performance and do not alter the properties of the soil itself are referred to the first group: the installation of soil cushions, use of sheet-pile enclosures, the development of lateral surcharges, reinforcement of the soil, etc. Methods that enhance the strength properties of the soil in the bed are referred to the second group: primarily the compaction and reinforcement of soil. The method of reinforcing bed soils, which is classed with the first group, occupies a special place in this classification.

Reinforced soil is similar to reinforced concrete; reinforcement here, however, does not fulfill the function a reinforcing cage, but functions only due to adhesion with the soil. The more reliable this bond, the more effectively this structure will function.

Reinforcement placed in the soil will change the strain field in the soil and partially unload the soil mass; this leads to an increase in the stiffness, and, consequently, the bearing capacity of the foundation. Either rupture of the bonds between the reinforcement and soil, or failure of the reinforcement itself is the functional limit of a reinforced mass [1].

One of the basic characteristic features of the method of reinforcement consists in the fact that by its functional name, it may go beyond the framework of purely structural methods of reinforcing soil beds.

The use of precast piles or cast-in-place piles formed with the use of pneumatic punches is the simplest alternate scheme of reinforcement. Additional strengthening of the soil occurs in this case as a result of its compaction in the perimeter zones of the piles being installed.

The investigations described in this study were conducted to ascertain the effect of the reinforcement of a soil bed by rigid rod structures on its deformation properties.

FORMULATION AND METHOD OF EXPERIMENT

The experiments were conducted under laboratory conditions, where the soil bed was modeled by a clayey soil placed in a special container. The cohesion of the soil was 15-20 kPa, and the angle of internal friction 20-22°.
A bench with a lever mechanism for transferring load onto the soil bed was developed and fabricated for testing the reinforced soil with a plate (Fig. 1). The following requirements for the functional characteristics of the bench were defined more precisely for its construction:

1) provision for a constant transfer of static load onto the soil, which eliminates shearing forces;
2) the possibility of stepwise regulation of the pressure on the soil within the range from 25 to 300 kPa; and,
3) convenience of maintenance (in placing the soil, arranging the reinforcing elements, taking measurements, etc.).

The bench is built in the form of a circular container 1 that is 630 mm in both diameter and height. Brackets to which lever arm 2 with hanger for the placement of weight 3 is connected by an axle are secured to the upper portion of the container. The ratio of the lever arms is 7:100. Plate 4 with a diameter of 250 mm is rigid with a groove in the upper portion for placement of a support roller.

Soil was placed into the container in layers 10-cm deep and compacted over the entire surface by dropping a flat 12-kg weight with a diameter of 250 mm from a height of 0.5 m. The upper layer of soil as graded along the top surface of the container.

After placing rods 5 (piles) in accordance with one of the schemes described below, the plate was set in the center of the container on the prepared surface of the soil, and the weight suspended on the hanger. The standard loading of the plate was assigned in accordance with [2].

The piles were modeled by smooth metallic rods 10 mm in diameter and 200-mm long.

The weight of the lever served as the weight for the first load step. In that case, the specific pressure of the plate against the soil amounted to 19 kPa. Every 15 min, an additional load weighing 7.5 kg was placed on the hanger, increasing the pressure of the plate on the soil by 25 kPa. A stepwise increase in plate pressure of from 19 to 300 kPa against the soil was ensured in turn. The displacements of the plate under load were measured after each loading.

Three arrangements of metallic rods were used to ascertain the role of reinforcement of the soil beds by rigid rod elements.

1. Rods (eight pieces) are driven into the soil after the latter has been placed in the bench in a circle with a diameter of 225 mm (the diameter of the plate is 250 mm). The ratio of the total area of the cross sections of all rods to the area of the loading plate is 1:78. After arranging the rods, the plate is set on the reinforced region (Fig. 2), and the testing is begun.

2. Eight rods are arranged in a circle with a diameter of 225 mm under the plate in conformity with scheme 1. Moreover, five rods of the same diameter are driven additionally in a circle with a diameter of 300 mm; these five rods fall outside the perimeter of the plate when set on the soil. The ratio of the areas of the total section under the plate to the area of the plate is 1:78.

3. All rods (13 pieces) are arranged inside a circle 250 mm in diameter, i.e., during testing, they are beneath the plate. Eight of them are arranged in a circle 225 mm in diameter, and five in a circle 150 mm in diameter and one at the center of the circle. The ratio of the total area of the cross sections of the rods to the area of the plate is 1:48.

TEST RESULTS

We conducted more than 20 plate tests of the reinforced soil.