The Influence of Different Types of Reinforcement on the Deformation Characteristics of Clay Soil in the Conditions of Seasonal Freezing and Thawing

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Abstract. The article aims to increase the bearing capacity of the base by means of using reinforcement. A comparative analysis of the impact of different types of reinforcement on the deformation characteristics of the soil in the Northern climatic zones is carried out. In this article, the parameters of clay soil were considered, which were used to calculate the optimal method of stabilization of the building. The value of the study was justified, despite the fact that clay soils have a high strength index, without additional design solutions, seasonal freezing and thawing can lead to an emergency.

1. Introduction
It is known that the erection of buildings and structures, as well as highways in areas where weak or structurally unstable soils occur, is a very labor-intensive and material-intensive process, which is explained by the need to increase the strength and reduce the deformability of the base soils.

It is possible to improve the construction properties of soils through their reinforcement - that is, strengthening and hardening by including special elements in the composition of soils that are capable of absorbing high compressive and tensile forces and having good adhesion to the surrounding soil that are not associated with the foundation. The reinforcing elements in the soil mass can be arranged vertically, horizontally or obliquely (in one, two or more directions), the soil reinforcement can be intermittent or can be different rows of cellular structures [1-5].

2. Methods
One of the ways to strengthen the foundation soils is to reinforce them with piles. In this case, the wells can be made in various ways: by screwing through spiral shells, punched or pressed. As a rule, cement-sand mixtures, concrete or slag concrete are used to fill wells. Due to the filling of wells with material and reusable drilling, the soil around the wells is compacted and strengthened.

In the upper zone of such a base compaction is created by tampers or soil cushions are arranged. This base layer is distributive, that is, it ensures a uniform transfer of the load from the foundation to the ground and the inclusion of reinforcing elements in the work. The depth of soil reinforcement in this way can reach 25m [6-9].

Reinforcement of the bases can also be carried out using piles in rolled wells. The drilling of wells in the ground is carried out with the help of special mounted working bodies of construction
equipment. In the process of rolling out the cavity of the wells are filled with a material with higher strength than reinforced soil, for example, concrete, gravel, rubble, sand, etc. As a result, strong elements with a length of up to 4 m and a diameter of 0.3-0.4 m are formed in the ground.

The reinforcement of foundations with micro piles and ground-cement piles is becoming more and more widespread, which is associated with the development of technologies and improvements in the equipment for their manufacture. Such piles have a diameter of 0.07-0.25 m and a length of 1.5 m.

To strengthen slopes, stabilize landslide-prone slopes and strengthen foundations and foundations of already existing buildings (structures), vertical or inclined devices are widely used. Their effective use is possible under different soil conditions [10-12].

There are the following methods for the manufacture of injection piles:

• with protection from clay or bentonite solution;
• with casing protection;
• using transitional augers;
• injection of the solution into the drilled wells.

3. Results and discussion

The reinforcement of the barrel of injection piles is carried out by spatial reinforcement cages or steel sheath pipes.

For the reinforcement of bases, the device of reinforced elements using inkjet technology, the high-pressure injections, which exclude the violation of the natural structure of the soil. The basis of inkjet technology is the use of a jet of water for cutting gaps in the ground.

The cracks formed in this way are filled with hardening materials. The described technology allows to obtain reinforcing elements of various shapes and with different locations. Examples include root-shaped supports, horizontal elements, separate pillars or solid walls, or complex-shaped cellular structures. Reinforcing elements, as a rule, are made in the form of soil-concrete and concrete piles of a sufficiently large diameter. Sometimes for their manufacture using binders based on chemical solutions or liquid glass [13-16].

Sand or limestone piles, as well as piles and compacted soil cushions of lime-soil mixtures can be used to harden weak water-saturated soils. Known methods of securing soils by silicatization, smolizatsi or the use of other chemical materials.

It should be noted that, known methods of reinforcement, despite their diversity, are very time consuming and have significant cost, while their reliability does not always meet the necessary requirements. Under the influence of these circumstances, research is being conducted on the development of new technologies and methods of reinforcement of foundations, and here great attention is paid to identifying new types of reinforcing materials [17].

High-strength geo synthetic materials (or geo synthetics) are the most promising for strengthening soils due to such properties as high strength, corrosion resistance, resistance to aggressive media and low temperatures, low creep and aging.

Geo synthetics are materials that contain at least one part of a polymer and are used in contact with the ground. The scope of geo synthetic materials is very wide: they are used to strengthen the weak foundations of buildings, various structures and the road bed, to create waterproofing and drainage in the ground, in the construction of embankments and retaining walls, for erosion protection of slopes. Geo synthetic reinforcing elements can be made in the form of bulk geo grids, flat geo grids, geo membranes, geo mats.

Geo grids are made of geotextiles. Geotextiles is an environmentally friendly non-woven material made from polypropylene fibers, has chemical resistance, resistance to thermal-oxidative processes and good physical and mechanical properties. Geo grids are a flexible honeycomb-type framework, the cells of which can be filled with various materials, for example, with vegetable soil, rubble or concrete. The general scheme of the geo grid is shown in Fig. 1. Geo grids are used to strengthen slopes, cones of overpasses, retaining walls and reinforcement of weak bases.
Figure 1. General scheme of the geo grid in working condition (a) and transport (b).

1 - welds; 2 - geotextiles; A, B - the length and width of the geo grid (module); A0, B0 - the length and width of the package; a, b - cell sizes along the diagonals; al is the size of the side of the cell; h is the width of the geopole (the height of the geo grid).

The coverage of runways and runways and highways, and they can also be used for strengthening slopes.

Figure 2. Examples of geo grids.

Geo mats are a polymeric material with a permeable structure. They consist of layers of polypropylene grids, which are superimposed on each other and are thermally joined. Examples of the geo mat structure are presented in fig. 3. Geo mats are used to combat landslides and soil erosion and to support vegetation on slopes and slopes.
Geo membranes are membranes of high-quality polyethylene with an admixture of a carbon stabilizer (Fig. 4). Designed for the construction of various hydraulic structures, as well as landfills, landfills, etc.

As experience shows, geo synthetic materials are rationally used in conjunction with gabion blocks when strengthening slopes, slopes, roads, and other structures. These structures impart stability to the slopes and promote infiltration and drainage of water.

A gabion block is a box of a certain size specially made from metal wire (Fig. 5), which is filled with a durable material, such as granite. To give the gabion structure greater strength, partitions (diaphragms) can be installed inside it. Gabions are also made in the form of cylinders, mattresses, etc.
Figure 5. Gabion block, a, b, h are the length, width, and height of the block, respectively; 1 - cover; 2 – aperture.

Options for strengthening the slopes using geo materials are shown in Fig. 6,7,8.

Figure 6. Strengthening the slope using geomat.

Figure 7. Options for strengthening slopes using geo grids.
1 - protective layer (sand, gravel);
2 – geo membrane;
3 - geotextiles;
4 - leveled soil without stones;
5 - soil

Figure 8. Option to strengthen the slope using geo membrane.

4. Conclusions
Improving the construction properties of soils is possible through their reinforcement - that is, strengthening and hardening by incorporating special elements into the composition of soils that are capable of absorbing high compressive and tensile forces and having good adhesion to the surrounding soil in the conditions of seasonal freezing and thawing.

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