Seminatural experimental studies of geotextile encased stone columns

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ABSTRACT: Article deals with issues related to problem of the applying of geotextile encased columns in the geological conditions of Perm region. Paper presents results of seminatural experimental studies of small-scale models of such structures, analysis of the results of the experiments, formulation of directions of the further research and experiments which are necessary to do.

KEYWORDS: soil piles, geotextile cover, experimental research, geotextile encased stone columns.

1 INTRODUCTION.

Buildings and structures which are constructed on soft soils often have serious problems with uneven or excessive setlements and overall stability. Using the methods of soil improvement like geotextile encased stone columns (GESCs) can overcome all these problems. Applying GESCs increases bearing capacity and reduces settlements of soil, also the method allows work in a very soft water-saturated soils. Relevance of such methods of ground improvement is now significantly increases due to the extensive use of geosynthetics in construction practice. Also economic development forces us to build different constructions on sites that were previously considered as not profitable due to ground conditions. Application of modern geosynthetics can significantly improve the performance of classic soil piles and helps to avoid the disadvantages associated with the constancy of cross-sectional geometry of the pile during production and explotation of soil piles.

Geotechnical conditions of the Perm Region of Russia Federation are presented by soft water-saturated clay soils with high deformability and low bearing capacity. Application of soil piles is a mechanical method of improving so it is most effective in clay soils, which predominate in the Perm region.

A large number of scientists are engaged in research in this area: Castro 2011, Gniel 2009-2010, Kempfert 2006, Kraev 2008, Paul 2004, Ponomarev 2003-2004, Trunk 2004, Ritchel et al 2012. Authors draw conclusions about the great effectiveness of this method for decreasing of settlements of the soft soil according to the results of all the studies.

It was determined the direction of the current study, namely the use of GESCs in Perm region, in previous papers on the subject, based on the analysis of existing research material (Shenkman 2011-2013). These constructions (GESCs) are the most rigid and most effectively reduce settlemets, and under certain conditions may act like a substitute for the classic piles. The results of past our reearch to a certain extent corresponds with the latest research complied by Almeida 2013

Soil piles are now widely used as a method to improve the weak soil base under the embankments. Therefore, an important component of future research is to examine its work when load transferring directly to soil piles, without the use of the distribution of elements or their height is limited. A series of semi-natural experiments with soil piles in geological conditions of Perm region were hold for this purpose.

1.1 *Seminatural experimental studies of geotextile encased stone columns*

Field tests of small-scale models of GESCs were carried out in the soft water-saturated clay soils at the construction site in the Perm. The geological structure from drilling wells within the studied depths (up to 14.0 m) Participating modern alluvial deposits of Quaternary (aQIV).

Top soil is developed everywhere on the surface with capacity 0.1 m Further at the site are alluvial soils presented by light-brown loams, silty light, with capacity 11 m underlain by crushed stone and pebble soil with layers of sand and loam. Brown clay layers were met at some sites with capacity 2.1-4.5 m Geotechnical section of testing site is presented in Figure 1.

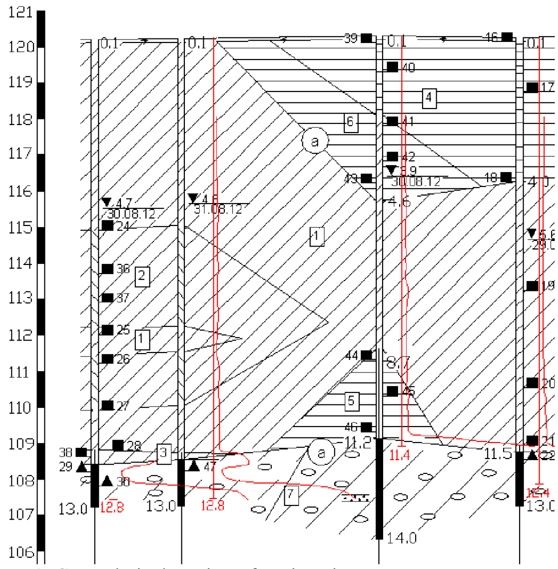

Figure 1. Geotechnical section of testing site

Model seminatural testing of GESCs was performed directly in the first engineering-geological element. Physical and mechanical characteristics of the soil are presented in Table. 1.

Table 1. Physical and mechanical characteristics of the soil

Name of soil	Deformation modulus, MPa	cohesion, c, кPa	Friction, φ, deg.	Soil density, ρ , g/cm3
Loam	7	12	8	1,92

Firstly, top soil was removed at the experimental and 2m deep pit was constructed to reach loam. CPT testing was held at the site to determine the uniformity of soil. CPT tests were held with equipment Geomil LWC - 100/100 XS. It can be argued that loams have spread to a depth of 11 m with stable values of deformation modulus from 4 to 6 MPa according to the results of CPT. This data corresponds well with the available historical data of geological surveys obtained at the time of construction on the site. Therefore, soil can be characterized as a homogeneous compressible soil with high degree of deformability. General view of the pit for testing is presented in Figure 2.

Figure 2. General view of the pit for testing

Tests of small-scale models of GESC were carried out in the course of the experiment. GESC was made from crushed stone of limestone rocks with fractions 0-20 which was wrapped with fiberglass mesh. General view is presented in Figure 3

Figure 3. General view of the small-scale model

The aim of the tests was to determine the effectiveness of this technology in the soil conditions of Perm Region and determining the most effective methods of using of GESCs for future use as an improved foundation of buildings and structures.

Experimental schemes which were considered during the tests:

- plate bearing test of soil with natural structure;
- plate bearing test of soil improved with single GESC;
- plate bearing test of GESC;
- plate bearing test of soil improved by group of GESCs (3 pieces).

These experimental tests are presented in Figure 4

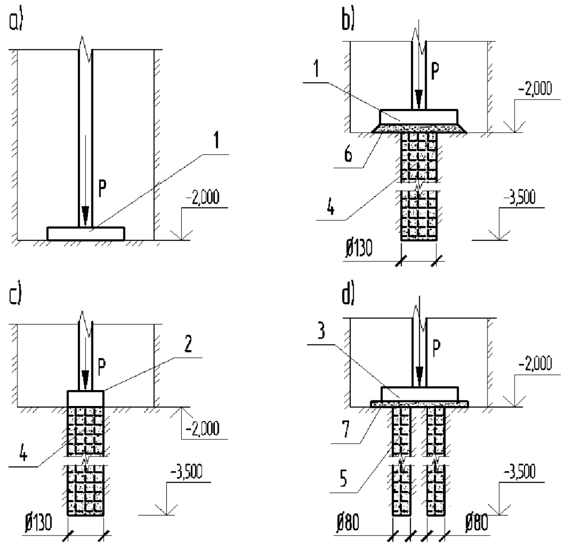

Figure 4. Schemes of experimental tests:
a) plate bearing test of soil with natural structure;
b) plate bearing test of soil improved with single GESC;
c) plate bearing test of GESC;
d) plate bearing test of soil improved by group of GESCs (3 pieces).
1 - hard plate 600 sm2; 2 - hard plate diameter of 130 mm; 3 - hard plate 4000 sm2; 4 – GESC diameter of 130 mm; 5 – GESC diameter of 80 mm; 6 - Seal sand; 7 - crushed stone.

The loading of small-scale models was carried by setting of plate test consisting of a support frame, the anchoring system, pneumatic loading device and of the deformation locking system. General view is presented in Figure 5.

Figure 5. General view of the experimental setup

Treatment of the results of the test was based on the methodology presented in GOST 20276-99 "Soils. Field methods for determining the strength and deformability". And also on the basis of selection of deformability modulus on method in accordance with SP 22.13330.2011 "Foundations of buildings and structures". Obtained "conditional" deformation modulus are shown in Table 2.

Table 2. Results of experimental data processing.

Scheme	a)	b)	c)	d)
"conditional" deformation modulus, MPa	0,9	2	40	4
Ratio of the area of the pile to the plate	0	0,2	1	0,06

It should be noted, that GESC in itself has the best deformation characteristics in comparison with the surrounding soil base, despite the scheme used in the form of friction pile, not based on hard soils. This method is less effective for use of soil piles (Shenkman 2011). There is no significant decrease in sediment soil base on the considered load range during loading of improved soil mass (scheme (b), (d), Figure 4). In our opinion, this could affect the following factors:

- Failed ways to incorporate GESCs to work.
- A number of authors (Gniel & Bouazza 2009) describes the effects associated with the fact that the soil must undergo some settlements before geotextile encased soil pile come into work. This may for example be associated with the compression of the pile during its construction, as well as in crushed stone packing in soil pile. This settlements under field testing may be around 5sm (Ritchel et al 2012). These conditions can also affect the experimental results.

2 CONCLUSION

Experimental studies have identified the main features of using GESCs:

- The additional foundation settlement associated with technology of inclusion into the work of GESCs(pre-compaction, crushed stone layers with the use of a mechanical seal) must be considered in case of disign of this method of improvement.
- It is established that GESCs is effective in soft watersaturated clay soils of Perm region.. This is due to low deformability of GESCs.
- Efficiency of improvement is largely dependent on inclusion of GESCs in the work or on technolodgy of construction of GESCs. Therefore, it is necessary to carry out experimental studies of GESCs, constructed according to the scheme close to the actual possible and at the same time ensuring their effective work.

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