Analysis of interaction of geosynthetics and collapsible soils on the examples of the use in Kazakhstan

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ABSTRACT: Collapsible soils must be stabilized to increase their strength and reduce compressibility. Only after preliminary works on the basis of a stable foundation can be built. This article focuses on the analysis of behavior, interaction of geosynthetics and collapsible soils on the example. Also from the geonet you can make a drainage layer filled with small rock. A layer of geogrid will prevent mixing of layers, impacts the drainage layer of crushed stone in collapsible soils.

Keywords: collapsible soil, geosynthetic materials, geotextile, geogrid

1 INTRODUCTION

Unsaturated soils with metastable structure may be relatively strong and stiff at their natural water content but may experience a radical decrease in volume upon wetting. Hence, they are termed Collapsible soils. One of the types of collapsible soil is loess [see 1].

Loess soils occupy almost 17% of the territory of Russia. The loess lay a solid cover in most parts of Ukraine (up to 80%). Large areas are covered with loess rocks in Central Asia, Kazakhstan, Eastern, Southern and Western Siberia. Quite often they are found in Belarus, the Volga region, Yakutia and other areas. The largest area of loess is in China (on the map China is always painted yellow - the color of loess). The map in Figure 1 (see Figure 1) of the distribution of loess rocks in the CIS, compiled by V. S. Bykova and S. A. Pastushkova ("loess rocks of the USSR", 1986)

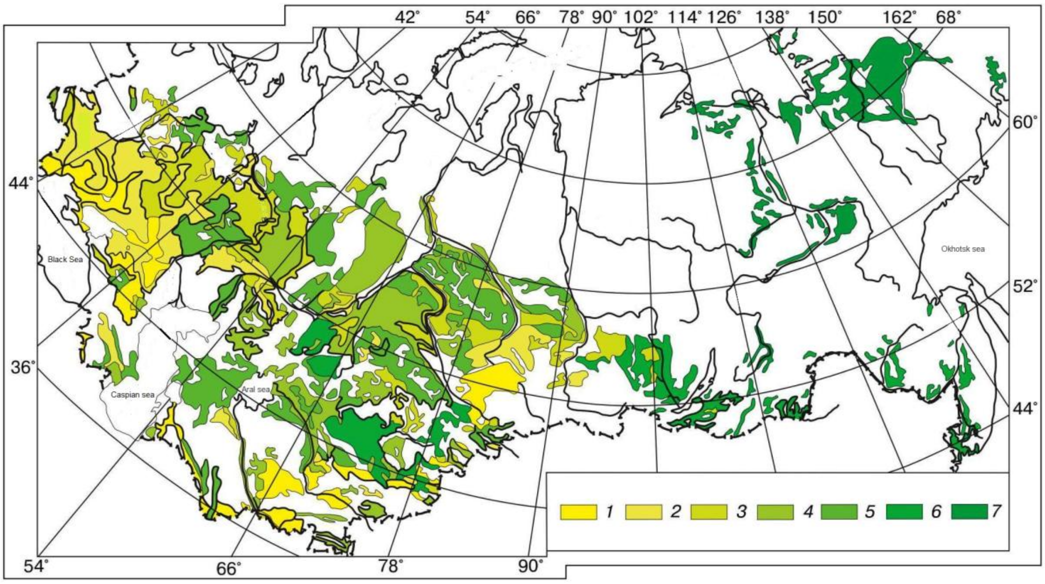


Figure 1 - Map of distribution of loess rocks in the CIS countries.

According to the experts, up to 45% of the cost of civil and structural works industrial facility on loess soils is spent on a set of measures to prevent deformation of structures due to subsidence of the foundations. Due to wide distribution of loess rocks in the territory of the Republic of Kazakhstan (up to 2\3 territories) the problem of combating subsidence of these rocks in the bases of buildings and engineering structures has always been relevant in our region.

Various methods are used to eliminate the collapsible properties of loess substrates. V.A. Obruchev (1904) explained the formation of continuous loess cover on high relief elements due to dust brought from remote areas (exotic dust). According to P.A. Tutkowski (1899), the winds waved glacial deposits and carried away dust away from the ice sheet, where it formed loess. American scientists F. Leverett (1899), T.Chemberlin et al. (1909) attached primary importance to the formation of silty strata at the expense of waving the river and water-glacial deposits of nearby valleys. Among the supporters who view loess as a breed formed in the water environment, it should be noted outstanding scientists PA. Kropotkin (1876), V.V. Dokuchaev (1892), A.P. Pavlova (1898), Yu.A. Skvortsova (1948), N.I. Tolstikhin (1928). In the opinion of these researchers, the formation of dusty sediments occurred as a result of the washout and subsequent re-deposition of slope rocks, the transfer and accumulation of mineral material in river valleys and lakes, as well as the transfer and accumulation of loess deposits by glacial streams. According to soil-eluvial hypotheses, silty sediments can accumulate in any way, and their transformation into loess with all the specific features of this rock occurs as a result of soil formation and weathering. The speakers of this hypothesis are L.S. Berg (1916), N.M. Simbirtseva (1900), B.B. Polynova (1934), I.P.Gerasimov (1939) [see 2].

With the recognition that multiple layers and/or high-strength geotextiles can reinforce foundations, it follows that soils beneath rigid walls, footings, piers, etc., having poor bearing capacity should also be a target for improved performance using geotextiles [see 3]. The situation follows that of Binquet and Lee [see 4 and see 5] on the improved bearing capacity of compressible sands using metal strips (thereby creating mechanically stabilized earth). They found definite improvement, which was further evidenced by an economic analysis showing cost savings. However, when corrosion was considered, the economic benefits were essentially lost. With noncorroding geotextile as the reinforcement, the problem of corrosion is obviated. What remains is the research needed to quantify the possible improvements.

Geogrids have been used to increase bearing capacity of poor foundation soils in different foundation: as a continuous layer, as multiple closely spaced continuous layers with granular soil between layers, and as mattresses consisting of three-dimensional interconnected cells [3]. The technical database for the single-layer continuous sheets has been reported by Jarrett [6] and by Milligan and Love [7].

2 REINFORCEMENT USING GEOSYNTHETICS THE BASE OF THE FOUNDATION

2.1 *Data on load and natural basis*

For calculation we consider the columnar foundation with the size of 2.7x2.7 = 7.29m2.
The pressure of the foundation pad is P = 0.05 MPa (see Table 1).

Table 1. Based on available baseline, water-saturated source data are provided.

Type of soil	Capacity of layer, m	specific weight, MN / m3	Specific connection, MPa	Internal friction angle, φ	Degeneration module E_{def}, MPa
Light brown color, solid cone > 15m	> 15м	0,0143	0,054	20	2,9

2.2 *Task submission*

The main task is to strengthen the groundwork to reduce the stress-strain state. The pressure that affects the natural base should not exceed the maximum permissible value. According to engineering-geological surveys, the pressure that affects the natural base is Psl = 0.025 Mpa [9].

The draft (full deformation) of the base shall not exceed the maximum permissible value in accordance with BNaR 2.02.01-83* [see 10].

In order to reduce the stress-strain state of the base, the use of geosynthetics is envisaged in the reinforcement of the artificial base, which is one of the most effective and rational ways to increase its strength and reliability.

The joint work of geosynthetics and coarse-grained material (crushed stone) will create a "hard" layer that will ensure a uniform distribution of the load on the underlying soil and, accordingly, will not allow the development of uneven deformations in the structure.

As a result:

- the uniformity of the base increases, which is important for ensuring the equal strength of the coating and reliability over the entire area;

- the penetration of coarse-grained material into the underlying loosely connected layers is practically excluded;

- optimum conditions are provided for compaction of crushed stone to the required value, and thus the design value of its modulus of elasticity and modulus of deformation is reached.

This is confirmed by experimental studies, conducted at the University of Incheon, South Korea and is detailed in the article written by Muzdybaeva T.K., and etc [8].

Consider the load-bearing capacity of the existing base and deformation of the base on the sole foundation in the case of waterlogging of the bearing layer of the base.

Define the design basis resistance in accordance with the BNaR 2.02.01-83* [see 10] according to the Equation 1 below:

$$R=(\gamma_{c1}\,\gamma_{c2}/\,k)[M_{\gamma}k_{z}b\gamma_{II} + M_{q}d_{1}\,\gamma_{II}' + (M_{q}-1)d_{b}\,\gamma_{II}'+M_{c}c_{II}] \tag{1}$$

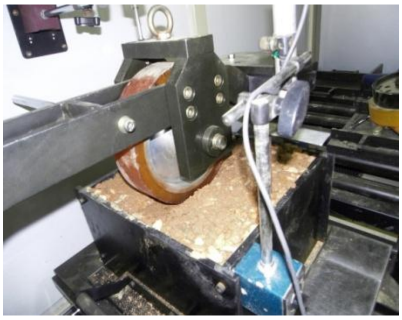
The strength condition is fulfilled.

3 WHEEL TRACKING TEST RESULTS AND DISCUSSIONS

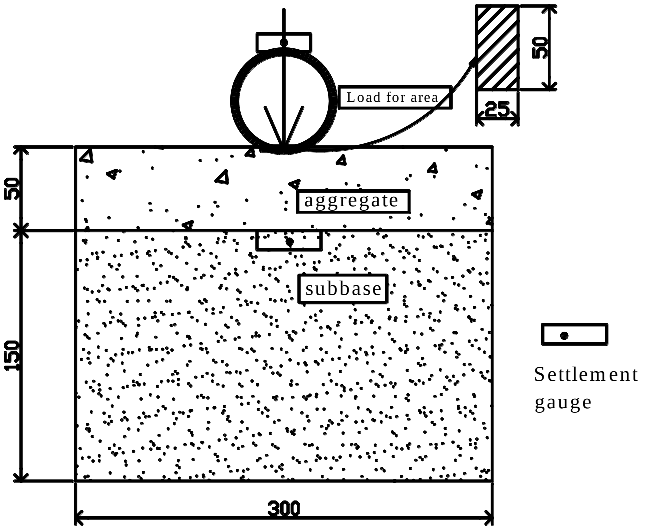
Fig. 2 shows a picture of the wheel track load test (see Figure 2). Wheel track load test were performed for, two layers soil, that is, 5 cm thick aggregate layer in the top and 15 cm thick subbase layer at the bottom. The soil box is width of 30cm, length of 30cm, height of 20cm. The geosynthetic material is installed between aggregate and subbase soil.

The cyclic loading was applied on the unpaved road by using the wheel tracking devices. Cyclic load from a moving vehicle was simulated by applying different loads to the wheel of the passing of a car wheel with loads of 30 kg, 20kg, and 15kg, respectively. The settlement level under the cyclic load was measured for the different reinforced unpaved road conditions [see 8].

a) Apparatus Wheel tracing test



b) Measurer instruments of the settlement.



c) the scheme of Wheel tracing test.

Figure 2. Wheel track load test procedure and schematic of cyclic loading.

To determine the ultimate bearing capacity of soil you can see in below. Three experiments were carried out with different variants of the reinforcement. The static load tests were conducted to determine the ultimate bearing capacity for each reinforcement conditions.

The static load tests were conducted by pressing a standard pin on the bottom, with a fixed rate of penetration. The measured values of the applied static load with the corresponding settlement for the depth of penetration of the pin into the ground are shown in Fig. 3 (see Figure 3).

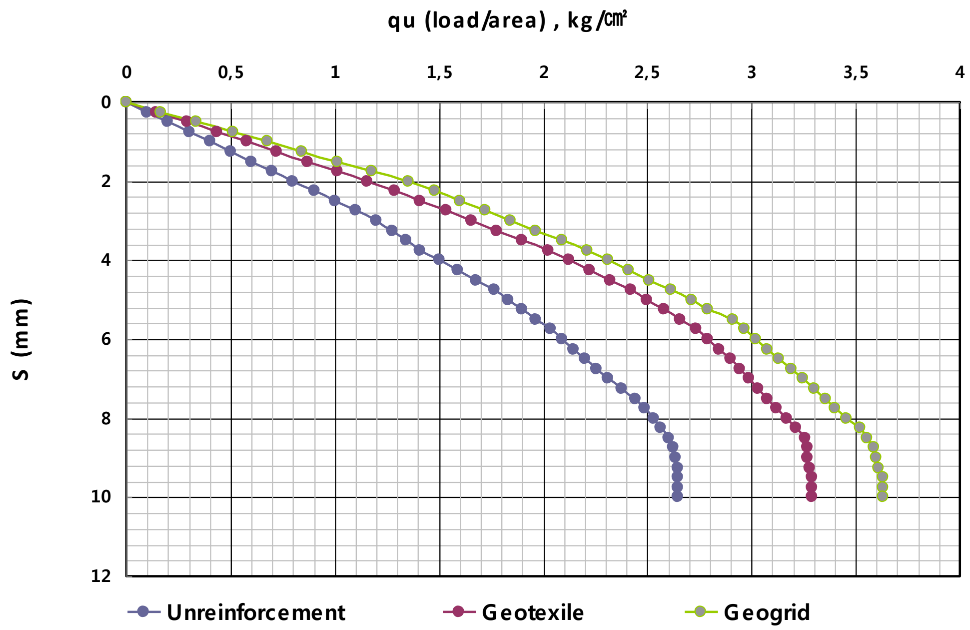


Figure 3. Determine the limiting bearing capacity of soil

The settlements of unpaved road with the corresponding number of cycles were measured for case of unreinforced, geotextile reinforced and geogrid reinforced unpaved road respectively. Each case of this wheel tracing test, the wheel loads versus ultimate load of unreinforced ground was applied as the range from 0.330 to 0.908.

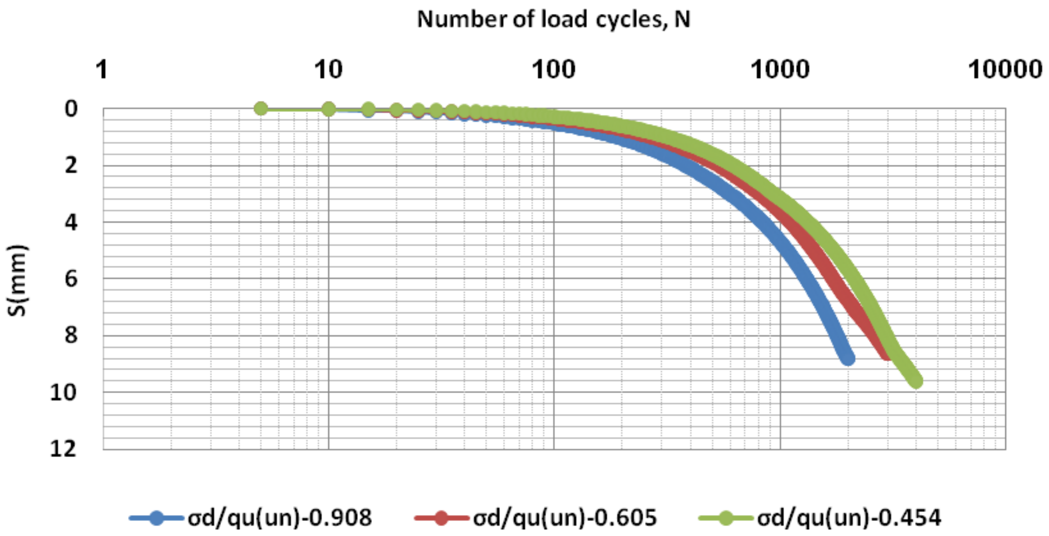


Figure 4. The settlement number of loaded cycles for unreinforced unpaved road .

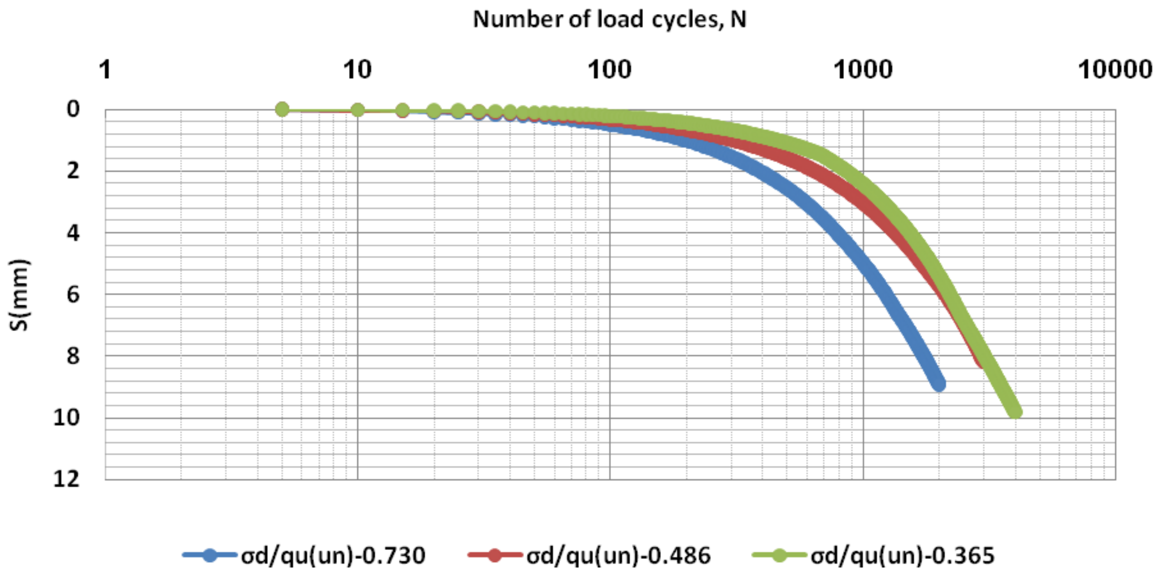


Figure 5. The settlement number of loaded cycles for with geotextile reinforced unpaved road.

From the wheel tracing test results shown in Figures 4, 5, and Figures 6, 7 as the intensity of wheel tracking increases the settlement load is also increased. While the number of cyclic loading is much reduce.

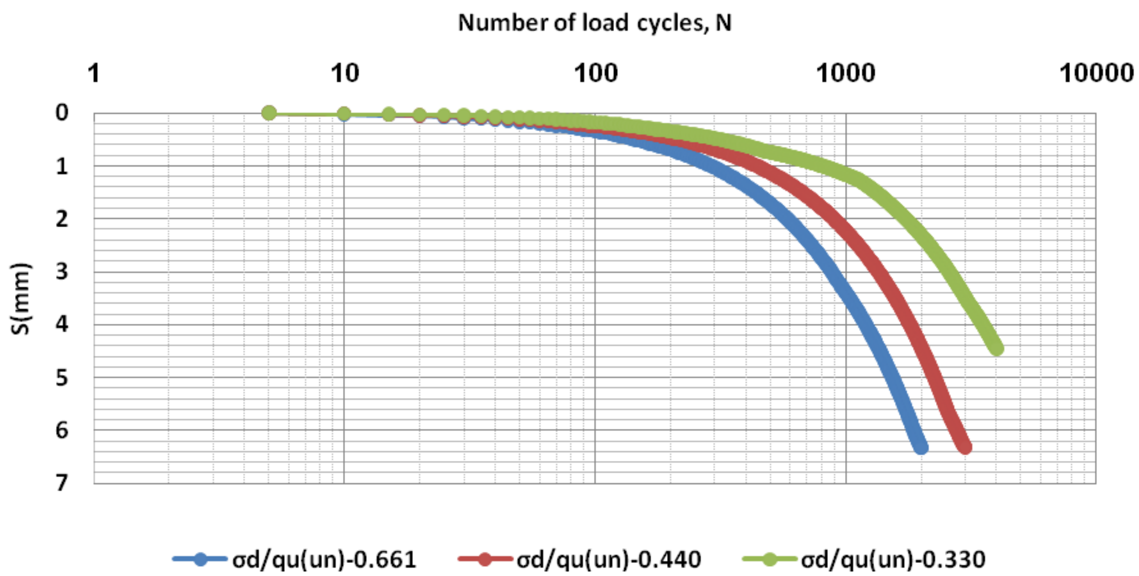


Figure 6. The settlement number of loaded cycles for with geogrid reinforced unpaved road.

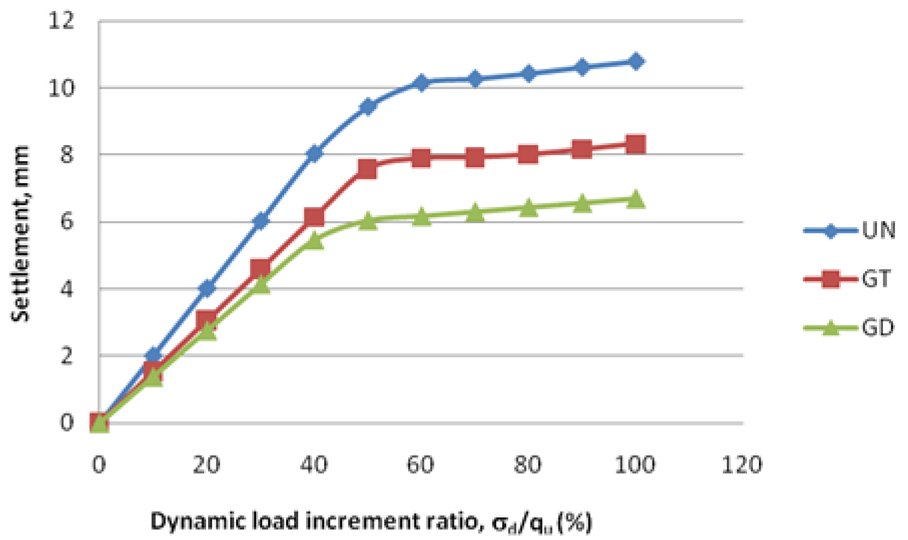


Figure 7. Settlement distribution according to dynamic load increament ratio.

According to the results of the research, the reinforcement with crushed stone allows to increase the overall (equivalents) elastic modulus of the construction by 6 ÷ 15%, decreases the value of indirect voltage in the layer by 25 ÷ 80%, and in the case of significant depression increases the deformation module more than twice.

In addition to the advantages of using the above mentioned geogridal, it extends the life of the coating to overhaul, with the additional advantages increasing the bearing capacity of the geogridically reinforced concrete by 2 to 2.5 times.

The computation scheme for the sealing base of the foundation is shown in Figure 8 :

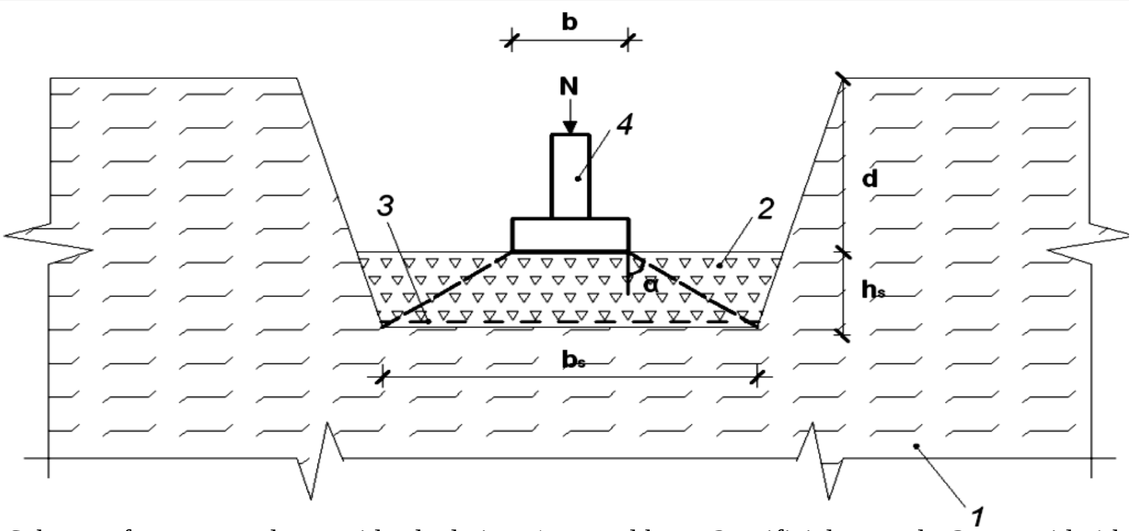


Figure 8 Scheme of compressed geogrid calculation. 1-natural base; 2 artificial grounds; 3- geogrid; 4-basement foundation (tape, stem).

4 CONCLUSION

When the base is reinforced with a "flat mattress" design:

1) Deformations of the base are actually reduced by 50%;

2) The stresses along the sole of the artificial base don’t exceed the initial subsidence pressure of the natural substrate.

3) Collapsible soils need to be stabilized, to increase their strength characteristics and to reduce the compressibility. Only after such preliminary work on the basis can build a stable foundation. Geosynthetics can cope with this task. From a cellular geogrid it is possible to make the draining layer filled with a small rock. The geogrid cage will prevent mixing of layers, pressing the drainage layer of

gravel into the weak soil. This investigations are important for understanding of interaction of geosynthetics -soils-foundation.

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