

Title: «Three-dimensional plastic geocells in the construction of railroad»

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To reduce subsidence and vibration of a railway track under the load of a train, a properly reinforced construction of a railroad bed is needed. This article was prepared in order to familiarize the professionals with a new system of subgrade stabilization, which includes the technology of three-dimensional soil reinforcement with Prudon-494 plastic geocells, and with the activity of 494 UNR OJSC.

In 2011, 494 UNR OJSC received the patent of Russian Federation No. 108 044 "Railroad track". A wide range of representatives of leading railway research and design institutions participated in its development. The essence of the patent is reinforcement of both railroads subgrade foundation and the subballast area.

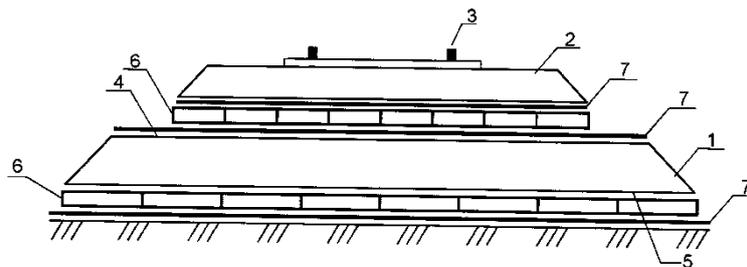


Figure 1 Structure of reinforcement of the railroad's foundation with plastic geocells

Figure 1 shows the design of a railroad, including an earthfill 1, a ballast section 2, and a track panel 3. Under the ballast section 2 and an embankment bed 5 on the main platform 4 three-dimensional Prudon-494 geocells 6 are allocated over the geotextile separation layer 7.

In order to prevent deformation in the form of subsidence in recesses, replacement of clay soils by draining soil with installation of geocells is foreseen. It is recommended to fill geocells with breakstone in the fraction of 20-40 mm in size, geocells are put in a fixing position with the help of L-shaped anchors, in order to fasten the geocell modules together stapler and steel brackets are used. Geocells are placed at a depth of 60 cm below the track panel. This system of roadbed stabilization is aimed at reduction of subsidence and the vibrodynamic impacts of trains through a more even load distribution.

494 UNR OJSC regularly conducts training in the field of design and construction with the use of Prudon-494 geocells, involving customers, contractors and research organizations. Along with training courses various lectures are given to the graduates of leading universities of the country; currently experts go to construction sites, where the Prudon-494 geocells are used, in order to assist in following the technology of material placement.

In 2011, UNR OJSC together with the department of Road and Track Facilities of the Moscow State University of Railway Engineering (MIIT) organized a seminar for the representatives of the Belarusian Railway Design Institute on experience, methodology and analytical prediction of three-dimensional Prudon-494 geocells application in the construction of railway facilities for the purpose of stabilization of the subgrade. As a result of the training there was developed a number of design solutions for the railroads of Belarus with the usage of Prudon-494 geocells in the construction of

the subgrade's foundation (Figure 2). The Republic plans to build the first segments of the high-speed railway line Minsk-Brest. Certain parts of the railway are located in wetlands, on the soft soils. Usage of the counterberm and reinforcement of the subgrade's upper layer with the help of Prudon-494 geocells is foreseen by designers.

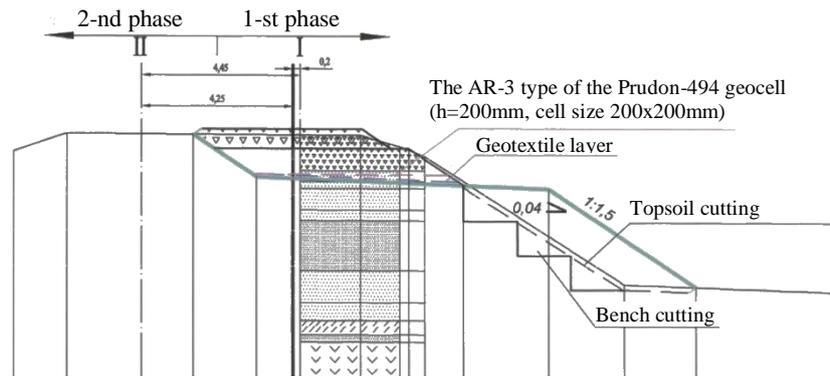


Figure 2 Railway line Minsk-Brest subgrade's structure

It should be noted that this technology finds understanding and acceptance in infrastructural projects' development of Russian Railways OJSC. Thus, in 2012 in frame of the IX Scientific and Technical Conference of MIIT in honour of G. Shakhunyants, in the report of vice-president of Russian Railways OJSC it was noted that one of the effective practical solutions for reinforcement of railway subgrade's foundation is the usage of three-dimensional geocells (Figures 3, 4).



Figure 3 Layout example from the report of the Vice-President of Russian Railways OJSC at the IX Scientific and Technical Conference of MIIT in honour of G. Shakhunyants



Figure 4 An example of an automated installation for laying geocells

494 UNR OJSC regularly carries out research work on the development of technology of three-dimensional soil reinforcement with Prudon-494 geocells.

For example, on the basis of the Strength of Materials laboratory at MIIT there was held a wide range of tests on Prudon-494 geocells in order to determine the possibility of their further usage for slope reinforcement of railway subgrade. The methodology of the experiment included:

- 1) Determination of tape's breaking strength (Diagram 1);
- 2) Determination of weld strength (Diagram 2);
- 3) Control of the geometric parameters of geocells.

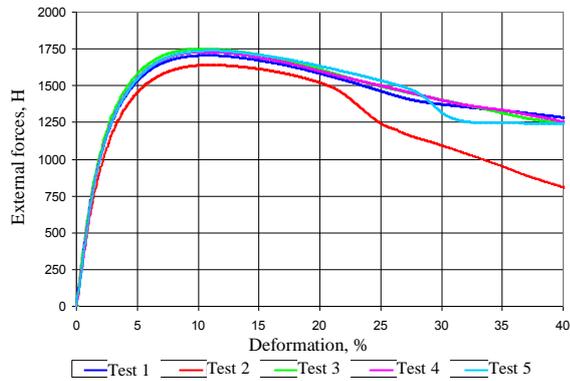


Diagram 1. Research of breaking strength of geocells' tape.

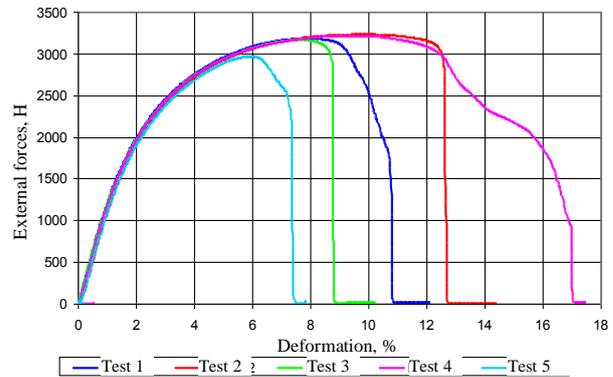


Diagram 2. Research of the strength of geocells' welded joints.

The test results proved high strength characteristics of the material in the elastic deformation zone (margin of safety was 30%) and satisfactory deformation properties. The findings confirm the stability of geocells' properties: variation coefficient of the load is 2.7%, variation coefficient of deformation is 2.3%.

Taking into consideration the findings and the results of tests experts recommend to use Prudon-494 geocells both for the slopes' protection, and in the construction of the subgrade of railroads in Russian Federation.

The specialists of 494 UNR OJSC carried out bench tests of Prudon-494 geocells with a filling aggregate in laboratories of several research institutes in order to determine their level of erosion protection. This way they intended to estimate the potential of using geocells under the active influence of water environment (Figure 5) (Table 1).



Figure 5 Mounting of stand for testing geocells with the filler which determines their level of erosion protection

The tests were carried out under the following conditions:

- the flow rate of the stone material leachability control - 1.3 m/s;
- duration - 15 minutes;
- fraction - 40-70 mm;
- the rock material mass put into cells - 761 kg;
- the average weight of the stone material put into a geocell - 5 kg.

Table 1 Test results of geocells with the filler which determines their level of erosion protection

Characteristic	Symbol	Requirement	Results
Damage of plastic geocells	-	absent	absent
Ratio of leached stone material mass to the stone material mass put into geocells before the test, % no more than	M	0,5	0

There were also carried out laboratory tests of the geocells' freeze resistance level, which were aimed at estimating the possibility of usage of Prudon-494 geocells in climate zones with low temperatures.

Due to the tests, the average numerical values of the freeze resistance level were determined: freeze resistance level of the tape - 91%, of the weld - 84%, which are higher than the normative values.

Over the past decades, the results of experimental and research works on Prudon-494 geocells were reflected in the normative-methodical documentation, which is actively used by leading design organizations of the Russian Federation. The result of this work are the objects constructed with the usage of Prudon-494 geocells on the territory of the Russian Federation and near abroad.

On the Yamal peninsula a railroad was built for the development of gas fields in the north of Western Siberia. Construction of the project was carried out in permafrost conditions, in constraint environment with the usage of local soils. Prudon-494 geocells were used in the construction of reinforcement of the foundation under the culvert (Figure 6).

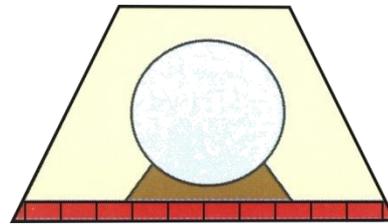


Figure 6 Construction of reinforcement of the foundation under the culvert with the usage of PRUDON-494 geocells

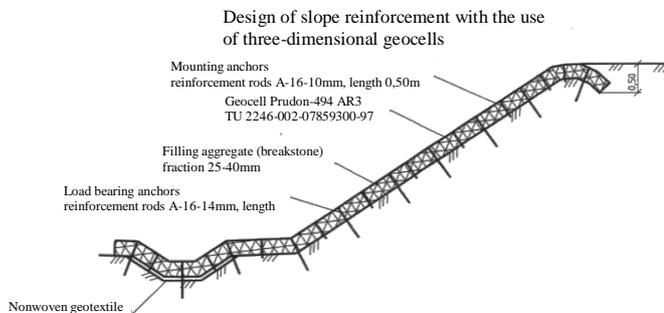


Figure 7 Structure of the slope of the railway subgrade

In Zabaykalsky Krai during the construction of the railroad for the development of mineral resources in the Chita region Prudon-494 geocells were installed in the slopes of the railway subgrade (Figure 7). Construction of the project was carried out with the monthly average temperature in winter of -28°C . Local rocky ground was used as the core material for geocells filling.

During the reconstruction of some sections of the North Caucasus and the Volga railroads Prudon-494 geocells were used to reinforce the slopes of the railroads (Figure 8). The location of the road in constraint environment on the rocky soil and in the coastal zone may be considered its distinctive feature or complicating factor.

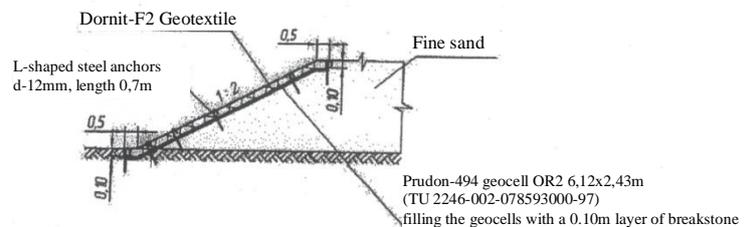


Figure 8 Structure of reinforcement of the subgrade berm's slope of the North Caucasian railroad

Regarding the prospective directions in design works one may note the railroad for transport connection between the Krasnoyarsky Krai and the Republic of Tuva and for the development of the mineral raw materials in the regions.

The railroad will be built in difficult climatic conditions. For the soil stabilization of the railway embankment it is proposed to use the technology of three-dimensional soil reinforcement with Prudon-494 geocells at the subgrade's foundation with the possibility to use local soils as geocells filler.

In general, it should be noted that the technology of soil reinforcement with plastic Prudon-494 geocells combined with the work on quality control can significantly improve the bearing capacity parameters of the subgrade.