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Reinforcement of foundations of wet road cuts with geotextile materials

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ABSTRACT: Peculiarities are considered in the use of geotextile materials for reinforcing the foundations of wet road cuts. Data are presented on stand studies using various types of geotextiles and various depths of a filled-up layer above them. Ways are given for improving the bearing capacity of the foundation considering its characteristics as well as those of the geotextiles applied.

Numerous investigations have shown that a reinforcing effect from the use of geotextile interlayer stems from the capability of a material, working integrally with the soil mass, to take and redistribute tangential stresses caused by both the temporary load and the soil dead weight.

In practice, this effect manifests itself in an increased bearing capacity of the reinforced soil layer.

When working out wet cuts, in most cases the reinforcement of the cut foundations makes it possible to avoid a need for replacing the weak soil. Thereby, the reinforcing geotextile interlayer, that prevents mixing the soil of the natural foundation and that of a filled up functional layer, not only provides the required stability of the weak foundation but also allows to carry out such technological operations as filling up the draining soil course and compacting the latter.

To evaluate a degree of the effect of reinforcing the wet cut foundations with geotextile interlayers, the authors performed stand tests in Soyuzdornii as well as built some trial structures on roads in various regions of Russia.

The stand tests were conducted on a circular test road in Soyuzdornii where a large-scale model of the road embankment was constructed, which enables to check the effect of reinforcing the foundation with the geotextile interlayer.

On one of the circular test road sections, three segments were built: the first with the use of the domestic geotextile "Dornit", the second with the French geotextile "Bidimë U-34, and the third (control segment) without the geotextile interlayer (Fig.1).

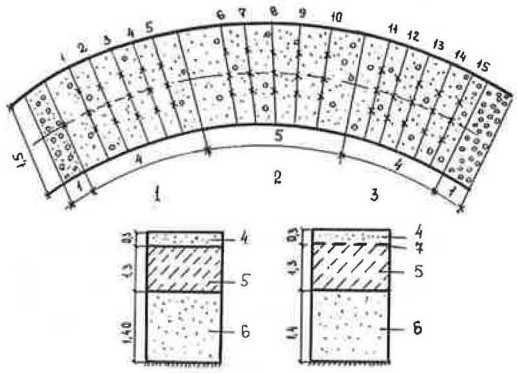

Fig.1 Scheme of experimental section and control cross-section arrangement at the circular test road in Soyuzdornii:
1-control; 2-with Dornit; 3-with Bidime; 4-sand; 5-Heavy loam; 6-Fine sand; 7-Geotextile.

"Dornit" is the first domestic needle-punched geotextile material that is manufactured from synthetic fibre wastes and fibres of utilized scraps.

"Bidimé U-34" is a French needlepunched geotextile material made from the polyether melt that was applied on jobs carried out in cooperation with the Rhône-Poulenc Company during construction of experimental sections on Moscow-Riga Highway.

These needlepunched geotextile materials that possess about the same strength and deformation characteristics were placed between the weak foundation and the filled up sand course. A 1.3m layer of overwetted heavy loam was formed as a weak foundation. The soil contained 55% of sand particles, had a plasticity index of 15.65 and a liquid limit of 27.7%.

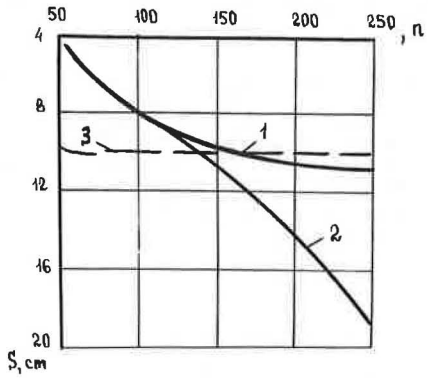

Fig.2 Rut depth versus number of load applications:
1-sections with interlayers; 2-sections without interlayers;

In the course of the experimental works the moisture content of foundation soil was constantly maintained close to the liquid boundary where = natural moisture content and = moisture content at the liquid boundary.

The sand course was filled up from fine sand with a 5.33% content of silty and clay particles.

A thickness of the filled-up sand course for all the sections was taken equal to 0.3m.

To evaluate an impact of live load, 250 passes of a wheel of the one-axis loading bogie were performed, and it was found that on the sections with geotextile interlayers, deformations in the form ruts occur much slower (Fig.2) with a tendency to gradual damping. The highest intensity of rut formation was recorded after the first fifty passes and a depth of the rut was 5cm. Then, up to the two hundredth pass the intensity continued to increase and stabilized at a 10 to 11cm depth of the rut.

On the control section, after 50 passes the rut depth was 6cm but no stabilization occurs to two hundredth pass and the rut depth increased to 14cm, continued to grow and reached 18-19cm to the 250 th pass. Thereby, the velocity of movement of the loading bogie dropped sharply, and this forced to stop the tests after 250 passes because of a danger of the electric drive damage.

Experimental studies carried out on the circular test road have substantiated the positive effect of the geotextile interlayer on increasing the bearing capacity of weak overwetted foundation and providing a possibility for the free passage of technological transport (high-capa-city vehicles) over the surface of the sand filled-up layer, even at its small depth, as noted above.

To assess the effect of reinforcement under natural conditions, a number of trial sections have been built on the agricultural roads in the Smolensk, Kalinin, and Moscow Regions.

The construction sites were characterized by the occurence of clay soils of the soft-plastic consistency having a moistening ty coefficient = 1.5, a high level of the ground water and long-term standing of the surface water (here where = natural moisture content and = optimum moisture content).

In order to provide a possibility to work for the compaction machinery and a normal traffic regime for the construction transport on a rough-graded foundation, the geotextile "Dornit" was placed, over which a 0.5m sand course was filled up. In winter, the thick-

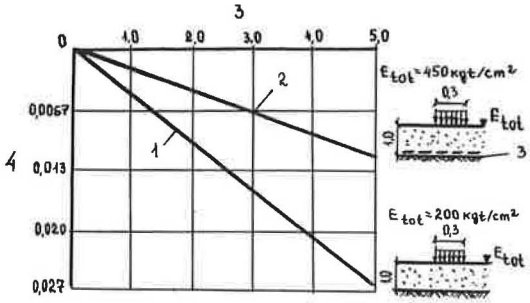

Fig.3 Change in stamp (=30cm) settlement under the application of unit load on control (1) and experimental (2) sections:
1-Unit, kgf/cm^2; 2-Relative deformation;

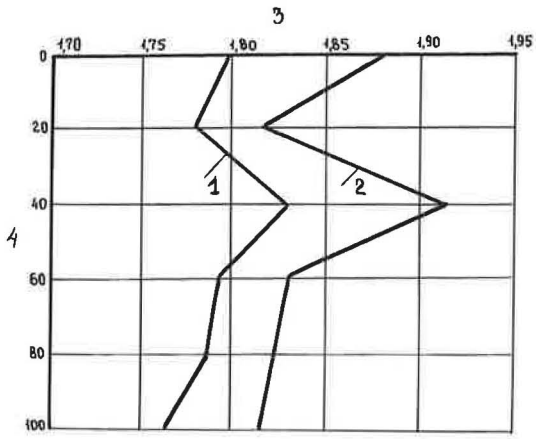

Fig.4 Change in soil density through the embankment height on control(1) and experimental(2) sections:
1-Soil density, g/cm^2; 2-Embankment height, cm

ness of this course was increased up to 1m.

Before laying the road pavement an investigation of these sections was carried out to assess the bearing capacity and the degree of compaction.

The bearing capacity of the subgrade was evaluated from the static stamp tests performed on the trial and control sections (Fig.3). Along with these tests, the degree of embankment compaction was controlled.

The results have shown that the coefficient of compaction through the embankment depth was 0.96 to 0.97 on the control sections and 0.99 to 1.0 on the trial ones (Fig.4).

Decreased stamp settlement, increased modulus of deformation and increased coefficient of compaction on the sections with geotextile interlayer are indicative of an increase in the bearing capacity of the foundation.

This principle of reinforcement was also successfully applied in building the subgrade in the wet cuts on Moscow-Riga Highway.

Thus, the completed experimental and trial works demonstrate the positive effect of reinforcing the foundation of wet road cuts with the geotextile interlayers.

The experience gained in the process of work performance allows to state that, when constructing the cuts, which foundations have the bearing capacity of 2.5 to 5 MPa, it is expedient to use nonwoven geotextile materials with the breaking strength not less than 60 N/cm, the breaking elongation not higher than 150%, and surface density not less than 300 g/m^2 at the material thickness not less than 2.5 to 3.0mm.

Such domestic materials as and 64 of SJC "Komitex" and some others meet the above requirements.

However, at the foundation bearing capacity of 1.5 to 2.5 MPa, it is recommended to apply nonwoven geotextile materials with the breaking strength not less than 90H/cm, the breaking elongation not higher than 100%, and the surface density not less than 400 g/cm^2 at the material thickness not less than 3.5mm. These requirements are satisfied by characteristics of such domestic materials as KM-1 and KM-2 SJC "Sovventex" as well as -43 and -63 of SJC "Komitex".

It is natural that at the lower bearing capacity of the foundation, as an interlayer, the use should be made of durable and less deformative geotextile materials, including woven ones or fine-cellular geogrids, such as those of polypropylene. Double-course interlayers with the lower course of the geogrid and the upper course of the nonwoven needlepunched fabric may be used as well. However, the choi-

ce of one or other variant of the reinforcement shall be made in each particular case with due regard of the following: soil type in the wet cut foundation; requirements imposed upon the bearing capacity and durability of the road structure as a whole; characteristics of geotextile materials available; economic expediency of using one or other structural alternative as compared with conventional solutions that include removing the weak clay soils and replacing them with the draining ones.