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Drainage structures with the use of geosynthetics on the roads of Russia

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ABSTRACT: The results are given on the application of geotextile materials in the drainage structures of various types in the road construction in Russia.

Drainage structures applied in the practice of road building can be divided according to their designation: lowering the ground water level to drain the subgrade cuts, low fills, places of datum level; lowering the filtration pressure with simultaneous drainage of the cuts, slopes (including the sliding ones); intercepting the surface and ground water at places where the retaining slide-protection structures are installed (supporting walls, cast-in-situ bored piles, etc.).

In compliance with the above directions, the use is made of the trench drainage of all types; slope drainage at the slope surface (or at shallow embeddment into the natural soil); behind-the-wall drainage, i.e. within the conjugation of the slide-protection structure with the soil, backfill soil included; trenchless horizontal drainage.

For the drainage structures it is mainly specified to use graded granular materials - crushed stone (gravel) and sand of the high filtration coefficient (at least 5m/day) in combination with asbestos-cement pipes or without them.

An analysis has shown that the service life of such structures is 3 to 5 years which is due to the absence of reliable protection of the granular materials against their colmatage as well as structural and technological shortcomings of conventional solutions. At a certain degree, a solution of this problem is connected with the use of geotextile materials and transforming the conventional drainage structures on their basis.

For these purposes, in the road construction practice in Russia the geotextile materials are used when installing the drainage. Needlepunched and thermal-fastened materials, mainly made of polypropylene, are applied as the geotextiles. During recent time a volumetric drainage geotextile material is increasingly used, which consists of a three-layered low-compressible fabric that is made of a volumetric impermeable core and thin permeable envelopes performing simultaneously as filters.

Unconventional under-trench drainage was first installed in Russia in 1975 during cooperative works carried out by Soyuzdornii and Rhône-Poulenc Company from France/1/ on Moscow-Riga Highway near the town Velikie Luki. Along with other experimental structures, 300m of the under-trench drainage (Figs. 1 and 2) were installed; for this purpose, instead of the conventional structure, consisting of an asbestos-cement pipe backfilled with crushed stone and sand, polyvinylchloride drainage pipes in an envelope of the geotextile material "Bidim", having surface density 200g/m^2, were placed. The drainage pipes of a 5 to 6 kg weight, supplied by the French party, had funnelled openings and slot perforation and were delivered in packs of 5 pieces.

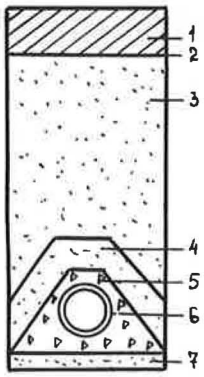

Fig.1 Type under-trench drainage: 1-compacted clay soil; 2-polyethylene film; 3-medium-sized sand; 4--coarse sand; 5- 10 to 20mm crushed stone; 6-asbestos-cement pipe 150mm in diameter; 7-coarse sand

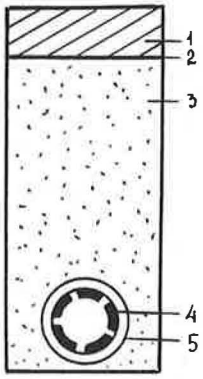

Fig.2 Under-trench drainage structure with a synthetic pipe in the geotextile envelope:
1-compacted clay soil; 2-geotextile interlayer; 3-medium-sized sand; 4-synthetic drainage pipe; 5-geotextile envelope

Each pipe was 5m long and 150mm in diameter. Upon installation of the inspection concrete manholes into an excavated trench 1.5m deep, the drainage pipes were laid. Their jointing was made by means of the funnels. One pack was sufficient for installing about 30m of the drainage. Places of jointing were additionally overlapped with the geotextile envelope ends.

Subsequent investigations have shown that the drainage is performing sufficiently up to now.

In 1994, similar under-trench drainage 1.5km in length (Fig.2) was built on MKAD-Kashira Road. The basic element of this drainage was a domestic flexible, perforated polyethylene-based pipe included into an envelope of the thermal-fastened geotextile. The perforated synthetic pipe was 165mm in diameter and 5m in length. The envelopes were made of the thermal-fastened geotextile Tipar (USA). The same material was used for an interlayer between the trench sand filling and the local soil to protect the sand from the colmatage.

During a two-year period the under-trench drainage of geosynthetics has performed reliably, draining water from the structural elements of the cut.

In this section, immediately on the cut slopes, the slope drainage was installed using the sand and geotextile.

The type structure of slope drainage called for excavating 100cm x 70cm trenches on the slope, filling them with 55cm of the crushed granite and then covering by 15cm of the vegetable soil (Fig.3).

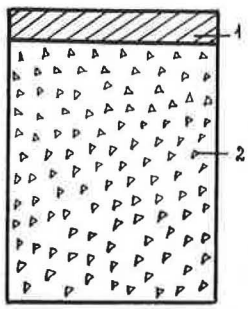

Fig.3 Type slope drainage structure:
1-compacted clay soil; 2-crushed granite

Operating experience obtained for such structures shows their low reliability due to fast silting of the trench with particles of the local soil adjacent to the trench walls.

The type structure of slope drainage was replaced by a structure that consists of a geotextile envelope filled with the sand having a filtration coefficient of 5m /day /Fig.4/).

The section was 750m long. In this case, the thermal-fastened geotextile Tipar (USA) was applied as the geosynthetics.

The works performed on the under--trench and slope drainage installation have made it possible to refine the structures and technology of the drainage installation using the geotextiles, to adjust the specifications on domestic geotextile materials and to work out recommendations on their use in the road sector.

To increase the water-draining capacity of the behind-wall drainage when building supporting structures under mountainous conditions, a drainage structure has been developed and installed on Sochi-Adler Road, which consists of a retaining wall, geotextile cloth fitting against its rear surface, and a perforated pipe placed into the wall bottom. On the rear surface of the retaining wall,vertical and inclined intercommunicated grooves were applied. The lower end of the cloth was wrapped around the perforated pipe.

Distance L between adjacent vertical grooves was determined from the condition:

$$L = \frac{b \cdot z \cdot C\sqrt{\frac{2}{3} \cdot g \cdot H_d}}{H \cdot n \cdot K_f - \delta \cdot K_{fg}},$$

where b = groove width, cm; z = groove depth, cm; C = Shezi coefficient; H = design ground water level, cm; n = soil porosity ; K_f = soil permeability coefficient, cm/s; δ = geotextile thickness considering its compression by the soil, cm; K_{fg} = longitudinal permeability coefficient of the geotextile, cm/s; H_d = design level of ground water lowering behind wall, cm.

The vertical and inclined grooves were formed during concreting the retaining wall body. These grooves can be of various cross-sections: rectangular, trapezoidal, and semicircular.

Such solution makes it possible to create artificially a volumetric drainage structure, in which the geotextile material easily drains the ground water to channels with subsequent discharging it beyond the structure.

On a number of sections of the same road, for the first time in Russia, trenchless horizontal pipe drainages were installed in order to drain the sliding slopes. Perforated synthetic pipes 150mm in dia, wrapped with the geotextile, were put into boreholes drilled to a depth of 110m. To wrap the drainage pipes, a domestic needlepunched geotextile was applied. The ends of the wrapped pipes were brought to 0.5m beyond the retaining wall. The use of geotextile has protected the drainage pipes against colmatage by the soil particles, and during 15 years the material has been performing well, providing the stability.

However, the most efficient solution to the problem of protecting the transport structures against the action of water is the development and application of a volumetric drainage geotextile material /2/, which consists of a high-porous core included into an envelope of thin geotextile material of high permeability. The material is 2cm thick and 50cm wide and its length in a roll is 25m. To connect adjacent elements, one of the drain ends has a widening - a funnel. The volumetric drainage material is designated for the application when installing all types of drainage. Its usage allows to replace fully the granular materials and the drainage pipes. Thereby, an improved reliability of the structure as a whole is ensured and there are substantial savings in operation costs.

The efficiency of the performance of a trial lot of the volumetric drainage material, together with refining the technology of drainage installation, has been checked up by Soyuzdornii in the road construction under various engineering-geological conditions. For instance, while installing the slope drainage in one of the cuts in the heavy clay soils on MKAD--Kashira Road, instead of the conventional structure, a technology has been applied, which includes the following operations: laying out of the axes of drain arrangement along the slope surface, trench excavation, filling and levelling the trench bottom using the sand, unrolling the volumet-

ric drainage material and backfilling the trenches with the sand. In a whole, ten drains of a 250m total length have been built.

Examination and observation of the state of the cut slopes and the drainage structures have indicated that after live years in service they are in a good condition.

Along with refining the technologies in the process of the drainage structure installation with the use of geotextiles, work has been carried out on defining more exactly requirements to the domestic geotextile materials themselves, the results subsequently having been used in drawing up the specifications for their serial production.

Water removing from under the foundations of soil structures was effectively provided by areal drainage structures. This structure consists of two geotextile layers with a crushed granite course 30cm thick placed between them, which are covered by the sand layer. Immediatly after the installation of such type of drainage, there occur intercepting of the ground water and its removing beyond the structure.

The experience on the use of geotextile materials in the drainage structures has allowed to work out a special diagram manual for the design and construction organizations.

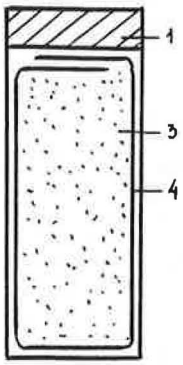

Fig.4 Slope drainage structure made of sand in the geotextile envelope:
1-compacted clay soil; 2-sand with 5m/day; 3-geotextile envelope

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