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The Performance of Geotextile Materials Used for Filtration and Separation in Different Structures as an Important Part of Geotextiles Requirements

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Abstract

Currently, a water discharge coefficient as an important feature of geotextile materials that affects their filtration capacity in a frozen condition is not included in the geotextiles material specifications. The higher the water discharge coefficient of geotextile materials is, the less ice they contain when frozen. The necessary requirements and corresponding mathematical relations for choosing the appropriate geotextile materials are presented in this study. Geotextile materials used as separating layers in a railway formation should meet the same requirement.

The effective diameter of the geotextile material pores (cells) was obtained by sieving through it the fine-grained quartz sand of pre-determined grain-size composition. Nevertheless, as microscopic research showed, particles produced due to the ballast abrasion and bridging (colmating) of the geotextile material have a plate-like shape. Consequently, the curve of their granulometric composition differs from that of the quartz sand.

Based on the experimental data, the criteria for the required mathematically calculated filtration flow diameter have been established to ensure that geotextile materials are not colmated during their designed life span. The theoretical, field and laboratory research conducted permitted to formulate the propositions on making amendments to the requirements and their modification boundaries depending on the area of geotextile materials application.

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Keywords: *geotextile; water discharge coefficient; colmating particles; drainage; frozen soils*

Experience gained in the field of geotextile material application in industrial, civil and hydraulic engineering permits assessment of whether geotextile material performance in different structures in different conditions is adequately reflected in the generally accepted geotextiles requirements of today [1, 2].

A greater part of Russia lies in the zone of seasonal deep-frozen soils. Thus, it is important that the frozen geotextile material does not prevent water flow from reaching the covered drain system through the thawed ground layer before the top-cover filling soil is defrosted [3]. Currently, a water discharge coefficient as an important feature of geotextile materials that affects their filtration capacity in a frozen condition is not included in the geotextiles material specifications. The higher the water discharge coefficient of geotextile materials, the less ice they contain when frozen [4, 5].

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Petersburg State Transport University (PSTU) has conducted research and laboratory tests on water discharge coefficient changes of geotextile materials over the course of time [6]. Three types of textile materials with a relatively high water discharge coefficient were chosen for the tests: Product-A, Product-B and Product-C. The samples were placed in a device with crushed rock inside. The devices were covered with PE filming. The tests were conducted at a temperature of 24-25°C to avoid evaporation from their surface. After three days, the water discharge coefficient of Product-A and Product-Bdecreased by 4-5% and that of Product-Cby 9.1%.

The effect of the water discharge coefficient on the filtration material performance in frozen grounds is shown in Table 1, from which it follows that the higher the water discharge coefficient of a geotextile material, the higher is its filtration coefficient in frozen grounds.

Table 1. The dependence of geotextile materials filtration coefficient on water discharge coefficient in frozen ground.

Geotextile type	Porosity n, fractions	Water coefficient μ, fractions	Volume of ice in the pores, fractions	Filtration coefficient K, m/s, in different conditions	
				defrosted	frozen
Product-A	0,89	0,78	0,12	$2,4x10^{-3}$	$3,2x10^{-4}$
Product-B	0,82	0,66	0,15	$3,2x10^{-3}$	$3,6x10^{-4}$
Product-C	0,76	0,64	0,14	$1,4x10^{-3}$	$1,9x10^{-4}$
Product-D	0,87	0,01	0,94	$2,6x10^{-3}$	0,0
Product-E	0,88	0,35	0,58	$2,9x10^{-3}$	$1,1x10^{-5}$
Product-F	0,82	0,38	0,49	$2,2x10^{-3}$	$6,9x10^{-5}$
Product-G	0,68	0,49	0,21	$0,5x10^{-3}$	$4,6x10^{-5}$

Table 1 shows that only three types of geotextile materials (Product-A, Product-Band Product-C) have a filtration coefficient exceeding the lowest permitted specification value of $1x10^{-4}$ m/s in a frozen condition.

When a geotextile material loses its filtration ability in a frozen condition, taking into consideration the fact that high-level ground water migrates to a frozen front section in winter, it will prevent the water from flowing and thick ice sublayers will possibly form under the geotextile material. The formation of ice layers can be disastrous for railway gauge geometry when soil thawing reaches the depth at which the geotextile material was laid.

Petersburg State Transport University has been conducting research on how the colmation of geotextile materials with soil particles finer than 0.05mm can affect their filtration properties.

The inspection of the geotextile materials taken from five sections of the Octyabrskaya railway, seven sections of the Moscovskaya railway and five sections of the Western-Siberian railway gave evidence that nearly ⅓ of the geotextile materials will be colmated and their filtration coefficient will decrease up to $\leq 7x10^{-6}$ m/s, which is considerably below the permissible level of $1x10^{-4}$ m/s. This is caused by the following factors. The effective diameter of the geotextile material pores (cells) was obtained by sieving through it the fine-grained quartz sand of pre-determined grain-size composition. Nevertheless, as microscopic research showed, particles produced due to the ballast abrasion and bridging (colmating) of the geotextile material have a plate-like shape as shown in Figure 1.