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Influence of Pressure on Water Permeability and Characteristic Opening Size of Nonwoven Geotextiles

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Abstract

Nonwoven geotextiles manufactured by mechanical carding process and bonding by needling process are investigated in this paper. Part of the samples was additionally bonded by thermal calendaring process. Sampling was conducted according to the standard for geotextile with certain modifications. The samples were tested for water permeability perpendicular to the plane of samples using loads of 2, 20 and 200 kPa. Characteristic opening size of geotextiles was tested using sieving method. Research shows that different applied pressures significantly change structure and properties i.e. thickness and water permeability normal to the plain under load of geotextile.

Keywords: Polypropylene; Polyester; Calendaring; Water Permeability with Load; AOS

1 Introduction

Nonwoven textile is a fabric composed of individual fibres mutually bonded by a certain process. For nonwoven productions different types of fibres are used. The choice of fibre depends on the desired properties of the nonwovens and the cost of of the chosen fibres [1, 2]. Artificial fibres are the raw materials for the production of nonwovens, and it dominates the world market, representing about 90% of the total fibre consumption. World consumption of synthetic fibres for nonwoven production is about 63% of polypropylene fibres, 23% of polyester fibres, 8% of viscose fibre, 2% of polyacrylic fibres, 1.5% of polyamide fibres and 3% of other special fibres [2]. From the above, it is evident that in the nonwoven industry, the three most processed types of fibres are polypropylene, polyester and viscose. Regarding to the previously mentioned samples, those made of polypropylene and polyester were chosen for this study.

Geotextile as drainage and filtration materials is used in earthworks for last 30 years. The functions provided by nonwovens in geotechnical applications include drainage, filtration, separations

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and soil protection, particularly in its stability and erosion control [3]. Nonwoven geotextiles are very permeable and are compressible materials. When under stress, as the thickness of the geotextile reduces, so does its coefficient of permeability and pore dimensions [4]. Where the filtration function of geotextile is of paramount importance, water permeability perpendicular to the plane is relevant, and the in-plane water permeability of geotextiles may be of greater significance, in the application of drainage function [5-7]. Therefore water permeability of geotextiles normal to the plane is one of the main parameters that can be used to characterize and compare geotextiles [8]. For separation, filtration and drainage-in-the-plane, the pore sizes, pore geometry and percentage open area of the geotextiles in the direction of flow are critical. Mentioned functions of geotextiles are dominated by their pore space characteristics, as these control the size of particles and the amount of water that may be transmitted through them [8-12].

Their usage is mostly successful, since design is based on an empirical criterion which sometimes differ from the real ones. Such practices can lead to erroneous predictions of the design. The biggest problem in practice is caused by force impact on the geotextile and the influence of external conditions during installation [13]. The issue of actual conditions and their impact on the geotextile has not been studied much [14, 15]. This paper studies the influence of pressures on the thickness (or porosity, which is associated with the structure of geotextiles), water permeability under pressures and characteristic opening size of geotextiles. The goal of this paper is to investigate performance of polypropylene and polyester needle punched and polypropylene calendered geotextile in use.

2 Experimental

The samples investigated in this paper are nonwoven geotextiles manufactured by mechanical carding process, bonded by needling process. Part of the samples was additionally bonded by thermal calendaring process. Two groups of samples were made from polypropylene and polyester fibres and bonded by needling. The third group of samples were polypropylene fibres bonded with needling and also additionally bonded with calendaring. Mass per unit area for all groups of samples is in the range between 200 and 500 g/m^2. The total numbers of tested samples were 12.

The sampling was conducted according to the standard for geotextile sampling HRN EN ISO 9862: 2005 with certain modifications [16]. The standard where modified, where detailed sampling plan has been made as well as number of measurements per sample was increased. For the sampling, a metal plate sizing of 60.3 cm x 60.8 cm with holes has been used for all specimens of the planned testing. The metal plate was moved according to 5-end satin weave with step of 3, in order to avoid repetition of sampling in longitudinal and transverse direction for the same type of testing. According to the standard for sampling, 10% of the sample width has to be avoided from the edges (40 cm). The sampling is presented in Fig. 1.

The thickness was tested according to the standard for geosynthetic consisting of single layers HRN EN ISO 9863-1: 2005 at specified pressures of 2, 20 and 200 kPa [17]. Density of geotextiles was calculated from mass per unit area and thickness values, using following equation:

$$\rho_{\text{geo.}} = \frac{M}{t} \tag{1}$$

where ρ is the density [g/cm^3], M is the mass per unit area [g/cm^2] and t is the thickness [cm]. For