Geosynthetics' non-standardized hydraulic tests

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ABSTRACT
Countless civil engineering projects use geosynthetics, from hydraulic projects to geotechnical landfills. To improve it, the hydraulic characterization is one of the main properties to be verified. When the material leaves the controlled environment of the factories and arrives at the field, it is subjected to the aggressive characteristics of the exogenous environment, what is detrimental to their physical integrity. Therefore, the paper studied the determination of water permeability test normal to the plane, without load made in a first equipment previously standardized and, in addition, the construction and calibration of two new equipment, for determination of water flow capacity in their plane and determining apparent opening size. The hydraulic behavior of four woven geotextiles were evaluated, two with monofilament polypropylene and two with multifilament polyester. The results when confronted with the database of the laboratory tests showed good correlation patterns between the characterization of a large part of the available geosynthetics, making the validation of the new equipment for the determination of hydraulic properties possible.

KEYWORDS: Degradation, Durability, Geosynthetics, Geotextiles, Hydraulic Tests

RESUMO
Inúmeros projetos de engenharia civil utilizam geossintéticos, envolvendo desde projetos hidráulicos até aterros geotécnicos. Para garantir bons projetos, a caracterização hidráulica é uma das principais propriedades a serem verificadas. Quando o material sai do ambiente controlado das fábricas e chega ao campo, ele é submetido às características agressivas do ambiente exógeno, que são fatores prejudiciais à sua integridade física. Este artigo avalia o comportamento hidráulico de geotêxteis tecidos. O estudo consiste na execução do teste de determinação de características de permeabilidade de água normal ao plano sem carga realizado em equipamento disponível no laboratório e, além disso, a construção e calibração de dois novos equipamentos, para ensaios de determinação da permeabilidade de água no plano do geossintético e determinar o tamanho de abertura aparente. Os resultados quando confrontados com o banco de dados dos testes de laboratório e outros coletados na bibliografia mostram padrões de correlação entre a caracterização de grande parte dos geossintéticos disponíveis, sendo possível a validação dos novos equipamentos para a determinação de propriedades hidráulicas.

PALAVRAS-CHAVES: Degradação, Durabilidade, Geossintético, Geotêxtil, Testes Hidráulicos

1. INTRODUCTION

1.1 Initial Considerations

Geosynthetics are polymeric materials, synthetic or natural, industrialized, with the capacity to perform one of many different functions, which are: reinforcement, filtration, drainage, protection, separation, waterproofing and control of surface erosion. The wide variety of geosynthetics available on the market today allows them to be used as a simpler and more effective alternative in different types of works. In projects of coastal erosion or riverbank containment, geosynthetic container system, generally composed of woven and non-woven geotextiles, are widely used because of their high level of performance. These are filled by water and/or soil to contain erosive processes in the sea or the river, and can also be used to stabilize slopes. This application requires several studies of its hydraulic properties.

The most common polymers in the manufacture of geotextile container system are: polypropylene (PP) and polyester (PET). The first is a thermoplastic having a melting point of approximately 165°C and a density of approximately 0.90 kg/m³. Its density is lower than the water, which allows it to float, being one of the lighter polymers. Also, PP is the polymer most used in the manufacture of geotextiles, reaching the mark of 85% of the total, according to Koerner (2012) and 65%, according to Ingold (1994). Already the second, thermally thermoplastic, but with a much higher melting point than PP, around 260°C, and with a density of about 1.38, i.e., is denser than water. Therefore, PET materials do not float. According to Koerner (2012), only 12% of this material is used in the manufacture of geotextiles and 30% according to INGOLD (1994). Establishing PET as the second most used polymer in its manufacture.

1.2 Hydraulic Properties

In works of coastal protection and river slopes where these products are used, it's necessary to study these properties. The geosynthetics have three hydraulic properties: normal permeability, filtration aperture and permeability in the plane.

The first the analysis takes into account the flow in the normal plane and can be evaluated with constant and variable load techniques. According to Vidal & Righetti (1990), the permissiveness is rarely a limiting factor in sizing of geosynthetics, already their choice is usually made through the filtration opening test.

The second, also referred as O_{90}, indicates 90% of soil particles that can cross the geosynthetic. This value is determined by wet sieving. Represents the smallest particle diameter that the geosynthetic can retain.

The third evaluates the permeability by planar flow. It is extremely important to observe that the load under the material can alter this characteristic. According to Koerner et al. (1984), Giroud et al. (2000) and Castelo & Gutierrez (2014), layer overlays, thickness and compressibility of geosynthetics significantly affect the change of this property according to the projects.

2. MATERIALS AND METHODS

2.1 Materials

Four types of woven geotextiles of different weights were used, two polyester multifilament and two polypropylene laminates. The Table 1 show respectively the names and mass per unit area of the materials studied.

Table 1. Mass per unit area of geotextile of the samples.

Sample	Mass per unit area (g/m²)
PET-340	340
PP-500	500
PET-740	740
PP-925	925

2.2 Methods

The tests were only possible through the construction of the equipment in the LED to characterizethe geosynthetics (Table 2). In order to better interpret the behavior of the geotextiles when it is applied in works hydraulic and to find a more adequate dimensioning, a characterization of these properties is made.

Table 2. Characteristics of hydraulic properties tests in woven geotextiles.

Test	Characteristics	Objectives	Standard
Determination of water permeability characteristics normal to the plane - k_n (m/s)	5 specimens. Head loss of 50 mm	Flow velocity	ABNT NBR ISO 11058
Determining apparent opening size - O_{90} (mm)	4 specimens. 10 min in vibrating sieve	Dimension corresponding to 90% passing	ABNT NBR ISO 12956
Determination of water flow capacity in their plane - k_p (cm²/s)	4 specimens. Overflow weirs at hydraulic gradients 0.1 and 1.0; Pressures: 2.9 PSI, 16.5 PSI, 29.0 PSI	Flow velocity under confining pressure	ABNT NBR ISO 12958

2.2.1 Permeability normal to the plane

In this test (Figure 1), the geotextiles woven must allow a flow of water perpendicular to their plane. The permeability normal to the plane depends mainly on the structure of the geosynthetics, i.e. their physical properties, and also, the filtration aperture property is closely linked. Its unit is in m/s, often expressed in terms of permissiveness, of unit 1/s. This is obtained by dividing the coefficient of permeability normal to the plane by the thickness of the geosynthetic. This property can be evaluated by analyzing cases where it is necessary to obtain results with constant load or variable load.

Figure 1. Equipment used to determination of the water permeability characteristics normal to the plane.

2.2.2 Opening size

The determination of the filtration aperture characteristic of a single layer of a geotextile, sandy material is used at fixed intervals. For the present test (Figure 2), the granulometry of fragmented quartz is used in the ball mill equipment.

In this method, a geosynthetic sample is defined under a metal gride and below a sprinkler system. Immediately after the soil is deposited on geotextile. The test begins with 10 minutes in a vibrating sieve by 0.25 Hz. Subsequently, evaluating the losses of granular material without system, retained support material and the passing material, which is in the water container of the water. The passive material is sieved and determines the opening of the geotextiles referring to 90% of this material.

Figure 2. Equipment used to determination apparent opening size.

2.2.3 Permeability in the plane

In this test performing, the woven geotextiles shall allow a flow of water in their plane. The tests are performed with the standard pressure 2.9 PSI, 16.5 PSI and 29.0 PSI for each of the hydraulic gradients employed 0.1 and 1.0. For each gradient, 3 measurements of time are taken for the water displacement of 1 cm in the burette for each normal tension established in the time. For the execution of this, 4 specimens of dimensions 10x5 cm² were used. Figure 3 shows the equipment used.

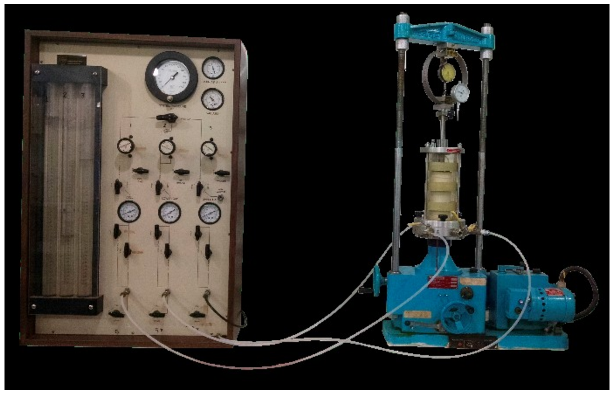

Figure 3. Equipment used to determination of the water flow capacity in their plane test.

3. RESULTS

The characterization of four woven geotextiles can be analyzed by their hydraulic properties in Table 1, 2 and 3.

Table 2. Permeability normal – k_n (m/s).

Sample	Standardized	Non-standardized
PET-340	0,020 ± 0,000	0,021 ± 0,001
PP-500	0,008 ± 0,000	0,008 ± 0,000
PET-740	0,005 ± 0,000	0,003 ± 0,001
PP-925	0,008 ± 0,001	0,007 ± 0,002

Table 3. Opening size test – O_{90} (mm).

Sample	Standardized	Non-standardized
PET-340	0,20 ± 0,01	0,21 ± 0,02
PP-500	0,18 ± 0,00	0,18 ± 0,01
PET-740	0,05 ± 0,00	0,06 ± 0,01
PP-925	0,12 ± 0,01	0,12 ± 0,02

Table 4. Permeability in the plane – k_p (cm²/s).

Sample	Standardized	Non-standardized
PET-340	0,050 ± 0,001	0,055 ± 0,002
PP-500	0,065 ± 0,001	0,067 ± 0,003
PET-740	0,150 ± 0,002	0,170 ± 0,008
PP-925	0,110 ± 0,001	0,110 ± 0,003

The results obtained from the three hydraulic properties in the four woven geotextile were presented comparing the standardized and non-standardized test with results side by side for better comparison.

The normal permeability presented the results with lower variation of the results according to the samples analyzed. Only PET740 presented a significant difference. This should have been caused by some unidentified procedure, such as preparation of the equipment, handling and improper preparation of the sample before the test.

In the database obtained by filtration opening test, there was no significant difference.

And the permeability in the plane of woven geotextile results in the polyesters were perceptible. The PET340 and PET740 showed a higher permeability in the plane response than values obtained in the standard test. It is believed that the rigid surface around the specimen is the reason for this variation.

4. CONCLUSIONS

The paper presented the results of the hydraulic characterization in four different weights of woven geotextiles in equipments developed in the laboratory. It can be appreciated that the tests in the equipments created were very good and the results were equivalent.

As advantages of the new procedures used to run out the hydraulic tests, it is important to highlight that in the opening size test (O_{90}) the amount of graduated sand used was lower than in the standardized tests and the diameter of the specimen has been reduced from 25 cm to 7 cm. Also, in the Permeability in the plane test the size of the specimen was reduced from 20x30 cm² to 10x5 cm² and as a consequence it decreased the system compression load. As disadvantages, the difficulties of building the adaptive equipments that need expensive materials can be pointed out.

This study extends the discussion about the use of standardized tests and their possible variations related to the size of the test specimens. According to the research, the variation of the scale did not prove to be a problem for the determination of the properties of the material, but an additional alternative, especially for durability studies, which require reduced specimens.

Also in this paper, the use of triaxial equipment in determination of water flow capacity in their plane permeability tests was presented. This mechanism has proved to be efficient and can become a standard complement procedure, which defines standard measures for this procedure.

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