Geotextile Characteristic Opening Size: The Influence of Some Test Parameters

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ABSTRACT: Designing a geotextile for filtration applications requires information on the characteristic opening size of the geotextile. Several techniques are available for measuring the characteristic opening size, but there is no one universally accepted. Three test methods are usually used: dry sieving, hydrodynamic sieving and wet sieving. The wet sieving test method was used to study the influence of some test parameters (soil granulometry, water flow rate and vertical amplitude) on the results of opening size measurement. For this purpose six nonwoven geotextiles were studied. The results showed that the test conditions can indeed influence results of the measurement of characteristic opening size.

KEYWORDS: Geotextile, Wet sieving test method, Characteristic opening size

1 INTRODUCTION

Where geotextiles are used as filters they must perform two functions simultaneously. One is to retain fine soil particles and the other is to allow the seepage of water from the protected soil. The ability of the geotextile to filter is a function of the size and distribution of the pores and the porosity. However, the distribution of the pores within the geotextile is difficult to determine. As a result, several indirect test methods have been developed. Three techniques are used: dry sieving, standardised in the United States, United Kingdom, Belgium and the Netherlands; hydrodynamic sieving, standardised in Canada, France and Italy; and wet sieving, standardised in Germany, Austria and Switzerland. For a given geotextile the results obtained are dependent on the test method used (Bhatia & Smith, 1995).

In order to obtain a unified standard, in Europe, the different existing national standards are being harmonised under the auspices of the European Committee for Standardisation (CEN). An index test has been developed based on the wet sieving technique. A specific parameter, the Characteristic Opening Size (COS also called O_{90}), indicates the size of the largest grain size particle that can pass through the geotextile.

A final draft European Standard was recently submitted for formal vote to the European countries (prEN ISO 12956). It has been drawn up by Technical Committee 189. Before becoming a standard the test method was validated. It was necessary to clarify the influence of some specific parameters, in order to determine the best test conditions. Therefore, during the work on standard harmonisation, intercomparision tests were performed in several countries. The results obtained have shown that O_{90} can be affected by test conditions, as reported by Faure (1996).

In this context, a test programme has been carried out in National Civil Engineering Laboratory (LNEC), to study the influence of some test parameters, namely the soil granulometry, the vertical amplitude and the water flow rate.

2 DESCRIPTION OF THE TEST PROCEDURE

The tests were performed based on final draft of the European Standard prEN ISO 12956 (Geotextiles and geotextile related products–Determination of the characteristic opening size).

In these tests a graded granular soil is washed through a geotextile used as a sieve. For each specimen a soil mass of 7,0 kg per square metre of exposed sieving area, is spread on the geotextile and watered by means of spray nozzle. The specimens were soaked in water, at laboratory temperature, and left to saturate for at least twelve hours. It is recommended that the nozzle flow rate should be approximately 0,5 l/min at a working pressure of about 300 kPa. A sieve apparatus was used (figure 1). During 10 minutes of sieving, the water and the soil passing through the specimen are collected. Then the soil that passes through is dried and weighed. The particle size distribution is plotted on a graph with sieve size on the horizontal axis, on a semi-logarithmic scale. The cumulative percentage of the combined passed granular material, of all specimens of a geotextile sample, is plotted on the vertical axis. The characteristic opening size O_{90} corresponds to the d_{90} of the particle size distribution curve (O_{90}=d_{90}).

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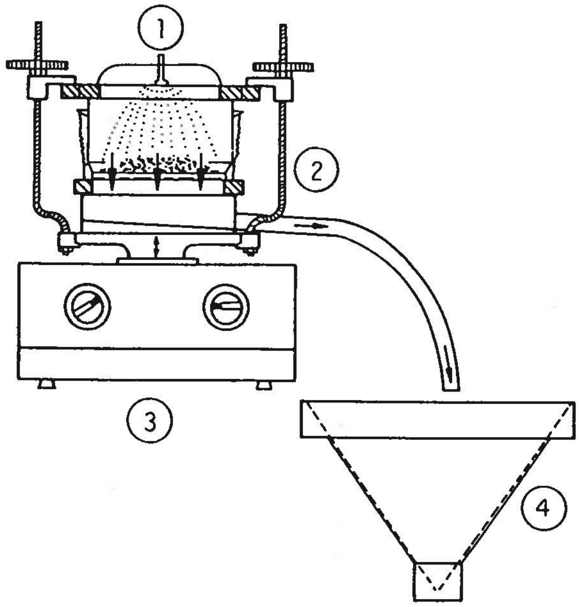

Figure 1. Example of apparatus: (1) spray nozzle, (2) clamping material, (3) sieving device, (4) collection device.

3 MATERIALS TESTED

Six nonwoven geotextiles were used in this work. Table 1 presents the fabrics tested.

Table 1. Geotextiles tested.

Geot.	Manufacturing process	Polymer type	Mass per unit area (g/m^2)
A	Needlepunched nonwoven	Polyester	133
B	Needlepunched nonwoven	Polypropylene	242
C	Needlepunched nonwoven	Polypropylene	476
D	Heatbonded nonwoven	Polypropylene	139
E	Needlepunched nonwoven	Polyester	134
F	Needlepunched nonwoven	Polyester	293

4 TEST PROGRAMME

Before the experimental programme started, the repeatability of the test method was studied. Geotextile B was selected to evaluate the O_{90} of over forty-eight specimens. The tests were performed with a vertical amplitude of 0,75 mm and with an average water flow rate of 1,4 l/min (at a pressure of 200 kPa). The soil used was the Soil 2 (see figure 2). The O_{90} obtained was:
- average = 84 µm
- standard deviation (s) = 4,5µm
- coefficient of variation = 5,2 %

Based on these values the repeatability of the test method was judged to be good.

During the tests several problems occurred:
- the soil tended to agglomerate on the surface of some specimens, preventing the soil from passing through the geotextile. When this happened, the water flow rate was increased until the agglomerate was broken up;
- water accumulated above some specimens. In these cases, the water flow rate was reduced to avoid soil particle loss.

Following the test on repeatability the O_{90} test conditions were studied. Firstly three geotextiles were tested with several soils. Then another three geotextiles were tested with different amplitudes and with two water flow rates. Table 2 relates the parameters analysed with the geotextiles used.

Table 2. Parameters analysed .

Geotextile	Repeat-ability	Soil granul.	Amplitude	Water flow rate
A			•	•
B	•		•	•
C			•	•
D		•		
E		•		
F		•		

5 TEST RESULTS AND DISCUSSION

5.1 Influence of Soil Granulometry on O_{90}

Three soils were used (figure 2). According to the CEN draft test method, the soil used must fulfil the following requirements: it must be cohesionless, the uniformity coefficient (C_u) must be greater than 3 and smaller than 20, the soil must not be gap-graded and the assumed O_{90} must be between d_{20} and d_{80}. Table 3 presents the features of the soils used.

Soil 1 was initially analysed using the ASTM series of sieves. This has fewer sieves than the ISO series. As result, the soil granulometry was not well defined for the particle sizes used to estimate O_{90}. Therefore, a new soil (Soil 2) was made up. The difference in particle size distribution obtained for Soils 1 and 2 shows how important it is to use a higher number of sieves. Thus, it is recommended to use the ISO series of sieves rather than the ASTM series.

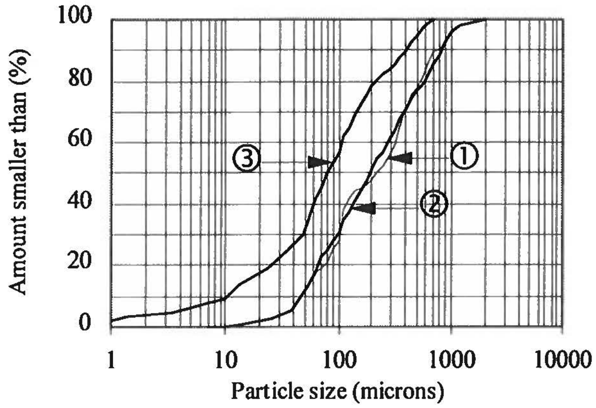

Figure 2. Particle size distribution of the soils used.

Table 3. Characteristics of the soils.

Soil 1	Soil 2	Soil 3
C_u= 6,8	C_u= 5,9	C_u= 10,3
d_{20}= 75μm	d_{20}= 67 μm	d_{20}= 25 μm
d_{80}= 532 μm	d_{80}= 583 μm	d_{80}= 218 μm

The tests were performed with an average water flow rate of 1,8 l/min (at a pressure of 200 kPa). The amplitude selected was 0,75 mm. The results obtained are presented on table 4.

Table 4. Variation of O_{90} with the soil granulometry.

Geotextile	Soil 1	Soil 2	Soil 3
	O_{90} (μm)	O_{90} (μm)	O_{90} (μm)
D	119	125	113
E	118	122	111
F	118	116	110

It seems that the O_{90} values are dependent on the soil used, at least for geotextiles with smaller mass per unit of area, since the one with higher mass per unit area only showed a slight difference in O_{90}.

Faure (1996) analysed the influence of soil granulometry in O_{90}, using the C_u of the soils as the reference parameter. He concluded that the C_u does not influence the value of O_{90} significantly.

Several problems occurred during the tests:

- water accumulated above some specimens of geotextile F when tested with Soil 1, and above some specimens of geotextiles D, E and F, when tested with Soil 3. The wet sieve pan outlet did not drain the water quickly enough. The solution adopted was to decrease inflow and the amplitude until the water drained;
- it was difficult to keep the amplitude constant for some specimens of geotextiles A, B and C tested with Soils 1 and 2. Changes occurred without any apparent cause. When this occurred, the operator had to adjust the amplitude manually.

5.2 Influence of Amplitude on O_{90}

The tests were carried out with two vertical amplitudes of 1 mm and 1,25 mm, keeping the water flow rate constant (2,4 l/min, at a pressure of approximately 200 kPa). Geotextile B was also tested with an amplitude of 0,75 mm. Soil 2 was used in the tests. The results obtained are presented in figure 3.

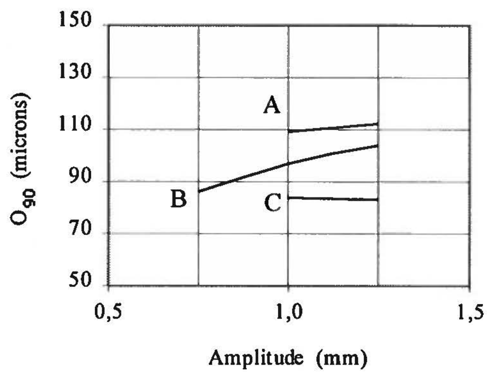

Figure 3. Variation of O_{90} with the amplitude.

Except for geotextile B, the results showed only a slight variation in O_{90} with the increasing amplitude. However, even with geotextile B it seems that O_{90} is not affected for amplitudes above 1 mm. Therefore, it is advisable to perform the test with amplitudes higher than 1 mm.

Several observations were made during the tests:

- the same problem with soil agglomeration on the surface of the geotextiles previously referred also

occurred with some specimens of geotextiles A and C, when tested with the amplitude of 1 mm, and with some specimens of geotextile A at an amplitude of 1,25 mm. In these cases, the solution adopted was to increase the water flow rate until the agglomerate was broken up;
- the difficulty with accumulation of water, also occurred with some specimens of geotextile C, when tested with both amplitudes, and with some specimens of geotextile B during the tests performed with an amplitude of 1,25 mm; Once more the water flow rate was reduced;
- it was difficult to keep the amplitude constant when some specimens of geotextile A was tested. It decreased without any explanation. When this occurred, the operator had to adjust the amplitude manually.

5.3 Influence of Water Flow Rate on O_{90}

The tests were performed with two water flow rates: 2,4 l/min (at a pressure of approximately 200 kPa) and 3,0 l/min (at a pressure of approximately 300 kPa), keeping the vertical amplitude constant (1 mm). Soil 2 was used in the tests. The results obtained are presented in figure 4.

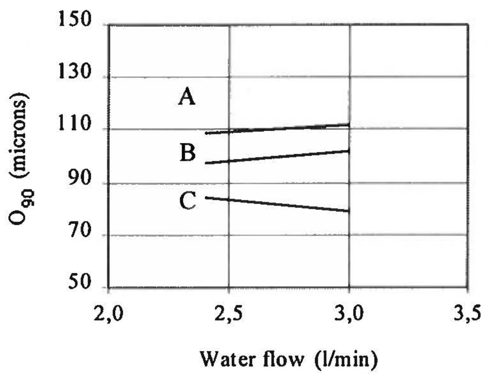

Figure 4. Variation of O_{90} with the water flow rate.

The results showed that there are no significant differences in O_{90} values obtained when water flow rate is varied, for the soil used.

During the tests several problems occurred:
- the soil tended to agglomerate on the surface of some specimens of the geotextiles A and C, preventing the soil from passing through the geotextiles. When this occurred the water flow was reduced once more. As tests progressed, soil agglomerates moved freely over the geotextile specimens;
- water accumulated above some specimens of the geotextile C, due to air that was trapped inside the top chamber. When this happened, the test was stopped and the water was allowed to flow through the inlet pipe, before the test was continued.

5 CONCLUSIONS

Based on the test results the following was concluded:
(1) for nonwoven geotextiles, soil granulometry seems only to influence O_{90} values for geotextiles with small mass per unit area. However, only a few geotextiles were tested, therefore, it is difficult to know if this influence may be attributed to the variability of the nonwoven geotextiles themselves;
(2) for nonwoven geotextiles, the O_{90} appeared to be influenced by amplitude, when the amplitude was smaller than 1 mm;
(3) for nonwoven geotextiles, the O_{90} seemed not to be affected by the water flow rate.

These conclusions must be seen in the light of the small number of tests that were performed, and the experimental difficulties encountered. The authors suggest that more tests of a similar nature should be carried out using more and different types of geotextiles.

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