Tearing strength tests in geotextiles to contribute in the evaluation of its durability in sulphurous groundwater environment

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ABSTRACT: In the present paper the results of the tearing strength tests are presented and discussed, relatively to three types of geotextiles: mechanical, chemical and thermal binding, considering the situation of the samples submerged during eight months into sulphurous running groundwater (continuous flow) and into sulphurous stagnant groundwater, in order to find out the stability of these materials in the course of the time. The final results are then compared to those obtained by the examination of properly stored samples. Finally, the global tendencies of the results of the tearing strength tests along the time, are compared with the global tendencies from tensile and static puncture tests and also with the results of permeability tests, performed in similar situations.

1 INTRODUCTION

Geotextile materials are frequently used for groundwater drainage, some times in places where they are in touch with sulphurous mineral water that, in many cases, are naturally hot. Because this type of water is frequently very aggressive to the majority of materials that are in touch, the doubt about the durability of these geotextile materials, when applied in these environments, is pertinent. Some results from similar studies but using tests different from those used in this work, were presented in Riscado dos Santos et al. (2002) and Ferreira Gomes et al. (2006). Elements about the quality and respective characteristics of sulphurous mineral water may be observed, for example, in Ferreira Gomes & Machado Saraiva (1997) and Ferreira Gomes et al. (2005).

2 MATERIALS AND METHODS

The studied geotextiles belong to the nonwoven type and three different types were used, i.e. a geotextile mechanically bonded (A), a geotextile chemically bonded (Q) and a geotextile thermically bonded (T).

The geotextiles A and Q are made of polyester and polypropylene respectively, whereas the geotextile T is made of 15% polypropylene and 85% recycled textile waste, essentially polyester, cotton and wool. The sulphurous groundwater used in this research comes from the Medical Spa located in Unhais da Serra (Portugal). It must be emphasised that this type of groundwater, when in continuous circulation, tends to form a whitish gelatinous residue (biojelly) which is typical of sulphurous waters (Fig.1).

To carry out this research, the geotextiles had to be previously cut in specimens (each one with the suitable dimension to fit the purpose of the tests), that can be divided in three groups according to the following criteria:

i) specimens submerged in vats with mineral water without circulation (stagnant water – SW), at a constant temperature of 20º C, inside the laboratory;

ii) specimens submerged in vats with running water (running water – RW), at a natural temperature of 37ºC, in the area close to the spring of the Medical Spa, inside a shack that had been especially designed to suit the referred purpose;

iii) specimens properly stored, protected from any action that might alter their quality, i.e., a shadowy place, protected from light, humidity and dust, at about a temperature of 20ºC.

The reason why the specimens have been studied only after having been submerged in vats with sulphurous water is that it is necessary to assess what may happen, in terms of the chemical alteration of the water, after it had been in contact with the geotextiles. In nature there is a continuous movement of the groundwater, as it is usual in a leaky artesian aquifer, such as the current situation, with a permeability coefficient of 2,3 to 3,1 m/day (Ferreira Gomes & Machado Saraiva 1977). When the water is circulating, and due to its continuous renovation, it is difficult to detect chemical changes in it. Anyway, it can be admitted that the reactive power of the sulphurous water in continuous renovation might be much greater than that of the stagnant sulphurous water; that is the reason why the research was carried out under those conditions.

The specimens i) and ii) have been tested for 6 continuous months and on the 8th month. After the samples had been taken off from the vats, they were placed in a shadowy, dry and ventilated place inside the laboratory for a single day; afterwards they were placed for two more days in a ventilated oven at 22ºC. The specimens iii) were just tested in the beginning, in the middle and at the end of the study, so that their results could be used as a reference.

The principal tests used in the present paper belong to the type tearing strength tests that generically follows the methodology presented in ASTM (1991). An universal dynamometric traction machine has been used, with constant elongation, a charge unit of maximal charge of 5 kN and grabs type AP102-96, 10cm width. On the specimens a trapezium has been marked, according with the Figure 2, in which a cut has been made in the middle of the smaller edge. The non parallel sides of the trapezium were fixed in the grabs of the machine. The grabs away from each other, initially 25mm, made possible that the specimen stayed stretched on the cut side and with a ply on the greater side (Figure 3). The velocity of the machine has been fixed in 300 mm/min, far enough to permit the cut to extend along all the width of the specimen. The values of applied force and respective extension were registered during the test in order to permit to get graphics of all results. For each result 5 specimens were tested, assuming that the resistance to tearing (T_s) is the average of the maximal values obtained from the 5 specimens. From using systematic tests of geotextiles A, Q and T, in two different environments (RW and SW), 5 specimens each, it resulted a total number of 30 specimens per month. During the months in which the dry environment were considered the total number of specimens were 45.

Other types of tests were used, some of them already presented in previous papers, and their results are presented for comparison with tearing strength tests. In concrete, they are the results of mass per unit area (EN965 1995), static puncture (EN ISO 12236 1996), tensile tests (EN ISO 10319 1996) and also the results of permeability tests (EN ISO 11058 1999).

3 RESULTS AND INTERPRETATION

The results obtained in the tests of mass per unit area, permeability test, static puncture test, wide-width tensile test and tearing strength test, in terms of mass per unit area (μ_A), velocity index (VI_{H50}), maximum plunger force (F_p), tensile strength (α_f), and maximum tearing strength (Ts), respectively, in specimens kept in a dry environment, are shown in Table 1. It must be emphasised that these results were obtained in three tests (months 0, 4th and 8th). These values will be used as reference for the analysis of the results obtained in the environments of running water and stagnant water.

Figure 1. (a,b) Geotextiles in vats with running water – RW, near the collecting zone in Unhais da Serra Medical Spa. (c) a close detail of the white residua; the white residua (biojelly) correspond to a typical natural product in this situation sulphurous groundwater.

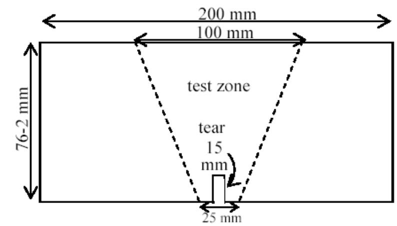


Figure 2. Scheme about preparation of specimens for tearing strength test; note: the specimens were selected with the major axe parallel to fabric direction of geotextiles.

Figure 3. Initial positioning of the specimens in the grabs of the tensile machine, for tearing tests of geotextiles.

Table 1.Results obtained from physical and mechanical tests of geotextiles in a dry environment in terms of average values.

Geo-textiles	μ_A (g/m^2)	VI_{H50} (m/s)	F_p (kN)	α_f (kN/m)	T_s (N)
A	157,76	0,0541	1,53	6,81	230,93
Q	158,95	0,0408	2,10	8,92	338,00
T	595,25	0,0054	0,26	2,08	85,10

In the sense of showing that during the 8 studding months alterations in geotextiles have been observed, specially in their permeability, the Figure 4 is presented with the results in terms of VI_{H50}, from the permeability tests and represented with some detail in Riscado et al.(2002). It must be emphasised that along the time the analysis of the values of VI_{H50} permits to conclude that sulphurous water in touch with geotextiles makes them initially more permeable and this situation comes probably from the aggressiveness of sulphurous water. The results of the physic-chemic analysis of aged water, presented with detail in Ferreira Gomes et al.(2005), give an orientation in the sense of the existence of chemical reaction between geotextiles and mineral water. The tendency to increase the permeability is inverted after some time and due to the appearing of "biojelly", which besides the clogging of geotextiles by external deposition, also has an effect of clogging internally. The biojelly is a paste similar to a whitish cream (Fig.1), fixing more superficially in textile Q but also internally inside the structure of geotextiles T and A.

The results of the tearing strength tests, relatively to running water (RW) and stagnant water (SW), carried out throughout the 8 months are illustrated in Figure 5. Examples of typical tests obtained from several geosynthetics are presented in Figure 6. The typical aspect of the specimen in open rupture is presented in Figure 7.

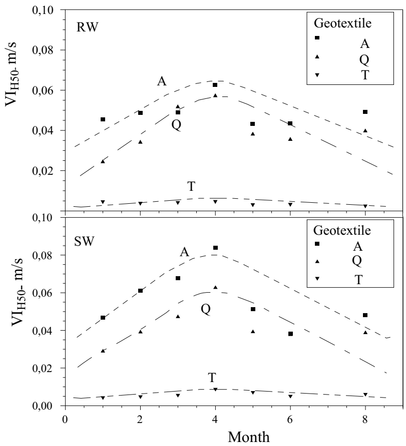


Figure 4. Evolution of velocity index (VI_{H50}) from tests in geotextiles immersed in water for 8 months long (Riscado dos Santos et al. 2002).

All tests show that geotextile Q is more resistant, followed by geotextile A and geotextile T. The results in terms of T_s, obtained after immersion in sulphurous groundwater, when compared with those in dry environment, are in general poor with the exception of geotextile A, when immersed in running water, which, after about 5 months of treatment, shows to be more resistant. The results of the tests, along the time (Fig.5), show that in stagnant water T_s decrease for all types of geotextile. In running water a decrease of T_s could be observed for geotextiles Q and T and a very curious situation could be pointed out for geotextile A in which, a long the time, the T_s increases; the explanation for this may be connected to the fact that its mechanical links are more stable faced to the aggressiveness of the sulphurous groundwater and also to the fact that the biojelly may act as a glue, increasing the resistance to tearing, once it is from the 5th month on that the increase is more significant.

Must be noticed that the tearing strength test is an excellent tool to study the durability of materials, because the tests are quick, precise and its result in terms of T_s permits to work in relative comparison as an index test to support durability. Similar situation may apply to the tests static puncture and tensile test, which have been used in the present work and the results presented in Ferreira Gomes et al.(2006). A synthesis of them is presented in Table 2, in terms of representative equations of the evolution of parameters along the time, jointly with decrease tax (-) of resistance in "%/month" or increase (+) for the case of occurrence of increase along the time. A detailed analysis of Table 2 permits to conclude that the rate of decrease in "%/month" can be observed generally in both SW and RW environments and for parameters α_f and F_p of static puncture and tensile tests, respectively, and that it must be noticed that the tendency for decrease is more evident for geotextile Q. The developing of biojelly, more evident for environment RW, creates a situation which is antagonistic to the aggressiveness of the water. The increase of μ_A that has been noticed especially in geotextile A is probably due to the appearing of biojelly.

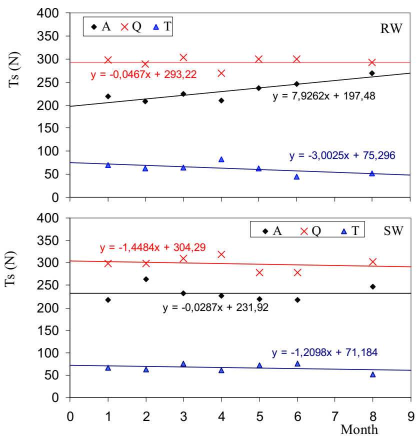
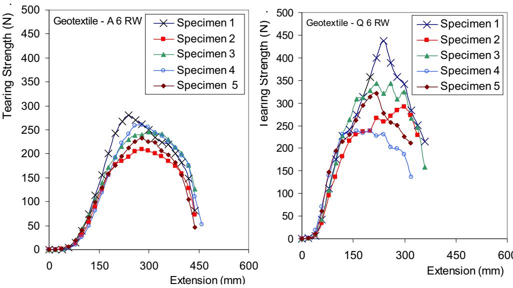


Figure 5. Results of mass per unit area (μ_A), maximum plunger force (F_p) and tensile strength (α_f), of geosynthetics tests, in running water environment (RW) and stagnant water environment (SW), for a period 8 months.

Table 2. Results of mass per unit area (μ_A), maximum plunger force (F_p) and tensile strength (α_f), of geotextiles tests, in running water (RW) and stagnant water (SW), for a period 8 months (from Ferreira Gomes et al. 2006).

Geotextile	Situation	Test –Equation	%/month
A	RW	$\mu_A = + 0,974\ t + 155,7$	0,63
	SW	$\mu_A = - 0,311\ t + 154,3$	-0,20
	RW	$Fp = + 0,010\ t + 1,4$	0,71
	SW	$Fp = - 0,017\ t + 1,5$	-1,13
	RW	$\alpha_f = - 0,004\ t + 6,4$	-0,06
	SW	$\alpha_f = - 0,044\ t + 6,4$	-0,69
	RW	$Ts = + 7,926\ t + 197,5$	4,01
	SW	$Ts = - 0,0287\ t + 231,9$	-0,01
Q	RW	$\mu_A = + 0,404\ t + 154,5$	0,26
	SW	$\mu_A = - 0,255\ t + 157,4$	-0,16
	RW	$Fp = - 0,011\ t + 2,2$	-0,50
	SW	$Fp = - 0,033\ t + 2,3$	-1,43
	RW	$\alpha_f = - 0,010\ t + 8,9$	-0,11
	SW	$\alpha_f = -0,141\ t + 9,8$	-1,44
	RW	$Ts = - 0,047\ t + 293,2$	- 0,02
	SW	$Ts = - 1,448\ t + 304,3$	-0,48
T	RW	$\mu_A = - 7,345\ t + 594,0$	-1,24
	SW	$\mu_A = - 5,208\ t + 600,5$	-0,87
	RW	$Fp = - 0,001\ t + 0,2$	-0,50
	SW	$Fp = - 0,009\ t + 0,3$	-3,00
	RW	$\alpha_f = - 0,080\ t + 2,2$	-3,64
	SW	$\alpha_f = + 0,019\ t + 2,0$	0,95
	RW	$Ts = - 3,003\ t + 75,3$	-3,99
	SW	$Ts = - 1,210\ t + 71,2$	-1,69

Unities: μ_A - g/m^2; Fp - kN; α_f -kN/m; Ts - N; t (time)-month.



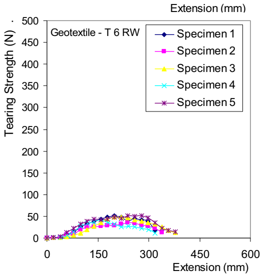


Figure 6. Typical results, in terms of tearing strength *versus* extension, for the several types of studied geotextiles.

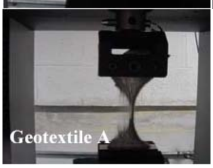


Figure 7. Images of the specimens in the moment of frank rupture of the tearing test.

4 CONCLUSIONS

The following conclusions could be drawn from the present study:

. tearing strength test is a good method to study the durability of geotextiles, because it is a precise and expeditious test, and the results in terms of Ts, obtained from specimens subjected to aggressive environments, presented as a rate of decrease/increase of T_s along the time, gives good orientation about the adequacy of the materials to be used in these environments;

. situations dealing with sulphurous groundwater are aggressive to geosynthetics; geotextile of mechanical consolidation of needle punching type (A) are more adequate to be applied in these situations; geotextile of chemical consolidation (Q) are less adequate because they are more easily altered due to chemical reactions with water elements as it can be seen through the physic-chemical analysis of the aged water used with these materials;

. more developed studies about durability of geotextile in sulphurous water environment must be carried on, not only using a longer period of time than that of this study as well as studding other geosynthetics.

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