Degradation of Geotextiles after Weathering Exposure

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ABSTRACT
UV radiation is very harmful to all the geosynthetics. Variations in physical and mechanical properties may occur due to degradation by outdoor exposure. This paper presents results of mechanical tests in PET and PP nonwoven geotextiles that were exposed to weathering (solar radiation, humidity, wind, rain) after 720 and 1440 hours (1 and 2 months). Properties were evaluated according to Brazilian standards (NBR). The results showed that the geotextiles presented some variations in tensile properties after exposure. The PET and PP geotextile samples became stiffer than fresh samples.

1. INTRODUCTION

Ultraviolet radiation and elevated temperatures are very harmful to all geosynthetics. Geotextiles show limited resistance to Ultraviolet (UV) light. Because of this, special attention must be given to avoiding exposure during storage, laying, and before applying the soil cover layer. During transport, storage, and processing geotextiles should be packed so that they cannot be damaged mechanically or by UV light. The life term of the material is determined by UV radiation (photochemical degradation) and thermal oxidation or a combination of these factors. Generally, factors such as intensity of radiation, temperature, and moisture are the agents that cause aging in polymers. UV stability may be improved with such additives as antioxidants agents and UV stabilizers. Evaluation of the effects of outdoor exposure is very important since many geotextiles may be exposed to UV effects.

This paper presents the results of tests on the tensile properties of PET and PP geotextiles that were exposed to weathering (solar radiation, humidity, wind, rain) after 720 and 1440 hours (1 and 2 months).

2. WEATHERING EXPOSURE

Temperature and UV radiation are very harmful to geosynthetics in general. Variations in physical and mechanical properties occur due to degradation caused by outdoor exposure. Solar radiation, temperature (elevated, depressed, and cycles and fluctuations), water (solid, liquid, and vapor) and normal air constituents (oxygen and ozone) are weathering factors affecting durability. Geosynthetics exposed to these factors start UV degradation that is a mechanism initiated by bond scission due to the UV wavelength that penetrated polymers and reaches the molecular structure. The UV region is further subdivided into UV-A (400 - 315 nm) which causes some polymer damage, UV-B (315 – 280 nm) which causes severe polymer damage, and UV-C (280 – 100 nm) which is found only in outer space. Polymers also show different sensibilities to wavelength: polyethylene = 300 nm, polyester = 325 nm, and polypropylene = 370 nm (Haxo and Nelson 1984, Koerner, 1998, van Santvoort, 1994 and Sharma and Lewis, 1994).

In general, natural weathering has been used exposing the samples on a suitable with specific orientation and some standards, such as ASTM 1435 (Outdoor Weathering Plastics) are used. This procedure is intended to define conditions for exposure of plastic materials to weather. It is a comparative test that depends on climate, time of year, atmospheric conditions, and so on, and as such gives only a fair indication of long-term behavior. Aluminum racks are constructed with the geotextile to be tested fixed to them and the samples can be placed at 0, 45, or 90 degrees to the horizontal and in different solar orientations. Generally, degradation is noticed as a change in color and variations in the physical properties: surface cracking and reduction of impact strength, tensile strength, and elongation (van Santvoort, 1994; Reddy & Buttul, 1998 and Koerner, 1998).

Artificial light sources (lamps) are used for laboratory simulations. They are compared with worst-case conditions or the solar maximum condition. Xenon arc exposure is widely used and has been adopted for use in geotextiles. Practice G151 provides general procedures to be used when exposing nonmetallic materials in accelerated test devices that use laboratory light sources. This practice (G151) describes performance criteria for all exposure devices that use laboratory light sources and replaces Practice G53, which describes very specific designs for devices used for fluorescent UV exposures. The apparatus described in Practice G53 is covered by this practice. Detailed information regarding procedures to be used for specific devices is found in standards describing the particular device being used. For

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example, detailed information covering exposures in devices that use carbon-arc, xenon-arc, and fluorescent UV light sources are found in Practices G152, G153, G154, and G155. Practices G152, G153, G154, and G155 are performance-based standards that replace Practices G23, G26, and G53.

In this sense, we must take into account that geographic location, temperature, wind, and moisture are factors very important in the UV degradation process of polymers. The relative durability of materials under actual use conditions can be very different in different locations because of differences in UV radiation, time of wetness, relative humidity, temperature, pollutants, and other factors.

One should never consider a laboratory exposure test as a total simulation of actual-use conditions in outdoor environments. Results from accelerated exposures must be considered as representative of actual exposures only when the degree of rank correlation has been established for the specific materials being tested and when the type of degradation is the same.

Results from a specific laboratory test may be useful for comparing the relative durability of a material exposed in a particular exterior environment, but will not be useful for determining the relative durability of the same material for a different environment.

3. MATERIAL AND METHODS

Geotextiles were exposed according to ASTM D1435. Samples were placed in a panel located in the east-west axis. Sunlight reached the samples during the entire day. Geographical coordinates were Latitude (20° 25' 23,5" S) and Longitude (51° 21' 22,6" W). The altitude is 335 meters. Climate conditions were monitored with a microdatalogger CR-23X. The medium values obtained are 26°C (temperature), 59 mm (precipitation), 65% (relative humidity), and 19 MJ/m2.day (intensity of global radiation).

Polyester (PET) and Polypropylene (PP) nonwoven geotextiles of two types were exposed and evaluated: PET (615 g/m^2) and PP (600 g/m^2). Tests were carried out in accordance with ABNT standards (Brazil standards): ABNT NBR 12568 (mass per unit area) and ABNT NBR 12824 (tensile properties). Properties were evaluated and compared to intact material. Figure 1 shows the samples exposed to weathering.

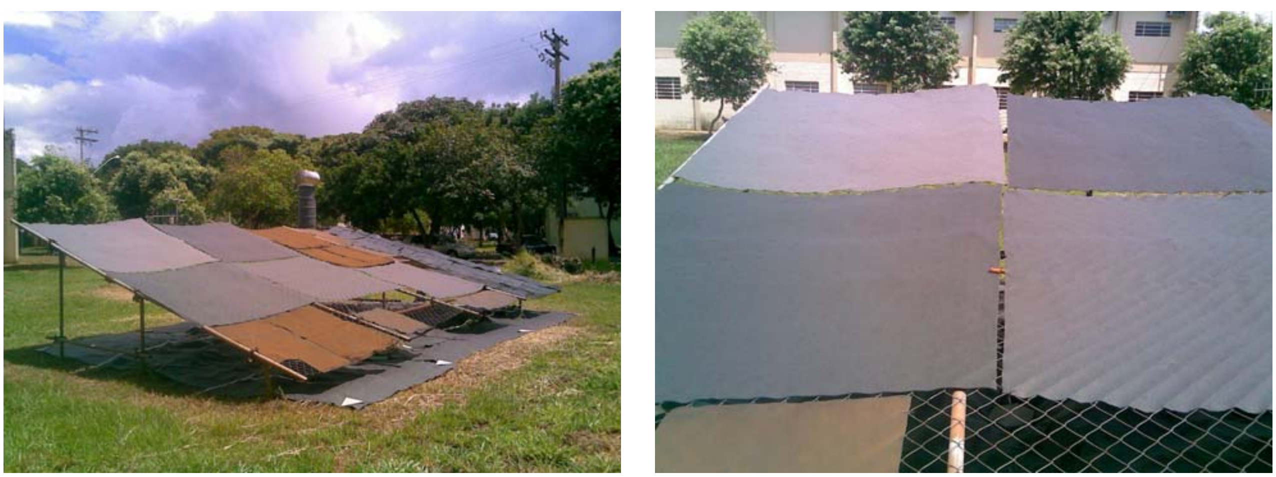

Figure 1. Geotextiles samples exposed to weathering.

4. TESTS RESULTS AND ANALYSIS

Table 1 compares the results obtained for both PET and PP geotextiles (intact and after exposure). Table 2 shows the percent of variations in these properties. A comparison of results of tensile properties is presented in Figures 2 and 3.

Table 1. Comparison of results of properties obtained for PET and PP geotextiles.

Geotextile	Condition	Mass per unit area (g/m^2)	CV (%)	Tensile Strength (N/m)		CV (%)		Elongation (%)		CV (%)	
				L	T	L	T	L	T	L	T
PET	Intact	615	7,48	28,92	35,44	4,76	4,19	65,5	66,44	4,33	7,09
	After 1 month	560	7,00	21,17	38,12	13,15	3,82	66,41	53,89	7,97	2,07
	After 2 months	500	7,00	13,31	32,37	3,35	4,74	55,77	38,01	1,90	6,87
PP	Intact	650	5,44	21,09	41,48	5,55	5,06	100,2	76,70	3,68	8,29
	After 1 month	600	5,00	25,31	32,30	3,83	6,57	57,15	50,66	1,39	4,76
	After 2 months	600	5,00	27,07	27,07	5,25	5,78	47,39	49,73	4,12	2,68

CV = Coefficient of variation; L = longitudinal or machine direction; T = transversal or cross machine direction

Table 2. Percentual variations of properties obtained for both PET and PP geotextiles after exposure to weathering.

Geotextile	Condition	Mass per unit area (g/m^2)	Tensile Strength (N/m)		Elongation (%)	
			L	T	L	T
PET	After 1 month	-8,94	-26,80	+7,56	+1,39	-18,89
	After 2 months	-18,70	-53,98	-8,66	-14,85	-42,79
PP	After 1 month	-7,70	20,01	-22,13	-42,96	-33,95
	After 2 months	-7,70	28,35	-34,74	-52,70	-35,16

(+) increases and (-) decreases

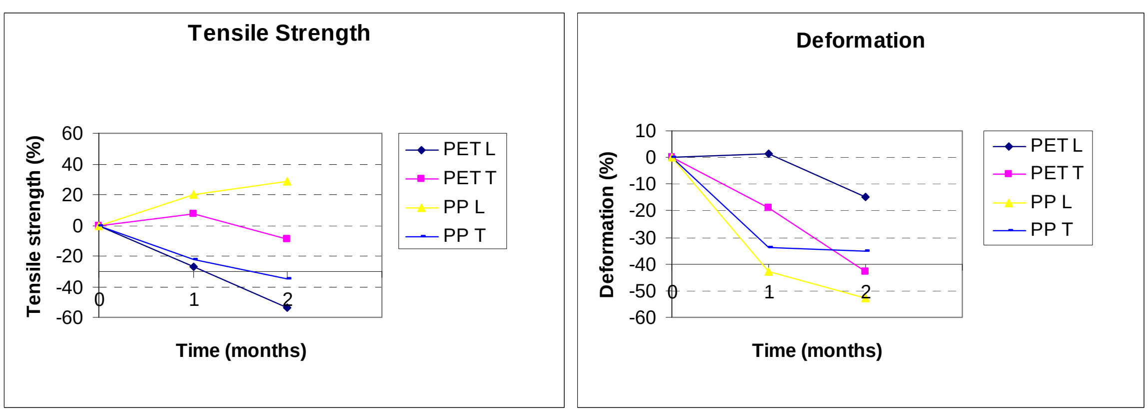

Figure 2. Variation in tensile properties.

Results show that the mass per unit area decreases after exposure (1 and 2 months) for both PP and PET geotextiles. The highest variation occurred for PET after 2 months, a decrease of 18,70%. This occurs due to the loss of additives such as antioxidant agents and UV stabilizers used to avoid UV degradation.

For tensile properties, PET and PP show the highest values in cross machine direction for intact samples. After exposure, tensile properties show a differential behavior for machine and cross machine direction:

Tensile Strength:

(a) PET: tensile strength decreased in the longitudinal direction after 1 and 2 months of exposure. Some increase occurred in the transversal direction after 1 month and some decrease in the last period.
(b) PP: the values presented increases in longitudinal direction after 1 and 2 months. The transversal direction showed decreases after the two analysis periods.

Deformation:

(a) PET: variations in deformations occurred in both directions but they were more expressive in transversal directions after the exposure periods.
(b) PP: variations were very significant for both longitudinal and transversal directions. The longitudinal direction showed the highest variation after 2 months of exposure.

In general, both PET and PP geotextiles showed significant decreases in deformation and some variation in tensile strength (see Table 2). PP geotextiles showed the highest variation (decrease) in deformation: 42.96% after 1 month and 52.70% after 2 months in the longitudinal direction. PET and PP became stiffer than fresh samples but the PP geotextile suffered the highest level of UV degradation: PP geotextile became more rigid than PET geotextile. Results show, for instance, that at the first month variations in machine direction in deformation in PP (decrease of 42.96%) were more significant than in the PET geotextile (decrease of 14.85%). This occurs because PP is more susceptible to UV degradation than PET. PP polymers present low resistance to weathering when compared to PET polymers (Agnelli, 2002).

5. SUMMARY AND CONCLUSIONS

Results of tensile properties in PET and PP geotextiles, which were exposed to weathering (solar radiation, humidity, wind, rain) after 720 and 1440 hours (1 and 2 months), were presented. Some decreases in mass per unit area occurred after exposure (1 and 2 months) for both PP and PET geotextiles. Tensile properties for PET and PP showed the highest values in cross machine direction for intact samples. In general, both PET and PP geotextiles showed expressive decreases in deformation and some variation in tensile strength. Both PET and PP geotextile presented some level of degradation. PP geotextile were more rigid and stiffer than PET geotextiles and showed the highest level of UV degradation. This fact is in agreement with the technical literature and with some research that has evaluated the behavior of geotextiles when exposed to solar radiation.

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