DEGRADATION´S ANALYSIS OF POLYMERIC GEOMEMBRANES AFTER WEATHERING EXPOSURE

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Abstract
This paper presents results of physical and mechanical tests in HDPE and PVC geomembranes which were exposed to weathering for some periods: 6, 12, 18 and 30 months. Geomembranes of two thicknesses were tested: 1.0, 2.0 mm (PVC) and 0.8, 2.5 mm (HDPE). The ASTM D1435 standard was used like a guide to evaluate the weathering degradation. The results showed that the geomembranes presented differential behavior concerning to the exposure. In general, the mechanical properties varied for both PVC and HDPE geomembranes. Results of punction and tear tests showed some increases with aging. PVC geomembranes became stiffer and HDPE were more ductile after the final exposure period.

Key words: geomembranes, weathering exposure, UV degradation, mechanical properties.

Introduction

In some geotechnical applications a geomembrane may be exposure for a short or long time. In spite of many advantages of geomembranes they can degrade when in contact with the sunlight. Sharma & Lewis (1994) say that geomembranes that are exposed outdoors may degrade and crack under prolonged exposure conditions.

Ultraviolet radiation and elevated temperatures are very harmful to all geosynthetics. In High Density Polyethylene (HDPE) geomembranes, for instance, may occurs oxidation degradation by which the molecular chains are cut off. If the oxidation starts, the molecular chains keeping the degradation process. This process results in a molecular structure totally changed, decrease of mechanical resistance and stress cracking phenomenon. In Poly Chloride Vinyl (PVC) geomembranes may occurs lost of plasticizers and volatiles resulting in decrease of elongation and brittle.

In this sense, this paper presents results of physical, tensile, punction and tear tests in HDPE and PVC geomembranes which were exposed to weathering (solar radiation, humidity, wind, rain) after 6, 12, 18 and 30 months (0.5, 1, 1.5 and 2.5 years).

Material and Methods

Geomembranes of two thicknesses were tested: 1.0, 2.0 mm (PVC) and 0.8, 2.5 mm (HDPE). The exposure periods were 6, 12, 18 and 30 months (0.5, 1, 1.5, and 2.5 years).

The ASTM D1435 was used like a guide in the proceedings to the weathering exposure. In this sense, a panel was built and located in the axis east-west. The samples are fixed in that way that they received the direct incidence of the sun along the whole day. Figure 1 shows the panel and the samples which were exposed to weathering. The place is located at the following geographical coordinates: 20° 22' S and 51° 22' W. The altitude is 335 meters. Monitoring of climate conditions was made with a microdatalogger CR-23X.

Physical and mechanical tests in HDPE and PVC geomembranes were evaluated and compared to intact material.

The following ASTM standards were used: ASTM D5199 (Measuring Nominal Thickness of Geotextiles and Geomembranes), ASTM D3776 (Mass Per Unit Area), ASTM D792 (Specific Gravity and Density of Plastics by Displacement), ASTM D638 (Standard Test Method for

Tensile Properties of Plastics), ASTM D4833 (Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products) and ASTM D1004 (Test Method for Initial Tear Resistance of Plastic Film and Sheeting).

Test Results and Analysis

The medium climate parameters obtained were: 25°C (temperature), 93 mm (precipitation), 66% (relative humidity) and 19 MJ/m^2.day (intensity of global radiation). Results of tensile properties, tear and puncture resistance are presented in Figures 2 and 3, respectively.

Physical properties showed small oscillations (0.5% – density, thickness and mass per unit area).

Concerning to tensile properties, results show some variations for both PVC and HDPE geomembranes after the periods of exposure. After the first periods PVC geomembranes showed oscillations: alterations in tensile resistance, decreases in deformation and increase in stiffness. After 18 months increases in deformation and elasticity were more expressive for PVC geomembranes (1.00 mm thickness were more affected). The samples became more rigid and stiffer than fresh samples. Concerning to HDPE geomembranes some variations occurred in deformation were more significant after 30 months. At this time, HDPE showed increases in deformation and some oscillations in elasticity. The behavior was characteristic of a ductile material.

Tear resistance showed some variations for both HDPE and PVC geomembranes. The PVC geomembranes showed a few minor changes by the all periods. Increases in tear resistance were verified but these values were not superior to 20%. Concerning to HDPE geomembranes the variations were more expressive than PVC. Variations were nearest 40% (increase) at 12 months. After 18 months the samples showed relevant variations but some decrease occurred at the last period. Interestingly the biggest thickness showed the high variations.

The puncture resistance it appears not suffers relevant variations for the HDPE geomembranes after the exposure. On the other hand, PVC geomembranes showed expressive variations for the smallest thickness. Increases in puncture resistance were superior to 40% after 18 months showed a little decrease in the last period.

Conclusions

Results of physical and mechanical properties in HDPE and PVC geomembranes which were exposed to weathering after 6, 12, 18 and 30 months were presented. A few minor oscillations in physical properties were verified. Mechanical properties presented differential behavior concerning to the periods of exposure. Results of punction and tear tests showed some increases with aging. Tear resistance in HDPE geomembranes showed variations (increase) more expressive than PVC. However, puncture resistance suffered increases more relevant mainly in smallest thickness. Some decreases were verified in the deformation of PVC. The samples became more rigid due to the lost of plasticizers. On the other hand, HDPE geomembranes became more ductile. In spite of the variations in elasticity, some increases in deformability were verified.

References

ASTM D638. *Standard Test Method for Tensile Properties of Plastics*. West Conshohocken, Pennsylvania, USA: American Society for Testing and Materials.

ASTM D792. *Specific Gravity and Density of Plastics by Displacement*. West Conshohocken, Pennsylvania, USA: American Society for Testing and Materials.

ASTM D1004. *Test Method for Initial Tear Resistance of Plastic Film and Sheeting*. West Conshohocken, Pennsylvania, USA: American Society for Testing and Materials.

ASTM D3776. *Mass per Unit Area*. West Conshohocken, Pennsylvania, USA: American Society for Testing and Materials.

ASTM D4833. *Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products*. West Conshohocken, Pennsylvania, USA: American Society for Testing and Materials.

ASTM D5199. *Measuring Nominal Thickness of Geotextiles and Geomembranes*. West Conshohocken, Pennsylvania, USA: American Society for Testing and Materials.

FAYOUX, D.; GOUSSE, F.; RUMMENS, F. Assessment on a PVC geomembrane in a landfill after ten years. *Proceedings Sardina*,v. 93, p. 369-378, 1993.

HAXO, H.; NELSON, N. Factors in the durability of polymeric membrane liners. In: international conference on geomembranes, 1984, Denver, USA. *Proceedings…* 1984. p. 287-292.

KOERNER, R. M. *Designing with geosynthetics*, 4rd ed. Englewood Cliffs: Prentice Hall Publ. Co., 1998.

REDDY, D. V.; BUTUL, B. *A comprehensive literature review of liners failures and longevity, submitted to Florida center for solid and hazardous waste management*. Florida: University of Florida, july 12, 1999. 156 p.

SHARMA, H. D.; LEWIS, S. P. *Waste containment system, waste stabilization and landfills:* design and evaluation. New York: John Wiley & Sons, Inc., 1994.

SUITS, L. D.; HSUAN, Y. G. Assessing the photo-degradation of geosynthetics by outdoor exposure and laboratory weatherometer. *Geotextiles and Geomembranes*, v. 21, p. 111-122, 2003.

VAN SANTVOORT, G. *Geotextiles and geomembranes in civil engineering*. Roterdam, Netherlands: A. A. Balkema, 1994. p. 517-518.

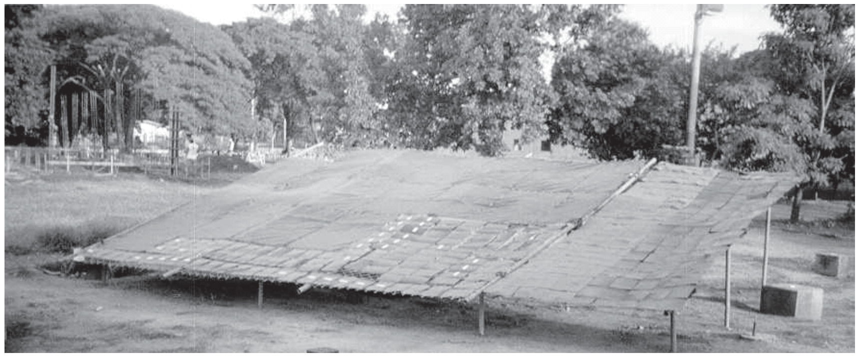

Figure 1 HDPE and PVC geomembranes samples exposure to weathering.

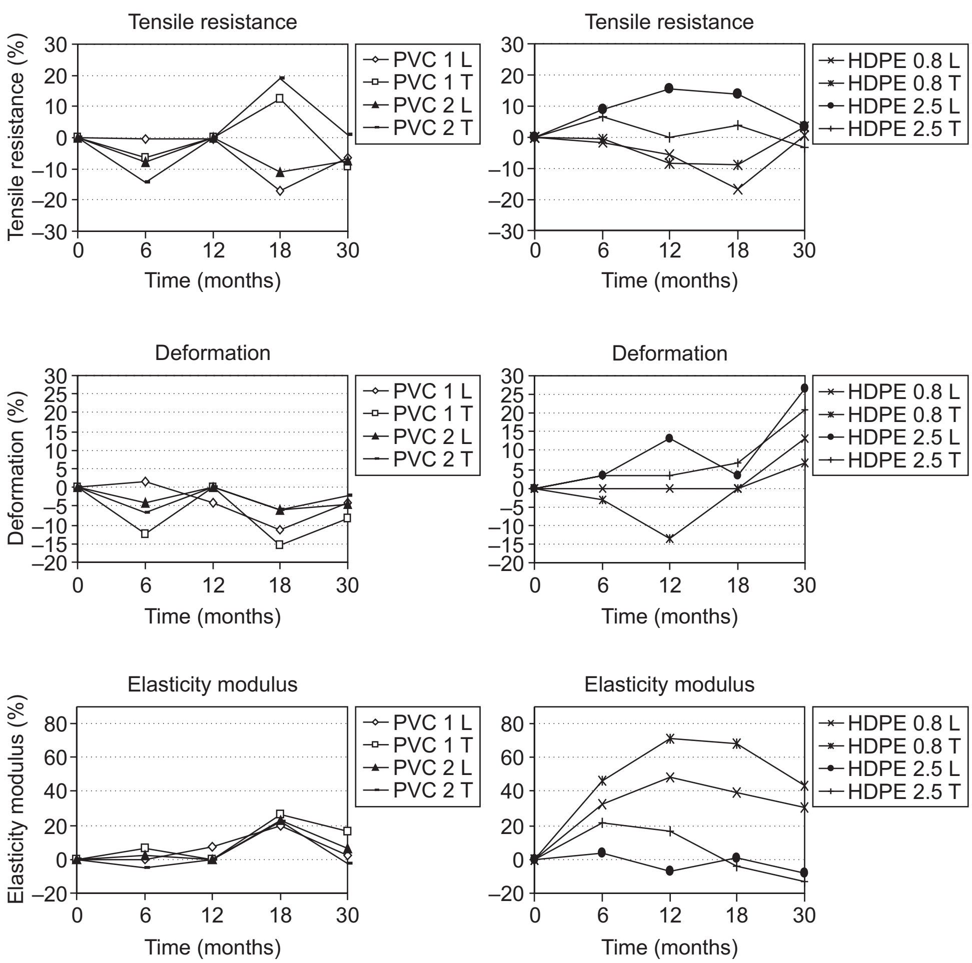

Figure 2 Tensile properties.

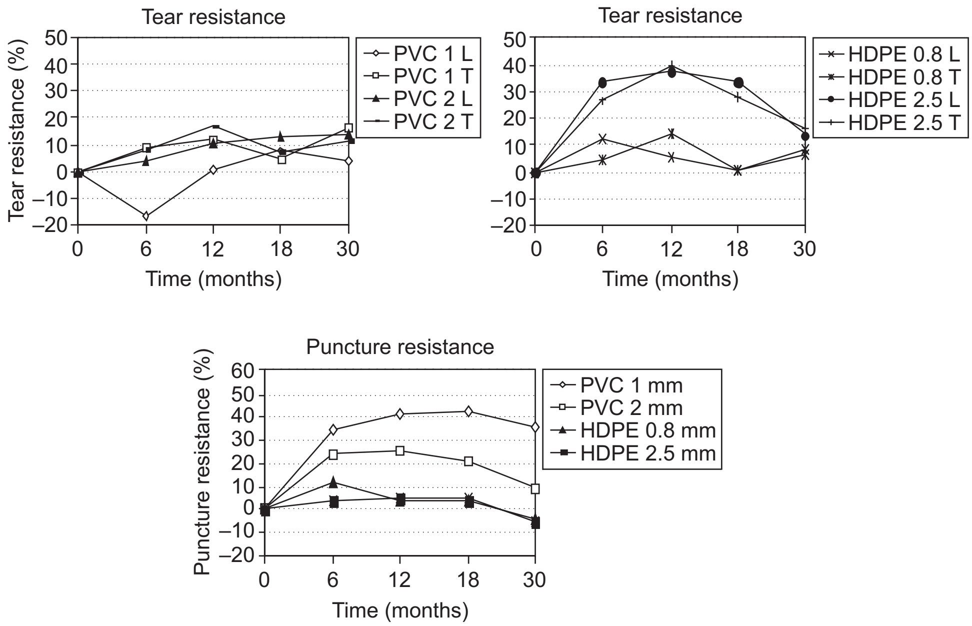

Figure 3 Tear and puncture resistances.