The durability of geosynthetics in environmental works

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The durability of geosynthetics in environmental works

J. L. E. Dias Filho and J. L. Silva

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Introduction

From the first projects in the 1950's up to present day, there are few works that have doubts about the geosynthetic behavior regarding its durability. It can be said that the main problems in geosynthetics are primarily mechanical damage and abrasion. Figure 1 illustrates general occurrences problems.




Figure 1. General occurrences of geosynthetics problems (from [1]Leshchinsky et al. 1996; [2]Kunz et al. (2014); [3]Alvarez et al. (2007) and [4]Bruscas (2015))

Objective

This presentation presents methodologies and studies that characterize the durability of geosynthetics in environmental works like in the Figure 2.

Figure 2. General occurrences of geosynthetics in environmental works

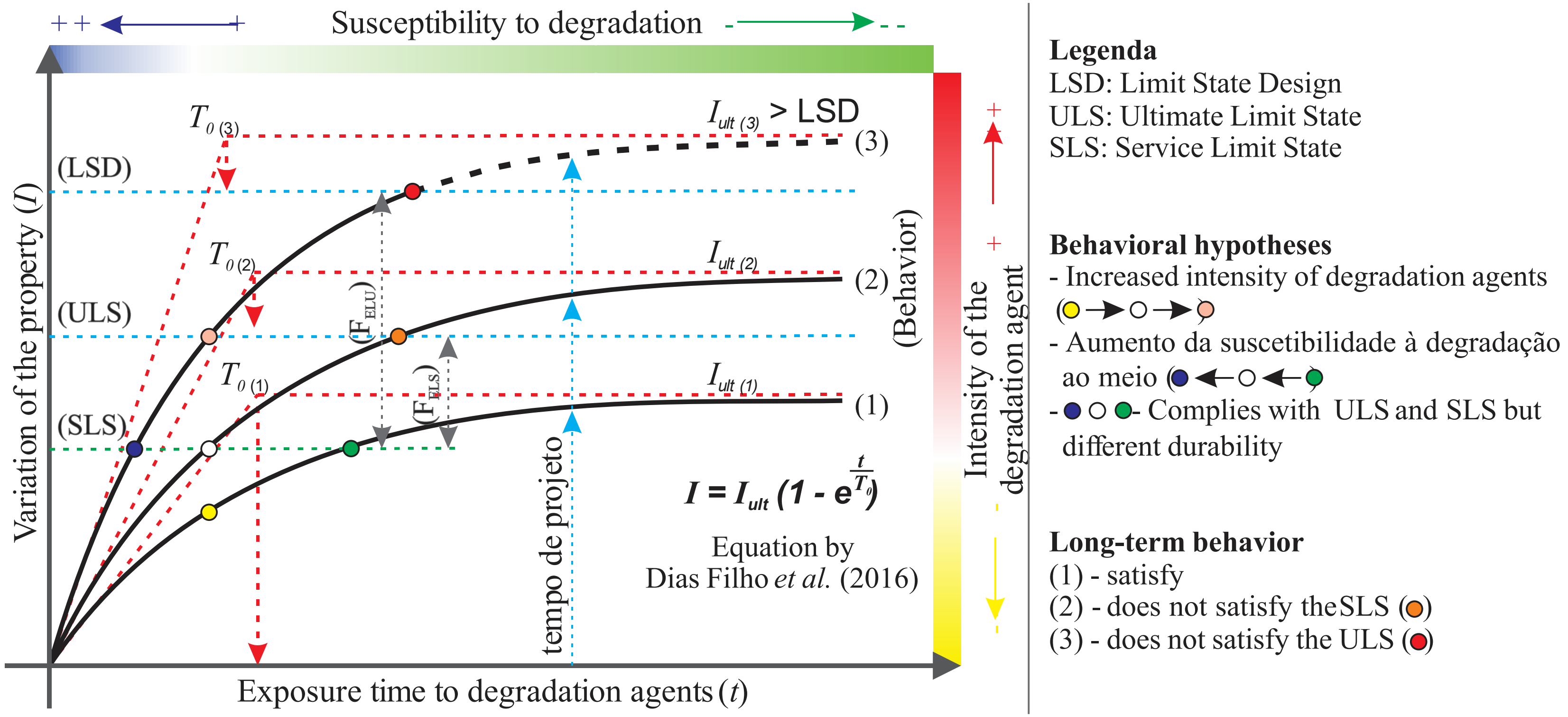
Methodology

Materials

Property	Polymers		
	PP	PET	PE
Tensile strength	***	*	*
Elongation at rupture	**	***	***
Creep	*	***	***
UV resistance (not stabilized)	***	**	*
UV resistance	***	***	***
Resistance to base	*	***	***
Resistance to microorganisms	**	**	***

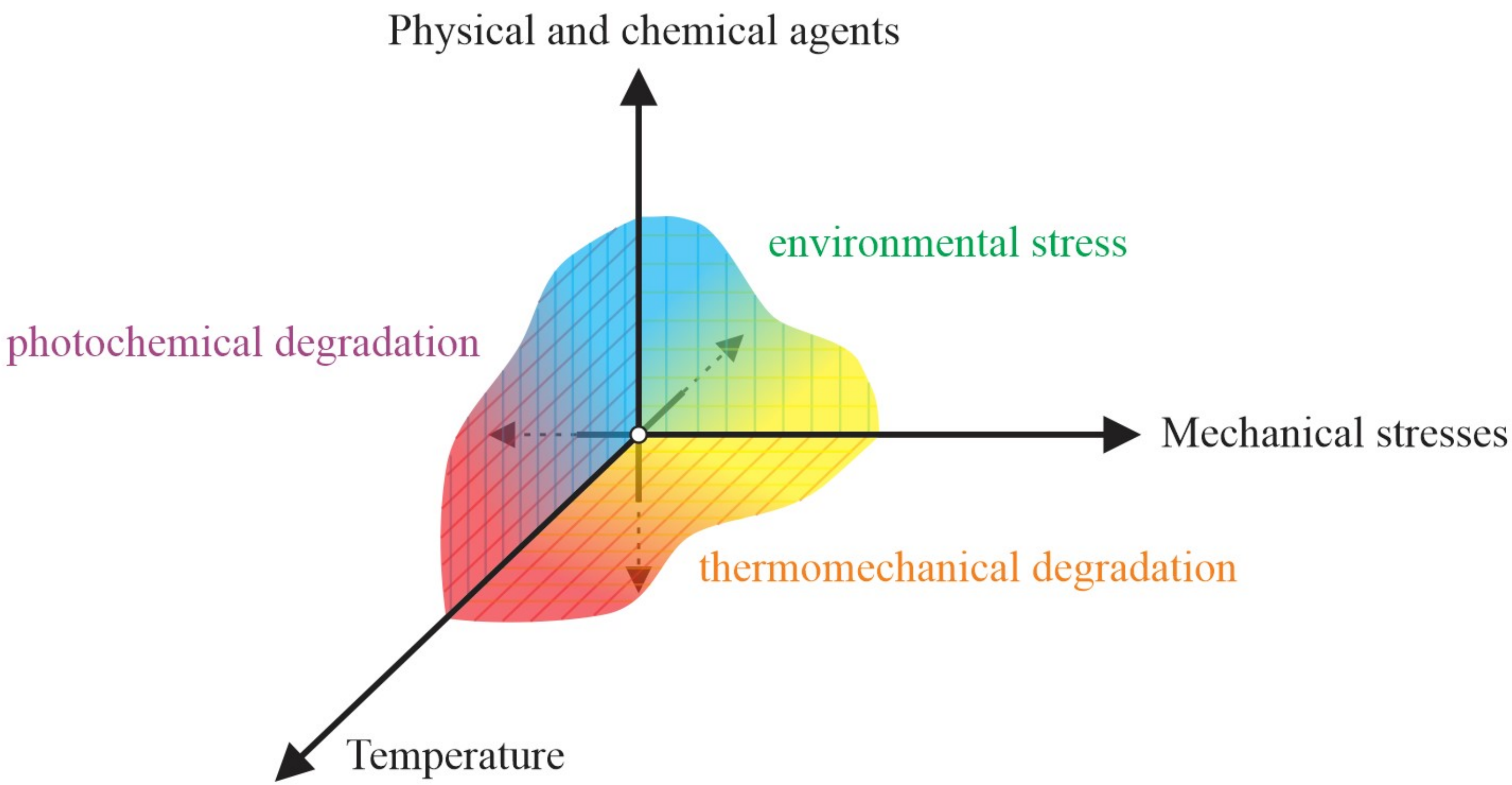
Methodology

Fundamental concepts

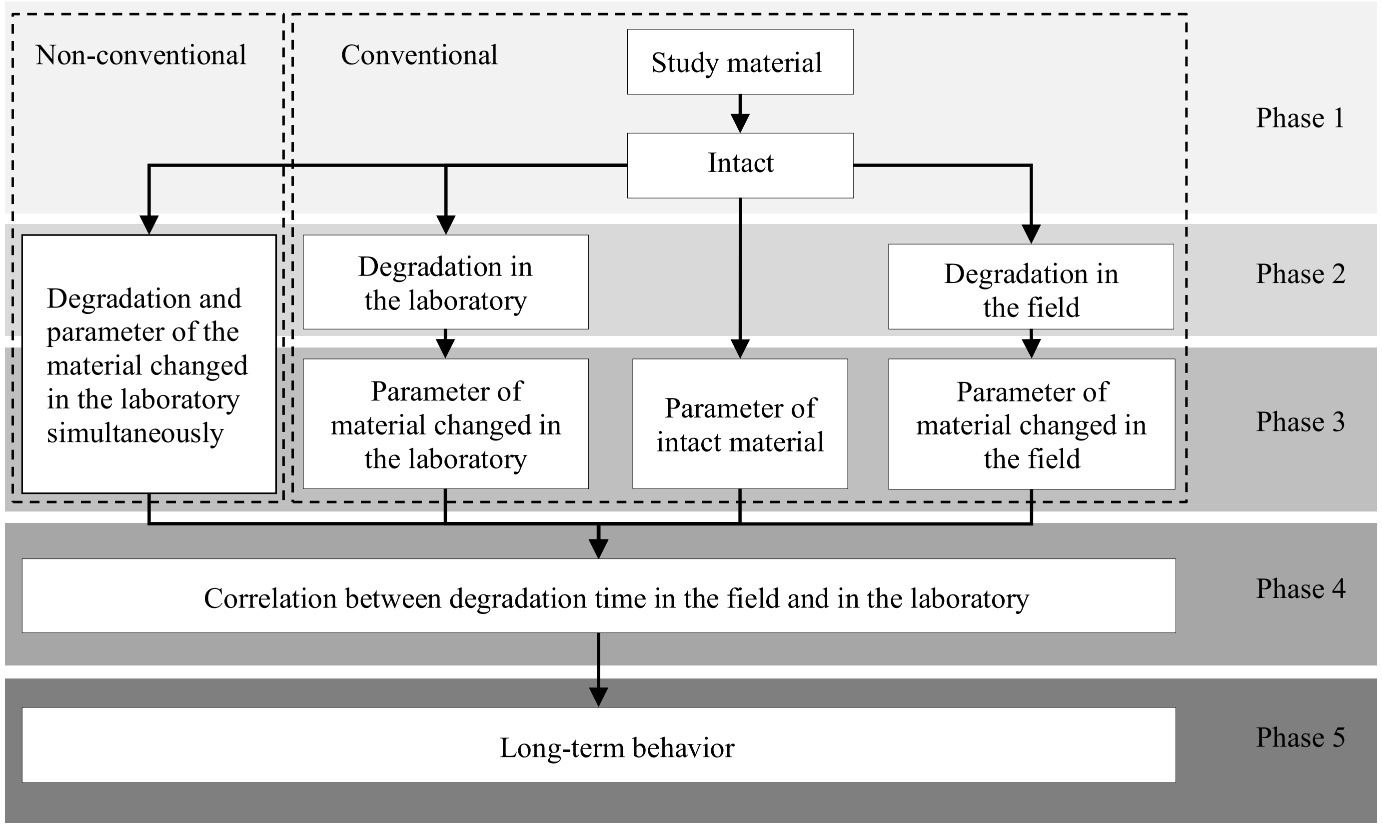


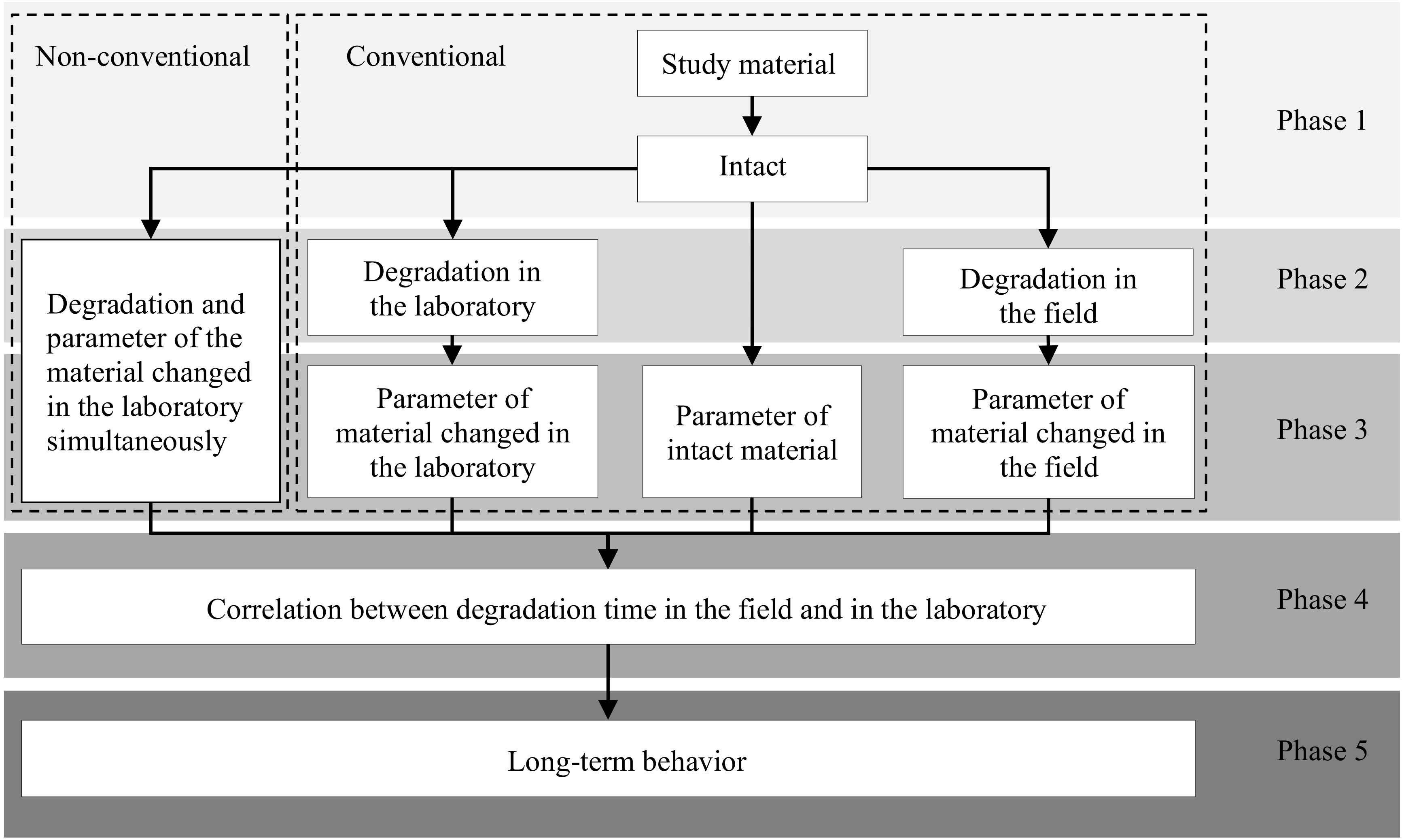
Methodology

Degradation



Results and Discussions




Non-conventional
Conventional
Study material
Intact
Phase 1
Degradation and parameter of the material changed in the laboratory simultaneously
Degradation in the laboratory
Degradation in the field
Phase 2
Parameter of material changed in the laboratory
Parameter of intact material
Parameter of material changed in the field
Phase 3
Correlation between degradation time in the field and in the laboratory
Phase 4
Long-term behavior
Phase 5

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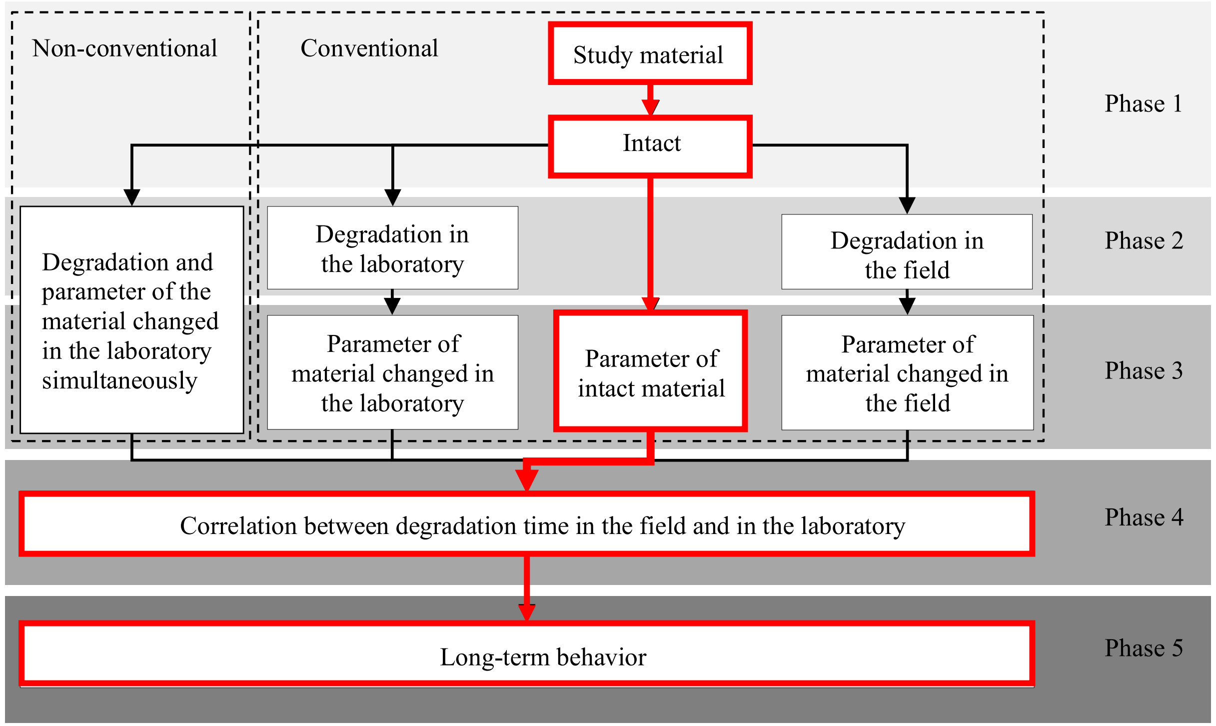

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CBR Test in Geosynthetics with Confined Support Using Sands

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ABSTRACT

The use of geotubes has become frequent in Geotechnical Engineering and, in terms of analysis, the main efforts applied in this field are based on the techniques of creeping, strengthing and also the drilling whose purpose is to analyze the material resistance in the puncture by taking the CBR test. This paper is focused on evaluating tension and deformation caused in the material which is practically found confined, allowing a better understanding about its behavior during the process. The results from this application have showed that tension and deformation are inversely proportional to the soil density condition. The main objective is to understand how confinement can change the geotubes design.

KEYWORDS: CBR test, confined punching, geotubes, woven geotextile.

INTRODUCTION

First Considerations

Geosynthetics are polymeric products which can be synthetic or natural. It is industrialized for playing different functions such as reinforcement, filtering, draining, protecting, separating, waterproofing and for surface erosion control [1]. The variety of available geosynthetics present in the current market allows its applications in several kinds of works. When specifically applied

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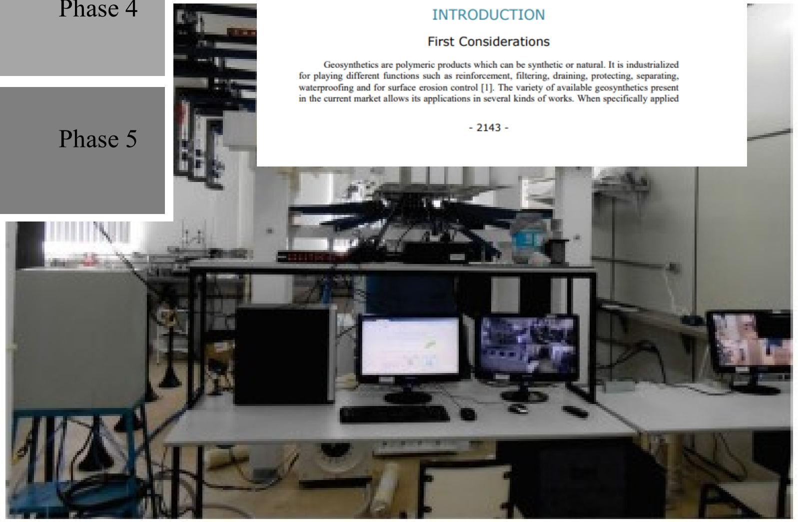

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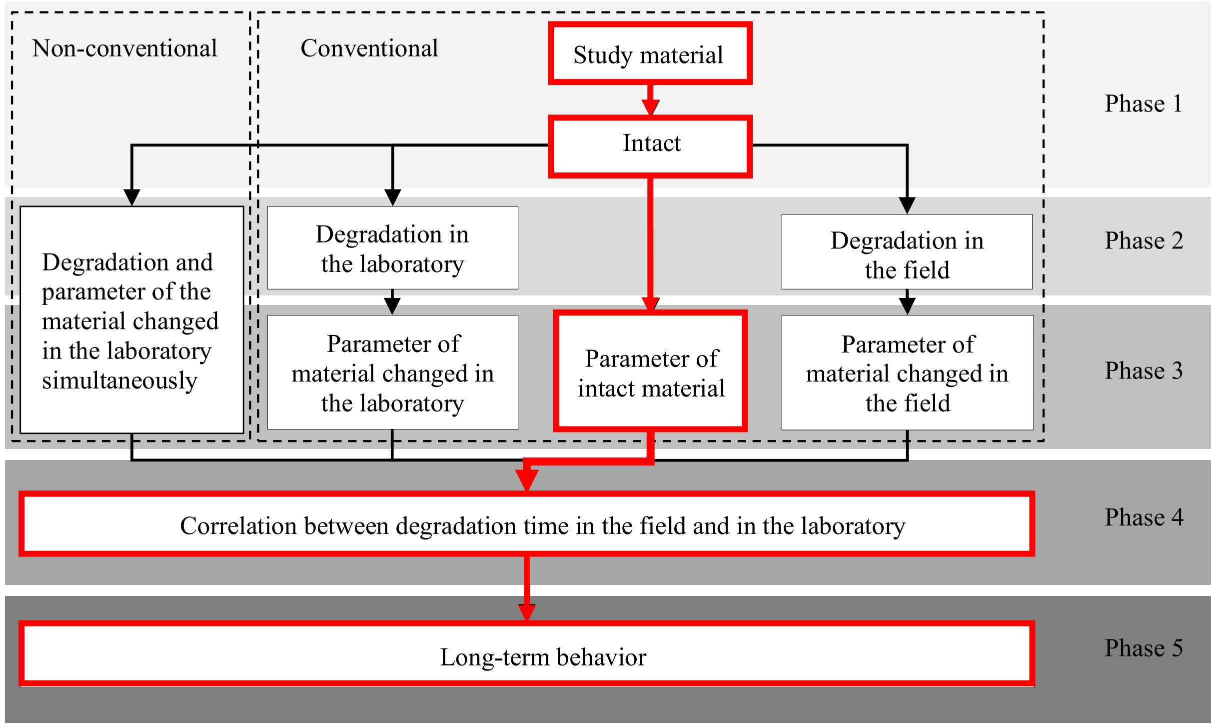

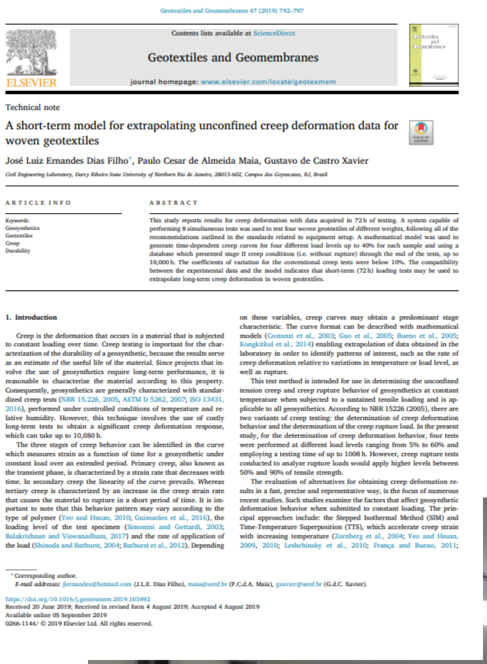

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Technical note

A short-term model for extrapolating unconfined creep deformation data for woven geotextiles

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ARTICLE INFO
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Creep
Durability

ABSTRACT
This study reports results for creep deformation with data acquired in 72 h of testing. A system capable of performing 8 simultaneous tests was used to test four woven geotextiles of different weights, following all of the recommendations outlined in the standards related to equipment setup. A mathematical model was used to generate time-dependent creep curves for four different load levels up to 40% for each sample and using a database which presented stage II creep conditions (i.e. without rupture) through the end of the tests, up to 10,000 h. The coefficients of variation for the conventional creep tests were below 10%. The compatibility between the experimental data and the model indicates that short-term (72 h) loading tests may be used to extrapolate long-term creep deformation in woven geotextiles.

1. Introduction

Creep is the deformation that occurs in a material that is subjected to constant loading over time. Creep testing is important for the characterization of the durability of a geosynthetic, because the results serve as an estimate of the useful life of the material. Since projects that involve the use of geosynthetics require long-term performance, it is reasonable to characterize the material according to this property. Consequently, geosynthetics are generally characterized with standardized creep tests (NBR 15.226, 2005, ASTM D 5262, 2007; ISO 13431, 2016), performed under controlled conditions of temperature and relative humidity. However, this technique involves the use of costly long-term tests to obtain a significant creep deformation response, which can take up to 10,080 h.

The three stages of creep behavior can be identified in the curve which measures strain as a function of time for a geosynthetic under constant load over an extended period. Primary creep, also known as the transient phase, is characterized by a strain rate that decreases with time. In secondary creep the linearity of the curve prevails. Whereas tertiary creep is characterized by an increase in the creep strain rate that causes the material to rupture in a short period of time. It is important to note that this behavior pattern may vary according to the type of polymer (Yeo and Hsuan, 2010; Guimarães et al., 2016), the loading level of the test specimen (Simonini and Gottardi, 2003; Balakrishnan and Viswanadham, 2017) and the rate of application of the load (Shinoda and Bathurst, 2004; Bathurst et al., 2012). Depending on these variables, creep curves may obtain a predominant stage characteristic. The curve format can be described with mathematical models (Costanzi et al., 2003; Guo et al., 2005; Bueno et al., 2005; Kongkitkul et al., 2014) enabling extrapolation of data obtained in the laboratory in order to identify patterns of interest, such as the rate of creep deformation relative to variations in temperature or load level, as well as rupture.

This test method is intended for use in determining the unconfined tension creep and creep rupture behavior of geosynthetics at constant temperature when subjected to a sustained tensile loading and is applicable to all geosynthetics. According to NBR 15226 (2005), there are two variants of creep testing: the determination of creep deformation behavior and the determination of the creep rupture load. In the present study, for the determination of creep deformation behavior, four tests were performed at different load levels ranging from 5% to 60% and employing a testing time of up to 1008 h. However, creep rupture tests conducted to analyze rupture loads would apply higher levels between 50% and 90% of tensile strength.

The evaluation of alternatives for obtaining creep deformation results in a fast, precise and representative way, is the focus of numerous recent studies. Such studies examine the factors that affect geosynthetic deformation behavior when submitted to constant loading. The principal approaches include: the Stepped Isothermal Method (SIM) and Time-Temperature Superposition (TTS), which accelerate creep strain with increasing temperature (Zornberg et al., 2004; Yeo and Hsuan, 2009, 2010; Leshchinsky et al., 2010; França and Bueno, 2011;

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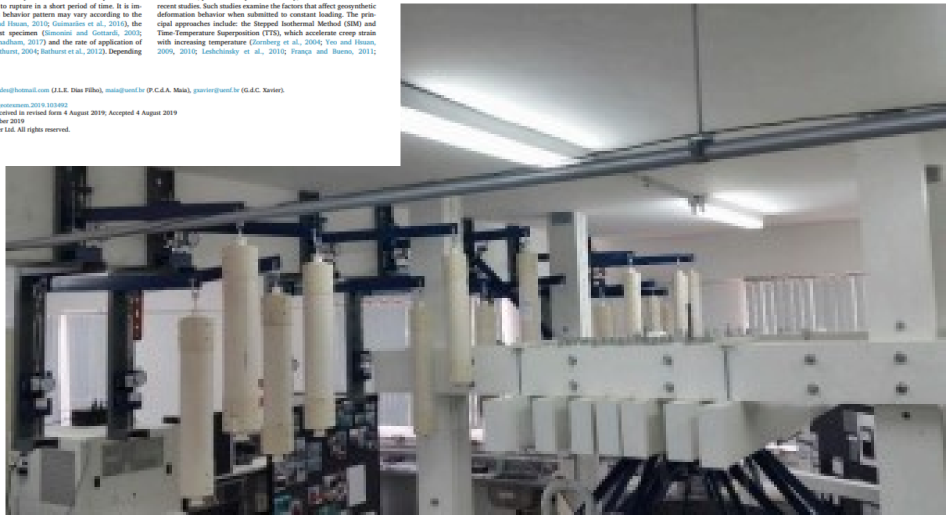

Reference	Geosynthetic type	Polymer	Load level analysed (T%)	Total time (h)	Method	c	d	e	R^2
Andrawes et al. (1984)	GTXw	PP	10, 20, 30	1000	conventional	0.005	0.626	0.600	0.986
Bueno et al. (2005)	GTXnw	PP	10, 20, 40, 60	1000	conventional	0.059	0.456	1.047	0.950
		PET	10, 20, 40, 60			0.044	0.611	0.980	0.950
Guo et al. (2005)	GGR	HDPE	20, 30, 40, 50, 55	1700	conventional	0.001	0.583	0.185	0.986
Yeo and Hsuan (2010)	GGR	PET	20, 30, 40	6	SIM	0.044	0.611	0.072	0.937
		HDPE	10, 20, 30			0.044	0.611	0.119	0.930
Becker and Nunes (2015)	GGR	HDPE	25, 40, 55	1000	conventional	0.130	0.618	0.982	0.976
			25, 40, 55		confined	0.001	2.044	0.101	0.932
Guimarães et al. (2016)	GTXw	PP	5, 10	2160	field test	0.070	0.585	0.316	0.930

GTXw = = woven geotextile; GTXnw = nonwoven geotextile; GGR = geogrid; PP = polypropylene; PET = polyester; HPDE = High density polyethylene; SIM = Stepped Isothermal Method; c, d = multiplication coefficient c ($\%/T^d$) and the dimensionless power d of the power behavior of "a" in Eq. (1); e = slope coefficient (%/kN/m) and the linear behavior of "b" of Eq. (1); R^2 = correlation coefficient.

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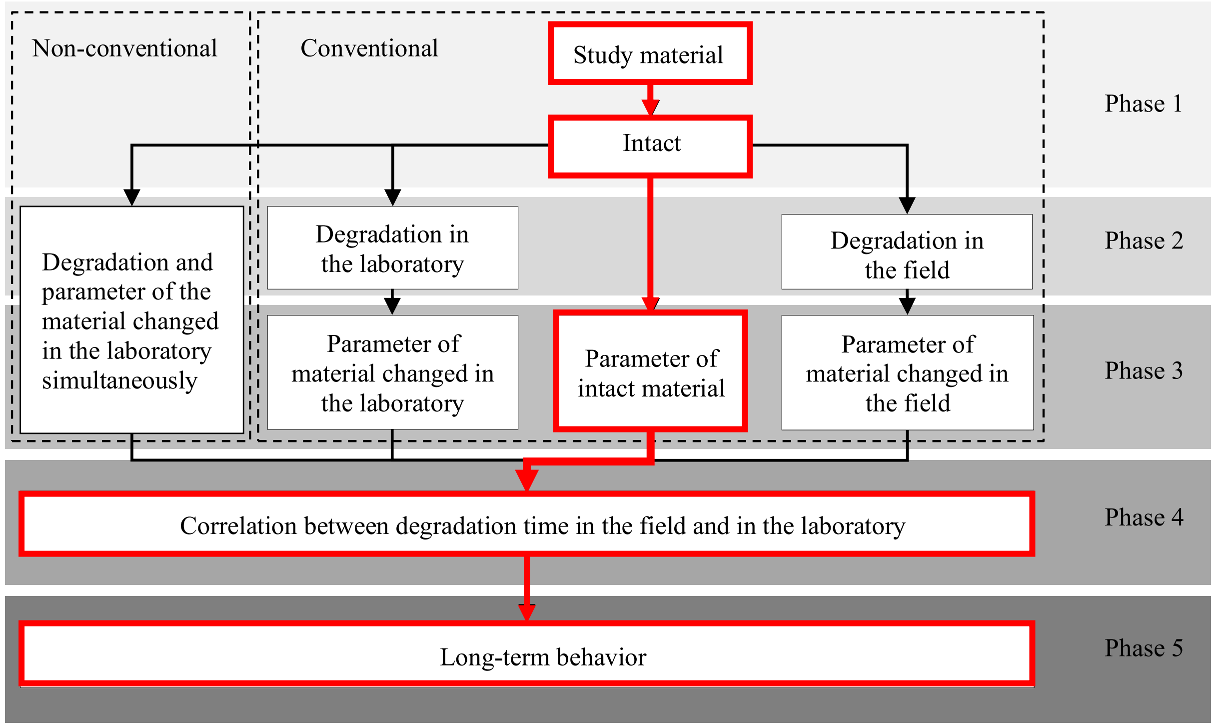


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Stress-strain behavior of geotextile: A proposed new indirect calculation using the static puncture test (CBR test)

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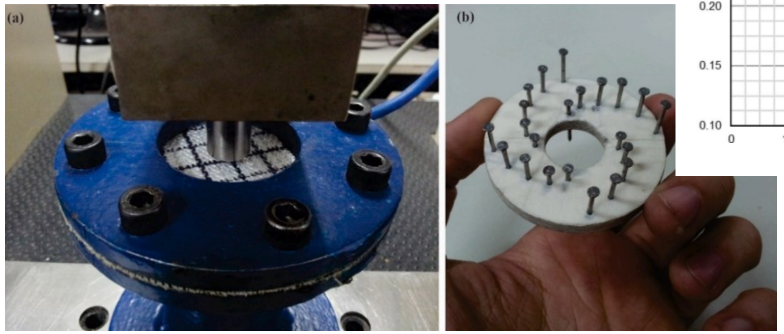
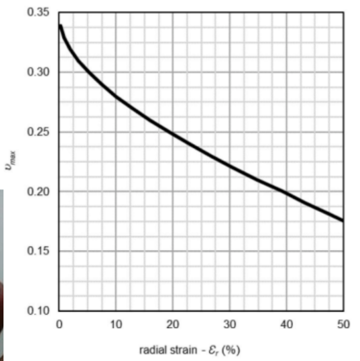
Indirect tensile strength

ABSTRACT





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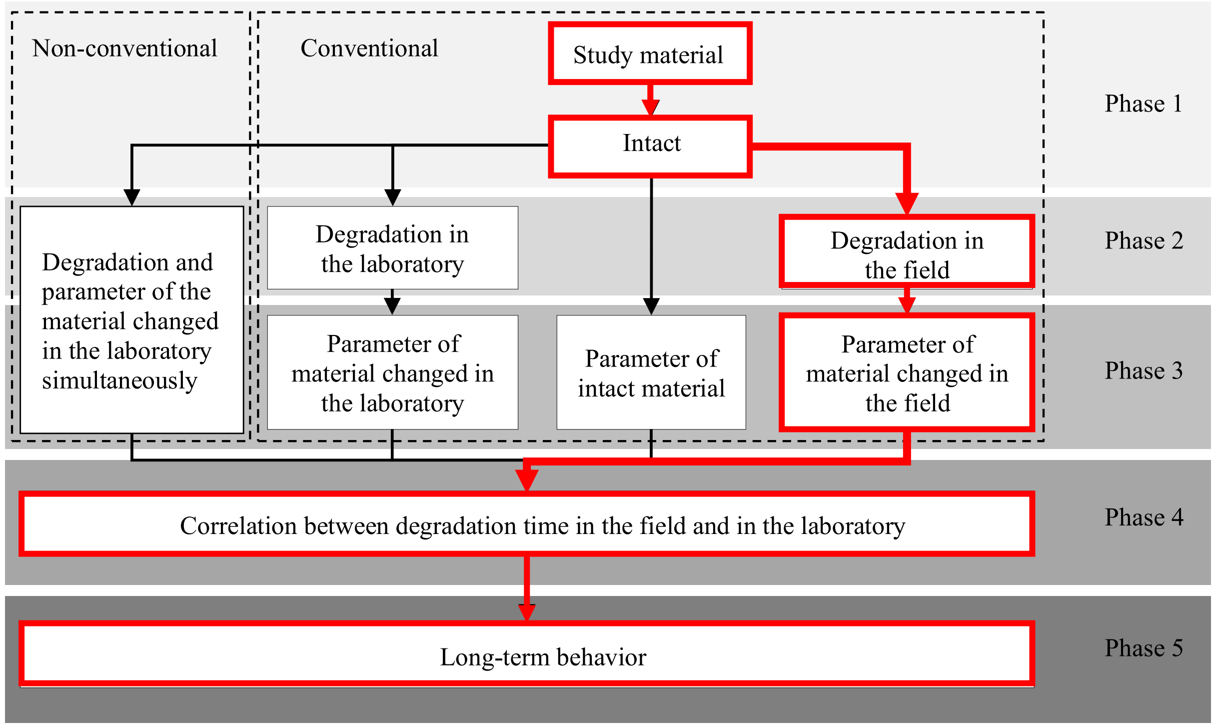

Geosynthetics International

Natural weathering effects of nonwoven geotextile exposed to different climate conditions

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ABSTRACT: Humidity, air temperature, rainfall and solar radiation all contribute to the weathering of geosynthetics. Over time, their useful life can be affected and changes in properties can be observed, which affects the performance of these materials. As geosynthetics durability analyses must encompass each work condition, assessing the climate effects is essential for design purposes. This study exposed a nonwoven needle-punched poly(ethylene) terephthalate geotextile to natural weathering in three Brazilian cities (different exogenous environments) for 18 months. Mechanical tests were conducted to evaluate the geotextile changes due to weathering. This was demonstrated by the results: exposure to weather leads to the deterioration of the geotextile mechanical properties and increased stiffness. After four months, the tensile strength fell by half, while the deformation needed more than 12 months to have this same reduction; ultraviolet radiation intensity was the most effective weathering condition in the field; humidity and rainfall can affect the stiffness of geotextiles; the impact of accumulated climate factors gradually showed a convergence in the response of geotextile to weathering. Thus, this work highlights the need to evaluate the climate conditions in each location to understand the material's behavior on the exposure time.

KEYWORDS: Geosynthetics, Geotextile, Durability

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1. INTRODUCTION

During outdoor exposure, usually in t
geotextiles are only left uncovered fo
being protected by another geotex

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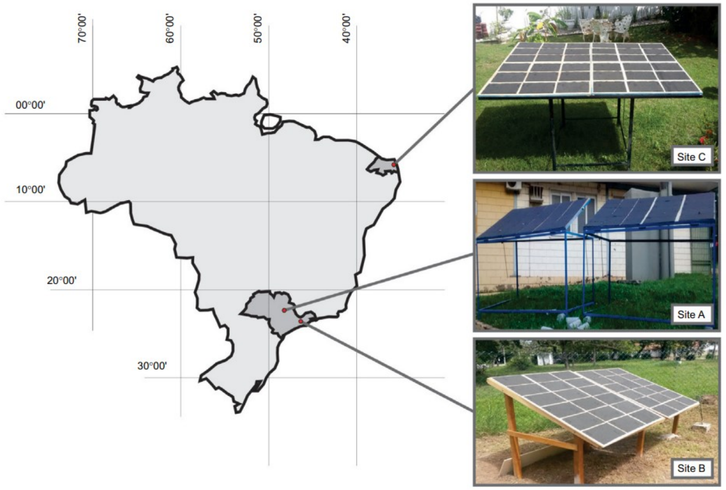

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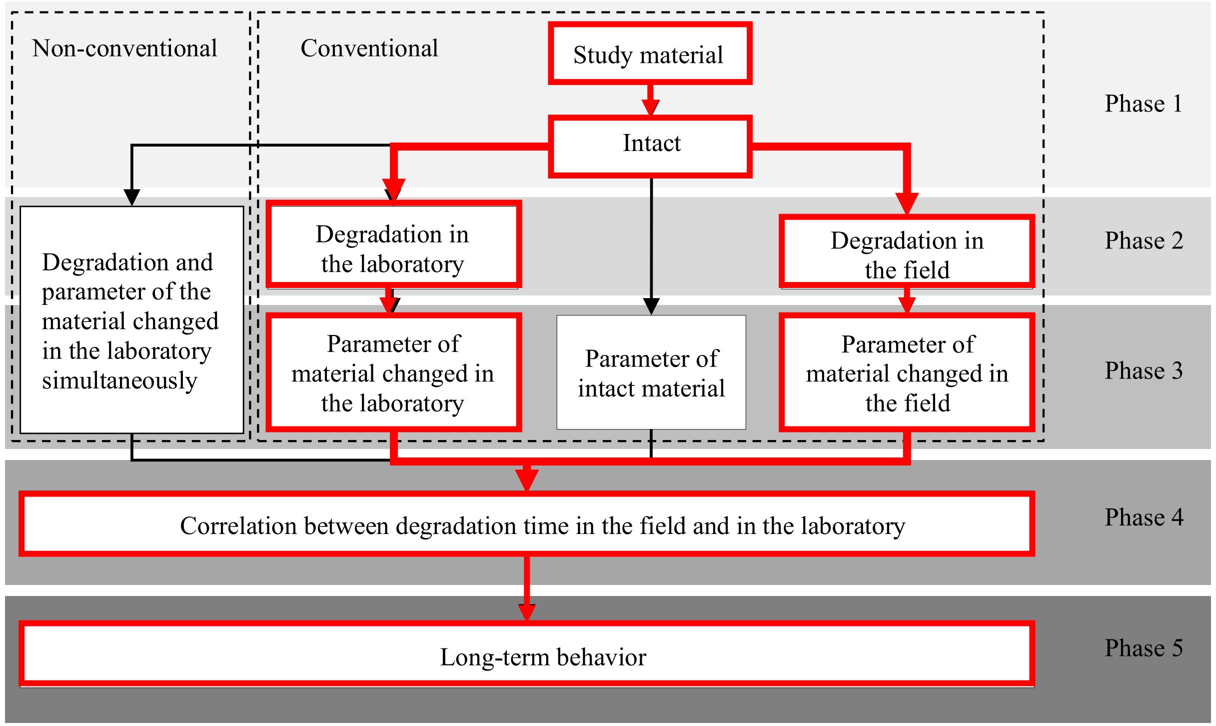

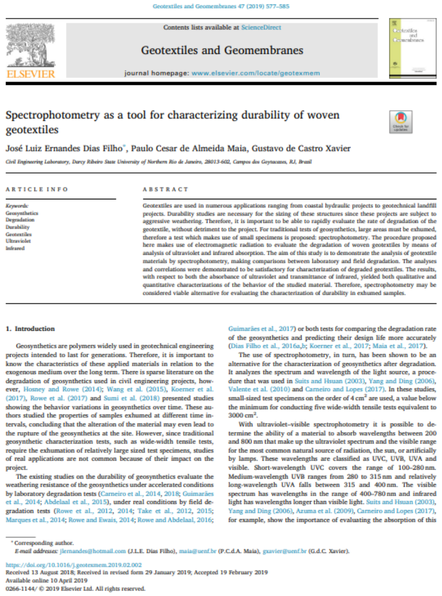
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Spectrophotometry as a tool for characterizing durability of woven geotextiles

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ABSTRACT

Geotextiles are used in numerous applications ranging from coastal hydraulic projects to geotechnical landfill projects. Durability studies are necessary for the sizing of these structures since these projects are subject to aggressive weathering. Therefore, it is important to be able to rapidly evaluate the rate of degradation of the geotextile, without detriment to the project. For traditional tests of geosynthetics, large areas must be exhumed, therefore a test which makes use of small specimens is proposed: spectrophotometry. The procedure proposed here makes use of electromagnetic radiation to evaluate the degradation of woven geotextiles by means of analysis of ultraviolet and infrared absorption. The aim of this study is to demonstrate the analysis of geotextile materials by spectrophotometry, making comparisons between laboratory and field degradation. The analyses and correlations were demonstrated to be satisfactory for characterization of degraded geotextiles. The results, with respect to both the absorbance of ultraviolet and transmittance of infrared, yielded both qualitative and quantitative characterizations of the behavior of the studied material. Therefore, spectrophotometry may be considered viable alternative for evaluating the characterization of durability in exhumed samples.

1. Introduction

Geosynthetics are polymers widely used in geotechnical engineering projects intended to last for generations. Therefore, it is important to know the characteristics of these applied materials in relation to the exogenous medium over the long term. There is sparse literature on the degradation of geosynthetics used in civil engineering projects, however, Hosney and Rowe (2014); Wang et al. (2015), Koerner et al. (2017), Rowe et al. (2017) and Sumi et al. (2018) presented studies showing the behavior variations in geosynthetics over time. These authors studied the properties of samples exhumed at different time intervals, concluding that the alteration of the material may even lead to the rupture of the geosynthetics at the site. However, since traditional geosynthetic characterization tests, such as wide-width tensile tests, require the exhumation of relatively large sized test specimens, studies of real applications are not common because of their impact on the project.

The existing studies on the durability of geosynthetics evaluate the weathering resistance of the geosynthetics under accelerated conditions by laboratory degradation tests (Carneiro et al., 2014, 2018; Guimarães et al., 2014; Abdelaal et al., 2015), under real conditions by field degradation tests (Rowe et al., 2012, 2014; Take et al., 2012, 2015; Marques et al., 2014; Rowe and Ewais, 2014; Rowe and Abdelaal, 2016; Guimarães et al., 2017) or both tests for comparing the degradation rate of the geosynthetics and predicting their design life more accurately (Dias Filho et al., 2016a,b; Koerner et al., 2017; Maia et al., 2017).

The use of spectrophotometry, in turn, has been shown to be an alternative for the characterization of geosynthetics after degradation. It analyzes the spectrum and wavelength of the light source, a procedure that was used in Suits and Hsuan (2003), Yang and Ding (2006), Valente et al. (2010) and Carneiro and Lopes (2017). In these studies, small-sized test specimens on the order of 4 cm^2 are used, a value below the minimum for conducting five wide-width tensile tests equivalent to 3000 cm^2.

With ultraviolet–visible spectrophotometry it is possible to determine the ability of a material to absorb wavelengths between 200 and 800 nm that make up the ultraviolet spectrum and the visible range for the most common natural source of radiation, the sun, or artificially by lamps. These wavelengths are classified as UVC, UVB, UVA and visible. Short-wavelength UVC covers the range of 100–280 nm. Medium-wavelength UVB ranges from 280 to 315 nm and relatively long-wavelength UVA falls between 315 and 400 nm. The visible spectrum has wavelengths in the range of 400–780 nm and infrared light has wavelengths longer than visible light. Suits and Hsuan (2003), Yang and Ding (2006), Azuma et al. (2009), Carneiro and Lopes (2017), for example, show the importance of evaluating the absorption of this

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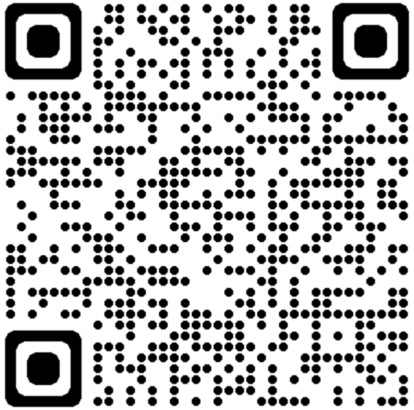

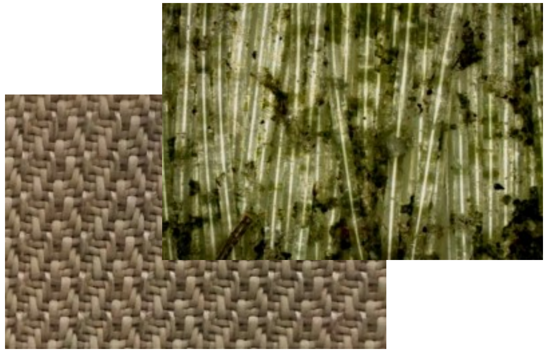

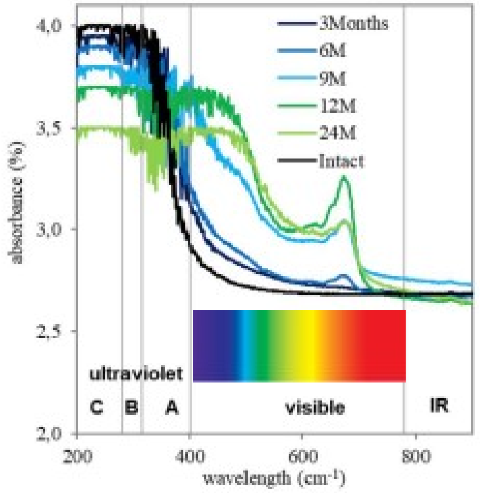

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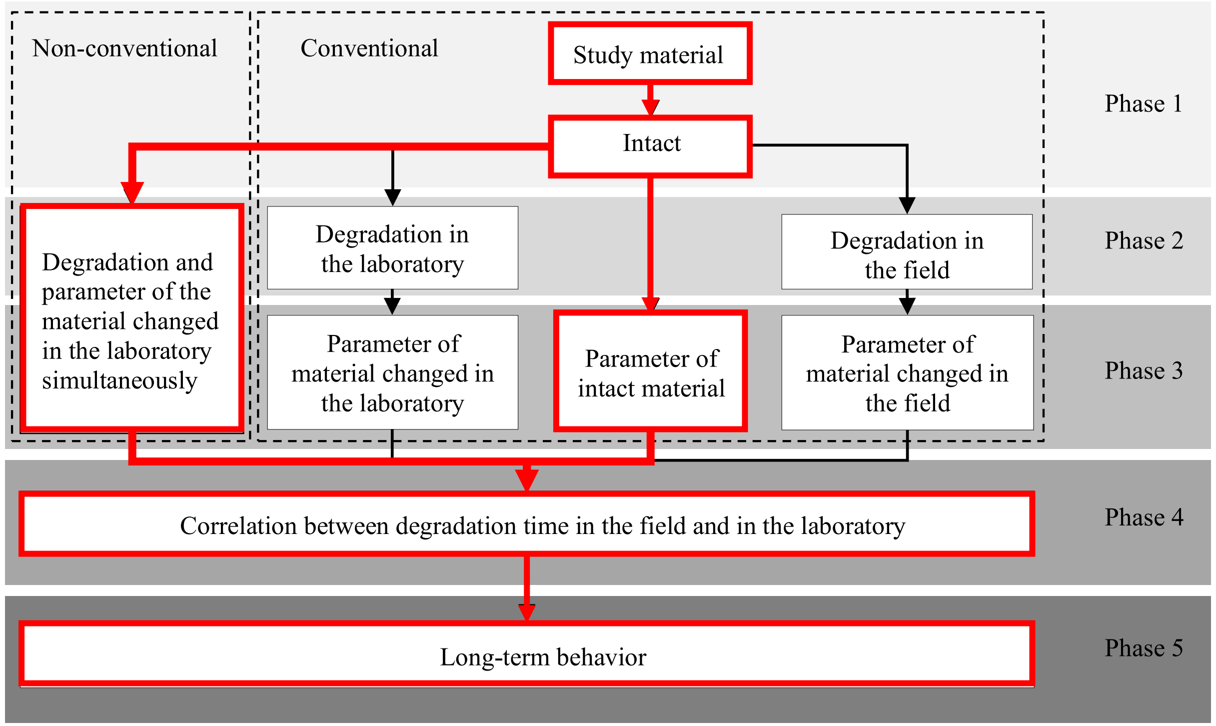

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ORIGINAL PAPER

A Non-conventional Durability Test for Simulating Creep of Geosynthetics Under Accelerated Degradation

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Abstract
The evaluation of the durability of geosynthetics for application in real structures is an important field of investigation. Within this field, the interaction between degradation agents that geosynthetics can be subject to, in their different applications, is an increasingly studied issue, because it can have direct implications in the design of the materials. Thus, this article explores a non-conventional test for geosynthetics, to simulate creep under accelerated conditions using a saturation and drying procedure simultaneous to the creep process. In this way, the material is closer to the exogenous field conditions as in, for example, riverside projects or even in coastal protection. For this, a total of 48 tests of conventional creep and under accelerated degradation conditions were carried out in 4 different geotextiles. From these tests, models were proposed and presented coefficients of determination greater than 0.84. Additional results indicate an increased strain rate ranging between 5 and 16 times in creep test from the moment that degradation simultaneous with creep is induced. Reduction factors greater than 3 indicated a very aggressive degradation process. In general, the study showed that ensuring the design life of geosynthetics calls for a simulation of degradation conditions that demand more from these materials. By enabling a more precise analysis of field conditions the creep test under accelerated conditions presents an excellent tool for project design. The significance of this study for geosynthetics design is in providing general knowledge of creep under accelerated conditions using equations and models to determine important geosynthetic parameters.

Keywords Geosynthetics · Geotextiles · Durability · Degradation · Creep

Introduction

Behavior characterization tests are widely used for all construction materials, providing essential data for the design and development of engineering projects. Technological advances have enabled the development of increasingly refined and accurate testing techniques. However, such tests are usually subject to limitations, especially related to stress–strain state and boundary conditions, which, in some cases, may not represent field conditions. This is relevant in the case of geosynthetics, given the complexity of modelling the intrinsic characteristics of the constituent materials, the geometry and the interaction with the soil. The long-term behavior of these materials is even more complex, which has led the scientific community to search for more representative procedures to simulate the behavior of these materials.

Geosynthetics are widely used in engineering across many types of projects around the world. The variety of regional conditions in the application of these materials means that there will be different degradation mechanisms acting. Understanding the exogenous environment and the degradation agents is fundamental to choosing the best form of characterization test to apply [1–5].

Solutions using sand-filled geosynthetic tubes, for example, are prominent in projects that aim to minimize the impact of surface dynamics processes. The main projects with these characteristics dated to the 1950s [6, 7]. Studies by Restall et al. [8] and Hornsey et al. [9] present damage from a common form of drilling in hydraulic projects, either through small holes generated by unintended sharp elements, or by the occurrence of knife cuts. The technical literature also presents problems related to the durability of

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Conclusions

This presentation shows a review of accelerated aging methods for geosynthetics presenting some studies and standards that allow for a durability analysis.

Considering the main raw materials used for geosynthetics, there is a greater use of PP and PET. Regardless of the base polymer, it is important to know its main characteristics to better target its application. Durability studies always evaluate the variation of geosynthetics properties according to the parameters of interest.

The methodologies to predict the long-term behavior of geotextile presented the ways of evaluating the durability in a conventional and non-conventional way. The standards and main articles show that conventional tests continue to be widely used. However, it is worth highlighting that current studies, which adapt the methodology according to the application of geotextiles in projects, are a more appropriate form of characterization to evaluate durability.

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Thank you

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