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Resistance of a nonwoven geotextile against mechanical damage and abrasion

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Abstract

The installation procedures (which induce mechanical damage) and abrasion can cause unwanted changes on the properties of the geotextiles. In this work, a nonwoven polypropylene geotextile was subjected to three degradation tests: (1) mechanical damage, (2) abrasion and (3) mechanical damage followed by abrasion (successive exposure). The damage caused by the degradation tests was evaluated by tensile, tearing and static puncture tests. Based on the changes occurred in the mechanical properties, reduction factors were determined. Results showed that the degradation tests provoked relevant reductions in the mechanical strength of the geotextile (higher reductions in the successive exposure to both degradation tests). The reduction factors for the combined effect of mechanical damage and abrasion obtained in the successive exposure to both degradation tests were different (slightly higher) than those obtained by the traditional methodology (determination of reduction factors separately for each degradation test and further multiplication).

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1. Introduction

Geotextiles are polymeric materials widely used in the construction of many civil engineering structures (like waste landfills, roads, railways, reservoirs or coastal engineering structures) due to technical, economic and environmental advantages. These materials are able to perform many different functions, such as separation, protection, reinforcement, filtration or drainage.

In their applications, the geotextiles can be in contact with many agents capable of having a negative impact on their short and long-term behaviour (deterioration of their physical, mechanical or hydraulic properties). The most common agents and/or types of degradation include: installation damage, abrasion, creep, action of liquids (like water or leachates), oxidation, weathering and the action of biological agents [1].

The damage that occurs during the installation process is originated essentially from handling the geotextiles and from the placement and compaction of backfills over them [2]. For some applications, the stresses due to the installation process can be higher than those in service [3]. The abrasion process results from a cyclic motion (friction) between the geotextiles and a contact surface [4].

Reduction factors are often applied in the design with geotextiles to account for the degradation that occurs over time. For example, for reinforcement applications the properties of the geotextiles are typically affected by a set of reduction factors related with installation damage, creep, atmospheric agents and chemical and biological agents [5,6]. Each partial reduction factor is determined separately (not considering the possibility of interactions between different degradation agents).

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The global reduction factor (used in design) is found by multiplying the different partial reduction factors.
The reduction factor for installation damage should be preferably obtained by field installation damage tests with similar conditions to real ones [7]. The reduction factors are very sensitive to the conditions used in the degradation tests, which implies some caution in their determination (the reduction factors need to represent accurately the degradation under real conditions).
A laboratory procedure (EN ISO 10722 [8]) has been developed to induce mechanical damage in geotextiles (and other geosynthetics). This method has been used by many authors to try to simulate installation damage conditions. However, the laboratory damage tests are unable to reproduce always the installation conditions or installation damage. This way, the term mechanical damage is used in this paper.
The standard tests for durability evaluation, the design methods and most studies found in literature about the durability of geotextiles consider the isolated action of the degradation agents. However, in real situations, the geotextiles will often be in contact with more than one agent. Thus, the damage suffered by the materials will always be the combined action of the different agents, which may be much different from the sum of their individual actions [9].
This paper studies the resistance of a geotextile against mechanical damage and abrasion. The main objectives of the work included: (1) determination of the effect of the degradation mechanisms in many properties of the geotextile and (2) comparison of the reduction factors obtained by the traditional methodology and by a new approach (successive exposure to both agents) for the combined effect of mechanical damage and abrasion.

2. Experimental description

2.1. Geotextile

The geotextile studied in this work was a nonwoven needle-punched made from polypropylene fibres with a linear mass of 8 denier and a length of 75 mm. The fibres were stabilized against the effects of thermo and photo-oxidation (the identity and the concentration of the stabilizers were not revealed by the producer). The geotextile had a mass per unit area of 300 g/m^2 and a thickness of 2.51 mm.
The sampling and preparation of test-specimens (for the characterization and degradation tests) were carried out according to EN ISO 9862 [10]. The specimens (prepared in the machine direction of production) were taken from positions evenly distributed over the full width and length of the sample (supplied in roll). The area next to the edges of the roll (about 100 mm) was rejected. The specimens for the same test were taken from different longitudinal and transverse positions of the roll.

2.2. Degradation tests

The geotextile was exposed to three degradation tests: (1) mechanical damage, (2) abrasion and, finally, (3) mechanical damage followed by abrasion (successive exposure to both degradation mechanisms).
The mechanical damage tests followed the guidelines of EN ISO 10722 [8]. The geotextile specimens were placed between two layers of a synthetic aggregate of aluminium oxide (corundum) and subjected to dynamic loading (ranging between 5 ± 0.5 and 500 ± 10 kPa) at the frequency of 1 Hz for 200 cycles. The grain size of corundum ranged from 5 to 10 mm. The equipment (a prototype) employed in the mechanical damage tests was formed by a test container (rigid metal box where the specimens and corundum were placed), a loading plate and a compression machine (a full description of the equipment can be found in [11]).
The abrasion tests were performed according to EN ISO 13427 [12]. These tests consisted in placing the geotextile in a stationary platform where it was rubbed by a P100 abrasive. The abrasive (installed in a slider plate) was moved under controlled pressure (6 kPa) along a horizontal axis (cyclic uniaxial movement) for 750 cycles. The equipment (a prototype) used in the abrasion tests was in compliance with the requisites of EN ISO 13427 [12].

2.3. Evaluation of the damage caused by the degradation tests

The damage suffered by the geotextile (in the different degradation tests) was assessed by visual analysis and by monitoring the evolution of some mechanical and physical (thickness) properties. Thickness (obtained at 2 kPa pressure) was determined according to EN ISO 9863-1 [13]. The mechanical characterization included tensile tests (according to EN ISO 10319 [14]), tearing tests (following the guidelines of ASTM D4533 [15]) and static puncture tests (according to EN ISO 12236 [16]).
The mechanical characterization tests were performed in a tensile machine from *Lloyd Instruments* (model LR 50K) equipped with a load cell of 5 kN (also from *Lloyd Instruments*). Elongation was measured using a

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