

# Investigation on durability testing of polyethylene(PE) geocells

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**Abstract:** In this article, the residual strength of PE geocells after accelerated aging is experimentally investigated. The characteristic is of key importance for the application of geocells, as it is related to their service life. The durability test is defined as essential in the applications standards of the product-EN 13 255:2016, EN 13 251:2016.

**Keywords:** geocells, resistance to oxidation, durability, aging.

## 1. Introduction

Geocells are increasingly being used in construction, with the accelerated standardization of their use further enhancing their use [1]. They represent a polymer structure bounded by ultrasonic welding (fig.1). Geocells provide good strength and have filtering properties. They have a standardized application for erosion control, railways, highways, etc according to EN 13250, EN 13251 etc. The product is relatively new and its application is growing, therefore the study of the characteristics is more and more relevant. The growing application also leads to higher requirements of all product characteristics. Along with all the mechanical characteristics that are subjects of researches - hardness, tensile strength, strength of internal structural junctions, yield strength, etc., an important aspect for use of these products is their service life [2].



Fig. 1 Geocells

## 2. Materials and methods

Mainly geocells are made of polyethylene. Its use is due both to its technical characteristics - chemically resistant to acids and bases, high physical and mechanical properties, etc., as well as economically - widely distributed and available virgin and recycled material. [3] Its complex of properties has established it as the main material for the manufacture of geocells. A PE mix of HDPE and LDPE, in a ratio of 6:1, with additions of masterbatch and UV stabilizers was chosen for the material. The choice is based on the following reasons - polyethylene is the most common material for geocells and one of the materials for which the standard EN 13438:2019 is applicable. The recycled to virgin ratio is 50 to 50%. The average thickness of the strips is 1.38 mm. 20 standardized samples were tested - width 200 mm  $\pm$  1 mm and with a length providing 300 mm distance between the jaws. The samples must be produced up to 24 hours before the test. The tests are made in an accredited laboratory.

The service life characterizes minimum period in which product can perform its application, provided that it is properly maintained. There is a tendency for more and more products to be tested for durability, as a key characteristic [4]. The durability test according to the standard is valid for 5 years, application that the chemical composition is not changed, a change of polymer in the composition

or a change of the concentration of polymer in the composition. Processed materials can be used without restrictions if the primary product meets the requirements.

The tested samples are first subjected to the Screening test method for determining the resistance to oxidation according to ISO 13438, which is characterized by storage in water under certain conditions and aging in a dryer. [5]. For polyethylene products, method A is used. The test consists of the following:

- Storage of the samples in water for 28 days with a water temperature of  $-80^{\circ}\pm 1^{\circ}$  (fig. 2).
- Aging in a dryer should be at a temperature of  $100^{\circ}\pm 1^{\circ}$
- Duration in the dryer is chosen for testing 50 years service life [6]. - 56 days



Fig 2. Storage in water of the samples

The samples should hang freely in the dryer (fig. 3).



Fig.3 Internal volume of the dryer

Control samples are stored for 6 hours in a bath and 6 hours in a dryer under the same conditions. The dryer must have a sufficient volume to store the samples and be equipped with a ventilation

hole, that allows controlling the temperature determined by the standard (fig. 4).



Fig. 4 The vent of the dryer

After aging, the two groups are tested for tensile strength and relative elongation according to EN 12 226.[7],[8]. The samples should be tested in both directions - machine direction{MD} and cross machine direction. The calculations of the residual strength and residual elongation at brake are carried out according to the following formulas :

$$R_r = F_r / F_c \text{ (in \%)}; \quad (1)$$

Where

$R_r$ -percentage retained tensile strength

$F_r$ -tensile load on exposed samples

$F_c$ -tensile load on controlled samples

$$R_\epsilon = \epsilon_r / \epsilon_c \text{ (in \%)} \quad (2)$$

$R_\epsilon$ -percentage retained elongation at brake

$\epsilon_r$ -elongation brake on exposed samples

$\epsilon_c$ -elongation brake on controlled samples.

### 3 Results and discussion

The results are tabulated in tables- 1,2,3,4,5,6,7,8.

Tab.1 Results of tensile strength,MD,controlled samples

Tensile strength	Unit	Standard	Result	Deviation of testing
Sample No 1	kN/m	EN 12226	26,35	No
Sample No 2	kN/m	EN 12 226	24,25	No
Sample No 3	kN/m	EN 12 226	23,78	No
Sample No 4	kN/m	EN 12 226	25,54	No
Sample No 5	kN/m	EN 12 226	24,47	No

Average. 24.86

Tab. 2 Results of elongation at brake,MD,controlled samples

Elongation at brake	Unit	Standard	Result	Deviation of testing
Sample No 1	%	EN 12 226	205	No
Sample No 2	%	EN 12 226	210	No
Sample No 3	%	EN 12 226	220	No
Sample No 4	%	EN 12 226	210	No
Sample No 5	%	EN 12 226	205	No

Average 210

Tab. 3 Results of tensile strength,CMD,controlled samples

Tensile strength	Unit	Standard	Result	Deviation of testing
Sample No 1	kN/m	EN 12 226	17,95	No
Sample No 2	kN/m	EN 12 226	17,98	No
Sample No 3	kN/m	EN 12 226	16,19	No
Sample No 4	kN/m	EN 12 226	17,88	No
Sample No 5	kN/m	EN 12 226	18,23	No

Average 17.65

Tab. 4 Results of elongation at brake,CMD,controlled examples

Elongation at brake	Unit	Standard	Result	Deviation of testing
Sample No 1	%	EN 12 226	145	No
Sample No 2	%	EN 12 226	155	No
Sample No 3	%	EN 12 226	135	No
Sample No 4	%	EN 12 226	140	No
Sample No 5	%	EN 12 226	140	No

Average 143

Tab. 5 Results of tensile strength,oxidized samples,MD

Tensile strength	Unit	Standard	Result	Deviation of testing
Sample No 1	kN/m	EN 12226	22,24	No
Sample No 2	kN/m	EN 12 226	20,35	No
Sample No 3	kN/m	EN 12 226	21,41	No
Sample No 4	kN/m	EN 12 226	22,57	No
Sample No 5	kN/m	EN 12 226	21,08	No

Average 21.53

Tab. 6 Results of elongation at brake,oxidized samples,MD

Elongation at brake	Unit	Standard	Result	Deviation of testing
Sample No 1	%	EN 12226	175	No
Sample No 2	%	EN 12 226	170	No
Sample No 3	%	EN 12 226	175	No
Sample No 4	%	EN 12 226	180	No
Sample No 5	%	EN 12 226	205	No

Average 181

Tab. 7 Results of tensile strength,oxidized samples,MD

Tensile strength	Unit	Standard	Result	Deviation of testing
Sample No 1	kN/m	EN 12226	16,45	No
Sample No 2	kN/m	EN 12 226	14,52	No

Sample No 3	kN/m	EN 12 226	17,10	No
Sample No 4	kN/m	EN 12 226	16,53	No
Sample No 5	kN/m	EN 12 226	16.15	No
Average			16.15	

Tab. 8. Results of elongation at brake, oxidized samples, CMD...

Tensile strength	Unit	Standard	Result	Deviation of testing
Sample No 1	%	EN 12226	110	No
Sample No 2	%	EN 12 226	115	No
Sample No 3	%	EN 12 226	105	No
Sample No 4	%	EN 12 226	110	No
Sample No 5	%	EN 12 226	110	No
Average			110	

According to EN 13255:2016 and related standards for the application of geocells, a product that is composed of new or recycled polyethylene can be considered sufficiently durable (for 50 years) in natural soils with a pH between 4 and 9 and a soil temperature  $\leq 25$  °C if it passes the residual strength setting test after oxidation (28 days at 80 °C in water and 56 days in a dryer at 100 °C)[9]. The results have significant repeatability, which is indicative of their validity. The results cannot be used to calculate another durability period, because of the specificity of the test standard.

#### 4. Conclusion

The following conclusions can be drawn from the investigation:

- Testing of PE geocells (with a ratio of HDPE to LDPE 6:1, with a ratio of 1:1 virgin and recycled raw materials) showed a residual strength of over 50%, which under the test conditions corresponds to a 50-year service life.
- All requirements of the exam standard have been met.
- The repeatability of the results and the low value of their range shows that the test is correct.
- The test results can be used as a basis for researching other products made from PE with the same or similar ratios of HDPE and LDPE.
- The study shows results significantly above the required 50% residual strength, but the results cannot be used to directly prove a longer service life of the products, because of the specificity of the test. This will be the subject of other studies, as well as comparative analysis with other standardized tests relating to service life and durability.

#### 5. Refferencies

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