INVESTIGATION OF GEOTEXTILE RESISTANCE TO THE ENVIRONMENT

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ABSTRACT

The aim of this work was to provide an investigation of nonwoven geotextiles resistance to the environment. When a geotextile is used in a civil engineering structure, it is intended to perform a particular function for a minimum expected time. It should be chemically and biologically resistant, whilst the assessment of the geotextiles durability and application requires a study. Therefore, in this research, the geotextile resistance was investigated in three directions: the resistance to microbiological attack by soil burial (EN 12 225), the resistance to the oxidation (ISO 13438) and the resistance to liquids (acid and alkali, EN 14030). All the samples were tested before and after the exposure according to standardized methods for determination of mechanical (CBR and strip test) and chemical properties (absorption, adsorption, specific amount of surface charge).

Keywords: *geotextile, separation, resistance to microbiological attack, resistance to oxidation, resistance to liquids, physical-mechanical properties, specific amount of surface charge*

1. INTRODUCTION

When a geotextile is used in a civil engineering structure, it is intended to perform a particular function for a minimum expected time, called the design life [1]. Any application may require one or more functions from the geotextile such as filtration, protection, reinforcement, separation and surface erosion control. Each function uses one or more functional properties of the geotextile, such as tensile strength. Assessment of the durability of an application using geotextiles requires a study. The durability is related to the change of a property of an installed geotextile with a time, and depends upon it polymeric formulation and polymer microstructure, on any additives and fillers compounded with it, the fibre geometry and fabric layout [2]. The geotextile should be chemically and biologically resistant what can be determined by application of standardized methods.

2. EXPERIMENTAL

Experimental part was done on the two different types of nonwoven geotextiles samples: the grey sample (*sample 1*) and the white sample (*sample 2*) donated by the company Regeneracija d.o.o., Zabok, Croatia. Before the test, the basic characterization of nonwoven geotextiles was performed (Table 1).

Table 1. Characterization of samples

Sample	Fiber composition	Mass per unit area [g/m^2]	Thickness [mm]
1	PES	271	0.996
2	PE	298	3.396

2.1 Resistance to microbiological attack by soil burial

EN 12225:2000 specifies a method for the determination of the microbiological resistance of geotextiles and geotextile-related products by a soil burial test. The method consists of exposing test specimens to microbial active soil under specified conditions. At the end of the exposure time, the test specimens evaluated visually, both before and after cleaning, and tested by measuring physical properties by different tests methods as CBR and strip test and absorption/adsorption properties tests.
The test soil shall contain a variety of micro-organisms. Natural soil was collected in the field. The moisture content of the test was 60 % of SMC (saturation moisture content).
Strips, 100 mm long, 25 mm wide, of a bleached, and untreated woven cotton fabric were used as a reference to test the biological activity of the soil.
Microbicides - an ethanol - water mixture 70:30 was used as a cleaning and disinfectant fluid after the soil burial test.
Test climate - A dark environment with admission of fresh air ventilation controlled at (95 ± 5) % relative humidity and (26 ± 1) °C was used to maintain the moisture content of the test soil at 60 % of SMC.

2.2 Resistance to acidic and alkaline liquids

According to the EN 140030:2001 resistance to acidic and alkaline liquids were determined. The test was used as a method of screening geotextiles for resistance to liquids of specific pH values:

- Acidic liquid test: an inorganic acid - 0.025 M sulphuric acid with 1mM ferric sulphate and 1 mM ferrous sulphate added (pH 1.5),
- Alkaline liquid test: an inorganic base - calcium hydroxide ($Ca(OH)_2$), used as a saturated suspension (pH 12.1).

Five specimens of each type of geotextile in both directions were immersed in the test liquids (sulphuric acid and calcium hydroxide) at a temperature of 60 ± 1 °C for a period of three days. After the liquid immersion, the exposed specimen is subjected to a tensile test and measured against a control specimen taken from the same production line.

2.3 Resistance to oxidation

According to the EN ISO 13438:2004, resistance to oxidation was determinate. It is an accelerated test for the evaluation of the rate of oxidation of polyolefin materials, in particular applicable to polypropylene and polyethylene based products. Five test specimens in both direction and for each type of geotextile were tested. Specimens were exposed to an elevated temperature in air (110 °C) over a fixed time period (28 days), using a regulated laboratory oven without forced air circulation. After the oven aging, the exposed specimen is subjected to a tensile test and measured against a control specimen taken from the same production line.

2.4 Absorption properties

The evaluation of some aspects of the behaviour of nonwoven fabrics in the presence of liquids was performed according to the ISO 9073-6:2000. In particular: the liquid absorbency time (LAT); the liquid absorptive capacity (LAC) and the liquid wicking rate (capillarity) (LWR) were determined for the untreated specimens and the specimens after a soil burial test.

2.5 Specific amount of surface charge

The specific amount of surface charge is one of electrokinetic properties of textiles. It changes with the change of material surface, impurities content, finishing and dyeing; indicating the state of material. The specific quantity of surface charge was calculated after dwelling in polyelectrolyte solution applying back-titration method [3] on Titrino 736 (Metrohm) using ionic surfactant electrode 6.0507.120 (Methrom). N-cetylpyridine chloride (N-CPC) was used as cationic, and Sodium dodecyl sulphate (SDS) as anionic surfactant polyelectrolyte solution.

3. RESULTS AND DISCUSSION

In the way of the easiest following determined results, all treatments with belonging codes are shown in Table 2.

Table 2. Treatments with the belonging codes

Treatment/Sample		Sample 1		Sample 2		Reference sample	
Microbiological		Before	Buried	Before	Buried	Before	Buried
		0G-M	**G-M**	**OW-M**	**W-M**	**O-CF**	**CF**
Oxidation		Before	After	Before	After		
		0G-OX	**G-OX**	**OW-OX**	**W-OX**		
Liquids	**alkali**	Before	After	Before	After		
		0-G	**G-AL**	**O-W**	**W-AL**		
	acid	Before	After	Before	After		
		0-G	**G-AC**	**O-W**	**W-AC**		

O – untreated, G – grey, W – white, OX - oxidation, M – microbiological, AC – acid, Al – alkali, CF-cotton fabric

3.1 Results of microbiological attack by soil burial

Results of determination microbiological resistance through mechanical characteristics by the static puncture test are shown in Figure 1. Results of determination microbiological resistance by strip test are shown in Figure 2.
From the results shown in the Figure 1 it can be seen that tensile strength of *sample 1* was increased after buried in soil for 6 weeks (from 575 to 716.6 N), whilst it decreased for the *sample 2* from 40004.6 N to 3330.7 N. Polyester fibres, *sample 1* are known as a fibres with a good resistance to microorganisms, especially bacteria. They are not good medium for growing up fungi and mildews, or attractive to insects, and therefore its strength remains.
On the other hand, it is to assume that the photo-oxidation enhanced microbiological degradation of s*ample 2* since it has been storage for a long period in the daylight. The oxidation process can be initiated both by chemicals in the soil of by microorganisms and influenced on the results of the mechanical properties [4]. The mechanism of degradation of polyethylene polymers is oxidation whereby the long carbon chain of the synthetic polymer is shortened. From the results of the microbiological resistance expressed through mechanical properties by strip test it can be seen that the tensile strength and elongation decreased for *sample 2* and reference cotton fabric. Reference fabric, in accordance with the standard was cotton fabric, shows significant decreased results, and drastically changed appearance of the sample surface after buried in the soil. *Sample 2* shown similar behaviour, so it can concluded that it is sensitive to soil, soil moisture, which significantly damaged sample.
Sample 1 shown good resistance to microorganisms by strip test. Increased results are because of Ca-carbonate (from tap water). Ca-carbonate deposited on the surface and in the structure of the *sample 1*. On that way increases the results of tensile strength. That deposition did not influenced on the elongation, indeed improved elongation.

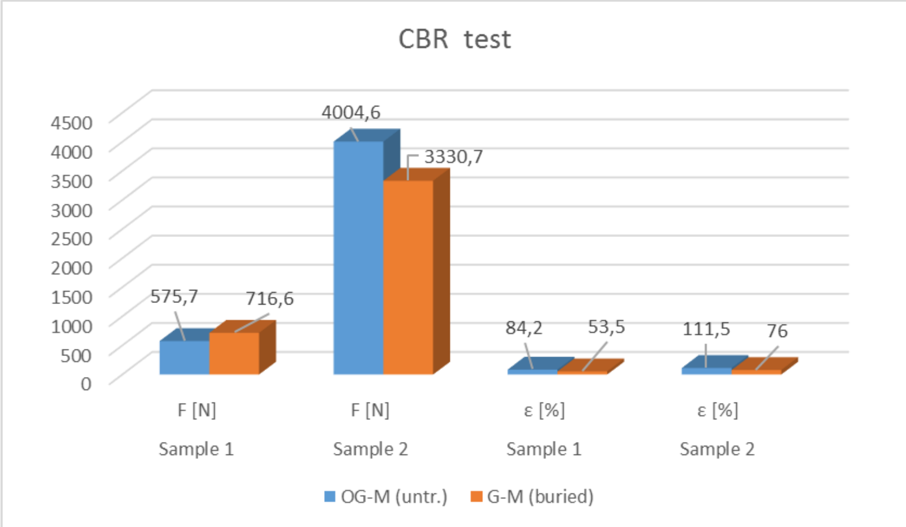

Figure 1. Results of CBR test

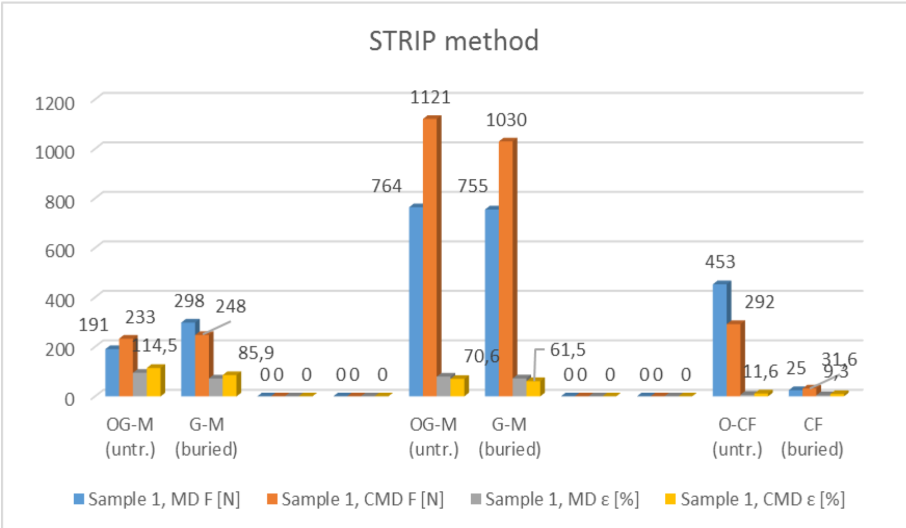

Figure 2. Results of strip test

3.2 Results of resistance to oxidation

Results of determination of resistance to oxidation through mechanical characteristics by strip test are shown in Figure 3. It is very important for geotextile, especially polyethylene (*sample 2*) that can lead to the degradation of performance properties. With this accelerated test it is obviously that *sample 1* has great resistance to oxidation, whilst the *sample 2* has not. The significant decrease of tensile strength and elongation of *sample 2* leads to recommendation that it cannot be used for applications in presence of oxygen.

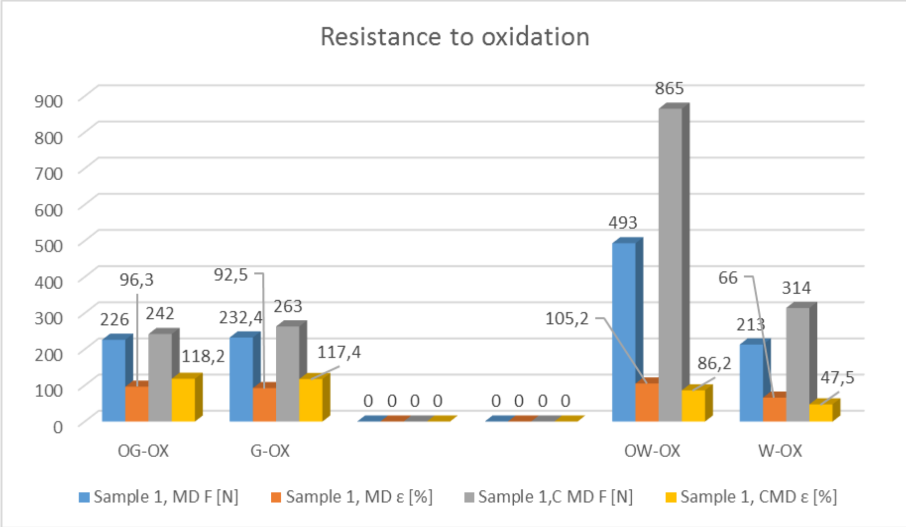

Figure 3. Results of strip test

3.3 Results of resistance to liquids

Results of determination of resistance to liquids through mechanical characteristics by strip test are shown in Figure 4.

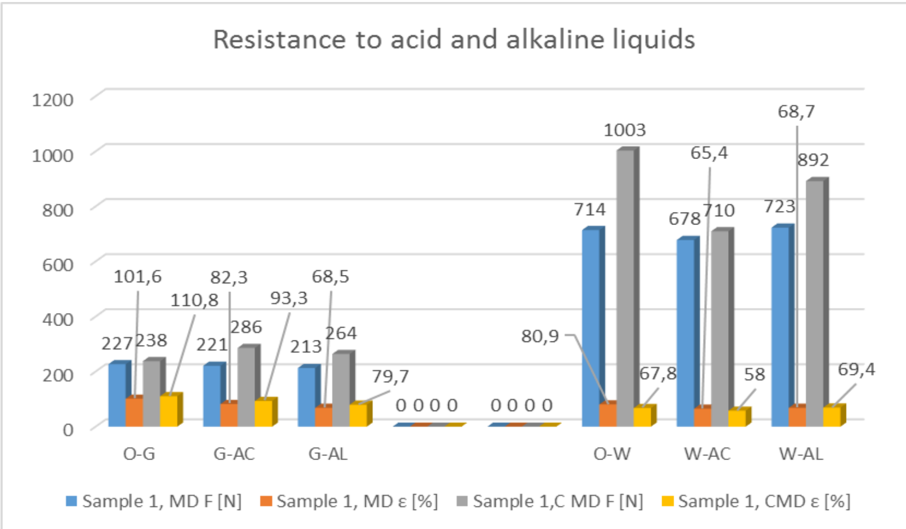

Figure 4. Results of strip test

In almost all civil engineering applications, geotextiles can be in contact with aqueous solutions of acids, bases or dissolved oxygen. Used specimens, polyester and polyethylene initially have good resistance to mention liquids. However, external influences may also affect product performance. Results shown in Figure 4 indicate different behaviour in the machine (MD) and cross machine direction (CMD) in acid and alkaline medium, but there is no significant difference between the results. For example, *sample 1* (MD) minimally losses tensile strength; from F=227 N to 221 N in acid or to 213 N in alkali. On the other hand, in cross machine direction it minimally increases. Results of elongation follow results of tensile strength. Similar behaviour has been noticed for the results of tensile strength and elongation of *sample 2*.

Based on the determined results it can be concluded that tested samples have good resistance to liquids (alkali and acid) and can fulfil their application properties in same or similar medium.

3.4 Summarized results of absorption and the specific amount of charge

In Table 3 summarized results of absorption properties and the specific amount of charge are shown.

Table 3. Results of the absorption properties and the specific amount of charge [5]

Sample CODE	F [N]		LAT [s]	LAC [%]	LWR [%]		Material adsorption of NLS [%]	Material adsorption of N-CPC [%]	q [C/g]
OG-M	191	233	2.4	339.5	3.26	3.34	5.52	10.70	-0.500
G-M	298	248	111.4	412.0	3.90	2.50	5.62	7.15	-0.148
OW-M	764	1121	4.0	686.9	3.00	2.88	-0.29	7.70	-0.770
W-M	755	1030	5.0	88.2	2.10	1.76	4.82	11.05	-0.602
OG-OX	226	242					5.12	-0.50	0.542
G-OX	232	263					6.72	5.60	0.108
OW-OX	493	865					4.27	7.00	-0.264
W-OX	213	314					-1.69	1.85	-0.341
O-G	227	238					1.82	5.30	-0.336
G-AL	213	264					10.62	5.30	0.513
G-AC	221	286					6.12	5.60	0.050
O-W	714	1003					-1.14	7.50	-0.833
W-AL	723	892					27.12	9.10	1.738
W-AC	678	710					11.42	-3.00	1.391

Based on the results of all obtained tests it can be noticed:

- microbiological attack by soil burial shown that PES nonwoven has better physical-mechanical (CBR and strip test) and absorption properties (liquid absorbency time, liquid absorbency capacity, liquid wicking rate and ionic surfactant adsorption) than PE nonwoven,
- PES nonwoven shown good resistance to microorganisms by strip test. Increased results confirm that. Except resistance, increased results are because of Ca-carbonate (from tap water). Ca-carbonate deposited on the surface and in the structure of the PES nonwoven, which increased tensile strength. That deposition did not influenced on the elongation, however improved it.
- PE nonwoven has been storage for a long period in the daylight, from the theory it is known that photo-oxidation may enhance microbiological degradation. The mechanism of degradation of polyethylene polymers is oxidation whereby the long carbon chain of the synthetic polymer is shortened. The oxidation process can be initiated both by chemicals in the soil of by microorganisms and influenced on the results of the mechanical properties.
- based on determined results it is hard to supposed the durability of the tested samples. From the researcher point of view, it is necessary to repeat the investigation because geotextiles are using in civil engineering applications and are expected to carry out one or

more functions over some period. These functions are mostly in 99.9 % in contact with the soil and it is essential that a geotextile performs effectively for the many years, 100 years and more.

- samples were buried for 6 weeks instead of 16 weeks according to the standard. With shorter time tendency was to obtain significant results in shorter time. In the future it will be great to repeat the same investigation but with samples buried 16 weeks and draw a correlation between results of the 6 weeks.
- results of liquid absorbency time (LAT) shown that soil causes slower absorbency, especially at PE nonwoven; more than 5 minutes (300 s). Soil fulfils the spaces between fibers in the nonwoven and decrease the liquid absorbency time. During the sterilization and cleaning time it was easier to clean PES than PE nonwoven who is thicker and voluminous. That influences on the effect of cleaning and it wasn't possible to fully clean sample 2 which significantly influences on the results of LAT.
- results of liquid absorbency capacity (LAC) shown for PES nonwoven increased capacity, and for PE nonwoven decreased. The reason for that is that PE has no free chemical groups for bonding (absorbing), and the soil (microorganism, fungi, bacteria) influenced on that as well.
- results of liquid wicking rate (LWR) showed a good capillarity for both tested samples. Before and after buried is present a good capillarity, of course after a little bit slower but it is present. That fact is important for tunnel construction and similar applications.
- results of surface charge and ionic surfactant adsorption confirmed LWR.
- in almost all civil engineering applications, geotextiles can be in contact with aqueous solutions of acids, bases or dissolved oxygen (resistance to liquids). Used specimens, polyester and polyethylene initially have good resistance to mention liquids. However, external influences may also affect product performance. Results shown different behaviour in the machine and cross machine direction in acid and alkaline medium, but there is no significant difference between results. Both samples have satisfaction resistance to the acid and alkali,
- resistance to oxidation is very important for geotextile, especially polyethylene, that can lead to the degradation of performance properties. With this accelerated test it is obviously that PES nonwoven has great resistance to oxidation but PE has not.

4. CONCLUSION

From the results it can be concluded:

- studies specifically related to durability and soil burial of geotextiles are limited,
- little fields research has been conducted on the degradation of geotextiles in soil burial applications,
- geotextiles used in civil engineering applications are expected to carry out one or more functions for a minimum expected time (design life),
- any application may require one or more functions,
- assessment of the durability of an application using geotextiles requires a study,
- with this thesis – study tendency was to obtain the knowledge about resistance (microbiological, liquids, oxidation) of two different most used geotextile samples through physical-mechanical and absorption properties,
- microbiological attack by soil burial shown that PES nonwoven has better physical-mechanical and absorption properties than PE nonwoven
- used nonwoven, PES and PE initially have good resistance to liquids – acid and alkali, resulting only in cationic character – higher surface charge
- with the accelerated test for resistance to oxidation it is obvious that PES nonwoven has great resistance to oxidation than PE one. PE nonwoven significantly loss tensile strength and elongation.

Therefore, tested samples, PES nonwoven can be used in civil engineering, whilst PE can not.

5. REFERENCES

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