Characterization of Polyester with Fiberglass Materials as reinforcement in Interior Dividing Walls

Tiago Santos[1], João Velosa[2,3], Luís Ramos[1,4], Raul Fangueiro[3,4], Paulo Mendonça[5]
[1]*ISISE - Institute for Sustainability and Innovation in Structural Engineering, University of Minho, Portugal*
[2]*Territory, Environment and Construction Research Centre (C-TAC), University of Minho, Portugal*
[3]*Fibrous Materials Research Group (FMRG), University of Minho, Portugal*
[4]*Department of Civil Engineering, University of Minho, Portugal*
[5]*School of Architecture, University of Minho, Portugal*
lramos@civil.uminho.pt

Abstract

Some synthetic fibers present better mechanical performance compared with the natural fibers. Therefor research works were carried out to focus the characterization of polyester and glass fibers to be used as reinforcements in the internal dividing walls. Results from polyester fabrics made of compression with or without fiberglass were obtained.

Keywords: polyester fabric, mechanical property, interior dividing walls

1. Introduction

The research and development of new sustainable materials, most of which are composites with fibrous reinforcement systems, allied with a growing concern on the environmental and economy topics, has created interest for building materials and especially in textile industries. However, these materials still do not have a significant implementation in the construction building industry or, at least, this implementation is not being explored in all their potentialities. As an example, the glass fibers are only used as reinforcements in order to increase the stiffness of composite materials (such as concrete). In the other hand, the natural fibers aren't explored and used as a building material. The usefulness of natural fibers in civil engineering applications is limited by their moderate or lower mechanical properties. Some synthetic fibers, like nylon, polypropylene and polyester present better mechanical performance compared with the natural fibers. Therefore this work is focused in the characterization of polyester and glass fibers to be used as reinforcements in the internal dividing walls [1, 2].

Geotextile are material which can fulfill the following functions: separating; filtering, reinforcing, draining and water proofing. The main objective in this study is to use as reinforcement on division walls coaling [3, 4].

2. Properties and test methods

The composite whose study is described in this paper was developed through cohesive bonding by heat and pressure of polyester geotextiles (PG) with one intermediate layer of fiberglass mesh (FG) (see Figure 1).


a) b) c)

Figure 1 – Set of images of the developing material: a) geotextile layer of polyester, b) the fiberglass mesh and c) manual heat press (University of Minho).

The table 1 presents the area density of polyester geotextile and fiberglass mesh also the temperature of the melting point for these materials.

Table 1 – Properties of polyester geotextile and fiberglass mesh [2, 5].

	FG	PG
Melting point (ºC)	1700	220-250
Area density (g/m2)	115	200

Note: FG – Fiberglass mesh (dimension of the mesh: 10 x 10 mm); PG – Polyester geotextile

Before the characterization of this propose composite structure, several tests campaigns only on the FG (fiberglass mesh) and on the PG (polyester geotextile) were carried out. Therefore, tensile test in both directions (weft and warp) of the fiberglass mesh, bending tests and punching shear tests have been performed to characterize the polyester geotextile structure.

The different standardized tests are as follows [6-10]:

(i) ISO 4606:1995 – Textile glass – Woven fabric – Determination of tensile breaking force and elongation at break by the strip method
(ii) ISO 9073-2:1995 – Textile – Test methods for nonwovens – Part 2: Determination of thickness
(iii) ISO 527-2:1993 – Plastics – Determination of tensile properties – Part 2: Test conditions for moulding and extrusion plastics
(iv) ASTM D 6241:1999 – Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50mm Probe
(v) ISO 178:1975 – Plastics – Determination of flexural properties of rigid plastics

In order to reduce the number of samples to be tested with various parameters, the Taguchi method was employed in the experimental analysis of the geotextiles [11]. This method consist the improvisation the characteristics of a process or a product by identifying and setting its controllable factors (parameters). Therefore, a total of nine geotextile's tests were considered, changing between the number of layers, the time of compression, the pressure and density, to get the better mechanical combination with low density and thickness, see Table 2. This will help us choose the final product by minimizing the parameters' variations of the product in relation to your goal that is to analyze the mechanical behavior.

Table 2 – The process parameters analyzed for polyester geotextile samples of tensile tests.

Specimen nº	Temperature (ºC)	Number of layers	Time (min)	Pressure (Bar)	Thickness (mm)
1	190	30	35	40	7,54
2	190	20	25	35	5,02
3	190	10	15	30	4,20
4	200	10	35	35	2,44
5	200	20	15	40	4,67
6	200	30	25	30	10,74
7	210	30	15	35	10,29
8	210	10	25	40	2,87
9	210	20	35	30	4,99

The mechanical tests of the fiberglass mesh between the geotextile compressed were performed according to the results. The method estimates the weighing of which parameter on the mechanical behavior (tensile and flexural strength) and considers the low possible thickness and density, the follow factors was been applied to make the geotextile with fiberglass mesh samples (PG+FG):

- Temperature of compression: 210 ºC
- Number of layers: 10
- Time of compression: 35 min
- Pressure of compression: 35 BAR

The orientation of the fiberglass mesh and the number of polyester geotextile layers on each side of the FG are given in table 3.

Table 3 – The descriptions of polyester geotextile and fiberglass mesh specimens for tensile and flexural tests.

Specimen nº	Description
1	5LPG+FG0º+5LPG
2	3LPG+FG0º+4LPG+FG0º+3LPG
3	3LPG+FG0º+4LPG+FG90º+3LPG
4	3LPG+FG90º+4LPG+FG90º+3LPG
5	3LPG+FG0º+2LPG+FG45º+2LPG+FG90º+3LPG

Note: nLPG – Number (n) of polyester geotextile layers; FGxº – Fiberglass mesh with orientation by xº.

All specimens were fabricated in the laboratory of polymers from the University of Minho (figure 1 c), and performed in Instron 4505 Universal testing machine, according to the standards. Table 4 presents the tests procedures in the tensile and flexural test.

Table 4 – Main characteristics of tensile and flexural methods applied in the experiment tests.

Tensile tests	FG	PG	PG+FG
Test specimen length (mm)	250	200	240
Test specimen width (mm)	50	20	20
Testing speed (mm/min)	50	100	100
Gauge length (mm)	100	100	100
Pre-load (N)	1	1	1
Number of samples by specimen	5	5	5
Flexural tests		PG	PG+FG
Test specimen length (mm)		130	80
Test specimen width (mm)		20	20
Testing speed (mm/min)		3.25	Table 5
Span (mm)		100	Table 5
Pre-load (N)		1	1
Number of samples by specimen		5	5

Note: FG – Fiberglass mesh; PG – Polyester geotextile

In the case of PG+FG tensile and flexural tests the testing speed and the beam span length are according to thickness of each specimen. These data are present in table 5.

Table 5 – Thickness, testing speed and span length of polyester geotextile and fiberglass mesh (PG+FG) specimens for tensile and flexural tests.

Specimen nº	Thickness (mm)	Testing speed (mm/min)	Span (mm)
1	2,84	1,20	45,50
2	3,37	1,40	53,92
3	3,74	1,60	59,84
4	2,85	1,20	45,56
5	3,36	1,40	53,82

Tensile strength (σ) was calculated from the maximum force (F_{max}) and the cross-section area

(A) (equation 1). The equation 2 gives the flexural strength, where σ_f is the stress in the outer surface in the midpoint (MPa), F is the applied load in newtons, L is the span length in millimeter, b is the width and L the thickness of the test piece both in millimeter.

$$\sigma = \frac{F_{max}}{A} \qquad (1)$$

$$\sigma_f = \frac{3FL}{2bh^2} \qquad (2)$$

These formulas are given by the standard ISO 527-2 and ISO 178, respectively.

3. Test results and discussion

3.1 Tensile strength

The results of the fiberglass mesh tests are given in table 6. These values are consistent with the resistance values given by the fiberglass' company. It was applied impregnate with an adhesive to prevent the ends of specimen from being damaged by the clamps' machine.

Table 6 – Results of fiberglass mesh tensile test.

	Break strength (N/50mm)	Extension breaking (%)
Weft	723,4	2,87
Warp	737,8	3,03

The experiment results of tensile strength, yield strength, puncture strength, ultimate strength, ultimate load and Young's modulus, are listed in table 7 for geotextile and geotextile with fiberglass tensile tests, respectively. It can be observed that high temperature have significant contribution for Young's modulus, as show specimen 8 and 9 of PG and specimen 2, 3, 4, and 5 of PG+FG, respectively. The 7 specimen of PG didn't have the same modulus of elasticity due to the low time of compression.

In order to increase the puncture strength the number of layers must be raised. Therefore the specimens number 1, 6 and 7 have the highest puncture resistance.

All polyester composite specimens (PG) have yield strain around 1,3 and 2,9 %, and the tensile strength range between 8 and 36 MPa. In the case of PG+FG, the yield strain range from 4,1 to 6,2% and the tensile strength from 24 to 33 MPa.

To study the contribution of fiberglass mesh in the polyester geotextile, a comparison between specimen number 8 of PG tests and specimen 4 of PG+FG will be foreseen. Therefore, the tensile behavior of both specimens is shown in figure 2. The first observation is the different ductility: the PG composite is considered as ductile material [12]. However, both have approximately the same tensile strength and the same Young's modulus. Note that in the PG+FG yield point, rupture in fiberglass is initiated with an apparent decrease in tensile strength, of 20%. After this reduction, the ductile of PG composite is governing the behavior.

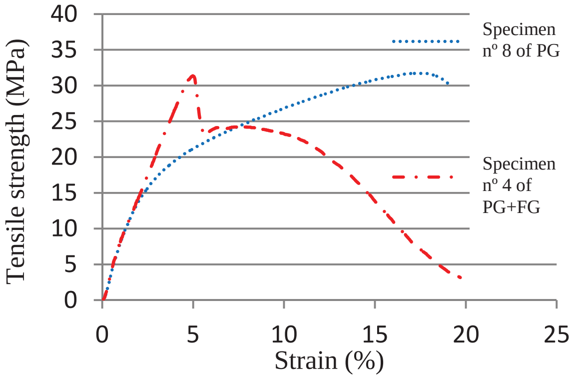

Figure 2 – Graph tensile-strain mean of the specimen nº 8 of PG and the specimen nº 4 of PG+FG.

Table 7 – Tensile tests results of polyester geotextile compressed and the polyester geotextile compressed with fiberglass mesh.

Polyester geotextile (PG) – results

Specimen number	Ultimate load (N)	Yield strength (MPa)	Yield strain (%)	Tensile strength (MPa)	Tensile strain (%)	Ultimate strength (MPa)	Ultimate strain (%)	Young's Modulus (MPa)	Puncture strength (kN)
1	1792	6,50	1,60	11,89	7,20	2,79	41,40	370	50,6
2	802	4,37	1,35	7,98	5,47	4,15	44,53	343	32,2
3	1388	7,19	2,16	16,54	16,12	4,32	32,88	331	14,8
4	568	10,40	2,88	11,65	4,46	3,71	17,44	426	13,6
5	1047	6,99	1,80	11,22	5,36	4,51	34,88	384	35,9
6	5057	9,11	2,28	23,16	19,88	9,46	25,92	378	45,7
7	5131	9,56	2,44	24,93	18,50	14,81	22,57	365	48,5
8	1768	15,57	2,55	30,85	16,70	30,36	17,68	602	18,6
9	3649	17,84	2,80	36,60	17,82	36,38	18,27	615	30,2

Polyester geotextile with fiberglass mesh (PG+FG) – results

Specimen number	Ultimate load (N)	Tensile strength (MPa)	Tensile strain (%)	Ultimate strength (MPa)	Ultimate strain (%)	Young's Modulus (MPa)
1	1337,98	23,89	6,16	2,45	30,46	387,94
2	2267,97	33,35	5,35	2,24	21,75	622,39
3	1862,58	25,17	4,83	3,40	22,96	520,86
4	1721,44	30,74	4,93	2,52	21,25	623,51
5	1859,97	27,35	4,13	3,12	18,68	663,04

3.2 Flexural strength

The results of the geotextile composite flexural tests are given in table 8. It can be seen that the parameters as temperature and compression in the fabric have significant effects on the values of PG flexural strength. However, the factor time of compression and factor number of layers do not have important effects.

Table 8 – Flexural tests results of polyester geotextile compressed.

Specimen nº	Flexural stress (MPa)					Mean $\bar{X}$ (MPa)	Standard deviation (s)
1	8,93	9,24	9,00	8,80	9,36	9,07	0,23
2	5,43	6,03	5,53	5,08	5,16	5,44	0,37
3	3,82	5,39	3,92	4,62	3,92	7,58	0,78
4	8,17	8,13	7,91	7,42	6,28	8,54	0,55
5	8,74	8,52	9,37	8,11	7,98	8,06	0,70
6	7,94	7,88	8,04	8,02	11,00	8,58	1,36
7	11,30	14,20	12,51	12,10	10,56	12,13	1,38
8	19,19	16,29	14,69	15,92	12,56	15,73	2,42
9	21,47	23,70	23,87	21,97	20,43	22,29	1,48

Table 9 is given the main results of flexural tests for polyester geotextile with fiberglass mesh.

Table 9 – Flexural tests results of polyester geotextile compressed with fiberglass mesh.

Specimen nº	Flexural stress (MPa)					Mean $\bar{X}$ (MPa)	Standard deviation(s)
1	21,76	22,43	22,2	20,31	19,85	21,31	1,16
2	11,63	12,45	12,83	12,51	12,48	12,38	0,45
3	9,94	11,09	9,83	9,73	9,31	9,98	0,66
4	18,96	17,76	16,74	17,14	17,22	17,56	0,86
5	9,67	11,41	11,52	11,20	9,75	10,72	0,91

4. Conclusions

This work shows the results of all tests performed aiming at helping the future research concerning the use of polyester and glass fibers to improve a composite material based of natural fibers for the interior of dividing walls. The objective of the fiberglass mesh in the composite material is to balance the stress distribution in the geotextile. Although has improved the mechanical behavior of geotextile composite, the fiberglass didn't brought the improvement desired. However, the fiberglass is very cheap and easy to apply and has given 12% more flexural stress. Therefore, the proposed composite material, with geotextile polyester plus fiberglass mesh, can be applied as support of the coating in the building's interior walls, due to their considerably low cost production and useful mechanical properties.

The conclusion stemming from this study is that polyester geotextile compressed used for coating of internal non-structural walls is better provided by the geotextile with fiberglass than the only geotextile compressed.

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