

Bellaterra : July 27th, 2018
Test Report nº : **18/16707-644**
Client: : **FIBER COMPOSITES, LLC**
181 Random Drive
New London, NC 28127 (USA)

TEST REPORT

TESTED SAMPLE:

On March 6, 2018 a sample formed by slats for pavement, of dimensions 1220 x 136 x 23,7 mm and with the following references according to the Petitioner, was received at LGAI - Applus:

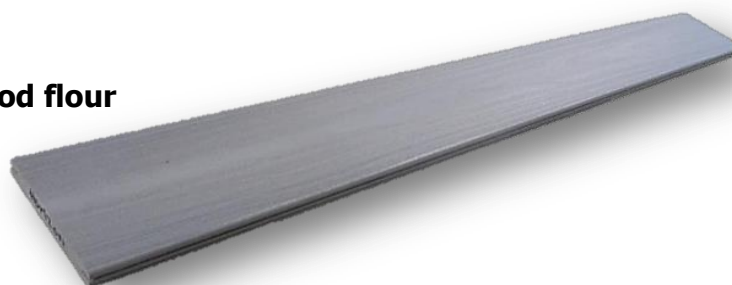
HORIZON

Color : Castle Gray

Composition:

1.) Wood fiber, wood dust or wood flour

2.) Polyethylene



REQUESTED TESTS:

According to standard EN 15534-1:2014. Composites made from cellulose-based materials and thermoplastics (usually called wood-polymer composites (WPC) or natural fibre composites (NFC))

- ✓ Slipperiness, inclination plan test, according 6.4.3. Based on EN 13451-1:2012 + A1:2018, Annex E
- ✓ Impact resistance, according 7.1.2.1. Determined according to EN 477:1996
- ✓ Swelling and water absorption, according 8.3.1. Determined according to EN 317:1994
- ✓ Linear thermal expansion, according 9.2. Determined according to ISO 11359-2
- ✓ Determination of the modulus of elasticity in bending and bending strength of profiles, Annex A
- ✓ Density, according 6.2. Determined according to EN 323:1994
- ✓ Resistance to artificial weathering, according 8.1. Using the basic principles of EN 927-6:2007
- ✓ Scratch resistance. Determined according to EN 15186, B method.

TESTS DATE: from 06/03/2018 to 24/07/2018.

RESULTS: See attached pages.

Laboratory Manager
LGAI Technological Center S.A.

Test Manager
LGAI Technological Center S.A.

The results indicated, make exclusive reference to the sample, product or material which is handed by Applus.

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TESTS:

✓ **Slipperiness, inclination plan test, according 6.4.3. Based on EN 13451-1:2012 + A1:2018, Annex E**

A person carrying out the test (test person) moves in an upright position forward and backwards on the surface subjected to the test. The surface is wetted with water containing a wetting agent. The inclination of the test rig is increased starting from the horizontal position until an angle has been reached at which the testing person feels insecure.

The testing person is a grown-up person with bare feet, whose feet shall have been wetted for at least 10 minutes

A flat plate measuring 600 mm in width and 2 000 mm in length, with an adjustable angle of inclination from 0° to 45° shall be used as testing equipment; one short side shall be hinged to the floor and a clinometers with divisions of 1° shall be fitted on a side of the rig, showing the angle of inclination of the plate in relation to the horizontal plane.

The test liquid shall be an aqueous solution of a neutral wetting agent in a concentration of 1 g/l.

The test specimen is a surface of at least 1 000 mm in length and 500 mm in width. Components of irregular shape shall be placed on aside the other, as nearby as possible, to cover the test surface of 1000 mm x 500 mm.

The test results are expressed according to three rating classes:

- Class A: 12°: the items with a test result from 12° to 17°
- Class B: 18°: the items with a test result from 18° to 23°
- Class C: 24°: the items with a test result from 24° upwards.

Angle of inclination (average value)	25°
Classification according EN 15534-1:2014	Class C: 24°

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✓ **Impact resistance, according 7.1.2.1. Determined according to EN 477:1996**

Test specimens cut from a profile are subjected to a blow from a mass falling from a known height onto the exposed surface at midway between the supports, at a specified temperature. After testing, the test specimens are examined visually to detect any presence of surface cracks and to measure the residual indentation.

Mass of the striker: 500 g
 Radius of the striker: 25 mm
 Falling height: 1000 mm

The test specimens shall be (300 ± 1) mm long the actual width and thickness of the profile. The impact position of the striker shall correspond to the weakest area of the test specimen. Each longitudinal edge of the test specimen shall be tested.

Specimen		Presence of surface cracks	Residual indentation (mm)
1	center	none	none
	longitudinal edge	none	none
2	center	none	none
	longitudinal edge	none	none
3	center	none	none
	longitudinal edge	none	none
4	center	none	none
	longitudinal edge	none	none
5	center	none	none
	longitudinal edge	none	none
6	center	none	none
	longitudinal edge	none	none
7	center	none	none
	longitudinal edge	none	none
8	center	none	none
	longitudinal edge	none	none
9	center	none	none
	longitudinal edge	none	none
10	center	none	none
	longitudinal edge	none	none

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✓ **Swelling and water absorption, according 8.3.1. Determined according to EN 317:1994**

The measurement of the dimensions in thickness, width and length of the specimens shall be carried to 24 h, 2 days, 4 days, 7 days, 14 days and 28 days after the total immersion into water at a temperature of (20 ± 2) °C.

The dimensions of the test specimens shall be 100 mm long and the actual width and thickness of the products.

Specimen	Water absorption (%)					
	24 h	2 d	4 d	7 d	14 d	28 d
1	0,8	1,0	1,2	1,5	1,7	2,1
2	0,8	1,0	1,2	1,4	1,7	2,0
3	0,8	1,0	1,2	1,5	1,6	2,1
4	0,7	0,9	1,1	1,4	1,7	1,9
5	0,7	0,8	1,1	1,3	1,7	1,9
6	0,7	0,8	1,0	1,3	1,6	1,8

Specimen	Swelling - length (%)					
	24 h	2 d	4 d	7 d	14 d	28 d
1	0,0	0,1	0,1	0,2	0,2	0,2
2	0,0	0,1	0,1	0,1	0,1	0,1
3	0,1	0,1	0,2	0,2	0,2	0,2
4	0,1	0,1	0,2	0,2	0,2	0,2
5	0,0	0,1	0,1	0,1	0,1	0,2
6	0,0	0,1	0,1	0,1	0,1	0,1

Specimen	Swelling - width (%)					
	24 h	2 d	4 d	7 d	14 d	28 d
1	0,0	0,0	0,0	0,1	0,1	0,2
2	0,0	0,1	0,0	0,1	0,1	0,1
3	0,0	0,0	0,0	0,1	0,1	0,1
4	0,0	0,0	0,0	0,0	0,1	0,1
5	0,0	0,0	0,0	0,0	0,0	0,1
6	0,0	0,0	0,0	0,0	0,0	0,1

Specimen	Swelling - thickness (%)					
	24 h	2 d	4 d	7 d	14 d	28 d
1	0,1	0,1	0,1	0,3	1,0	1,3
2	0,1	0,2	0,3	0,4	1,7	1,8
3	0,2	0,3	0,3	0,5	1,0	1,6
4	0,0	0,1	0,1	0,2	1,3	1,4
5	0,2	0,2	0,3	0,5	1,3	1,5
6	0,1	0,3	0,5	0,7	1,5	1,5

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✓ **Linear thermal expansion, according 9.2. Determined according to ISO 11359-2**

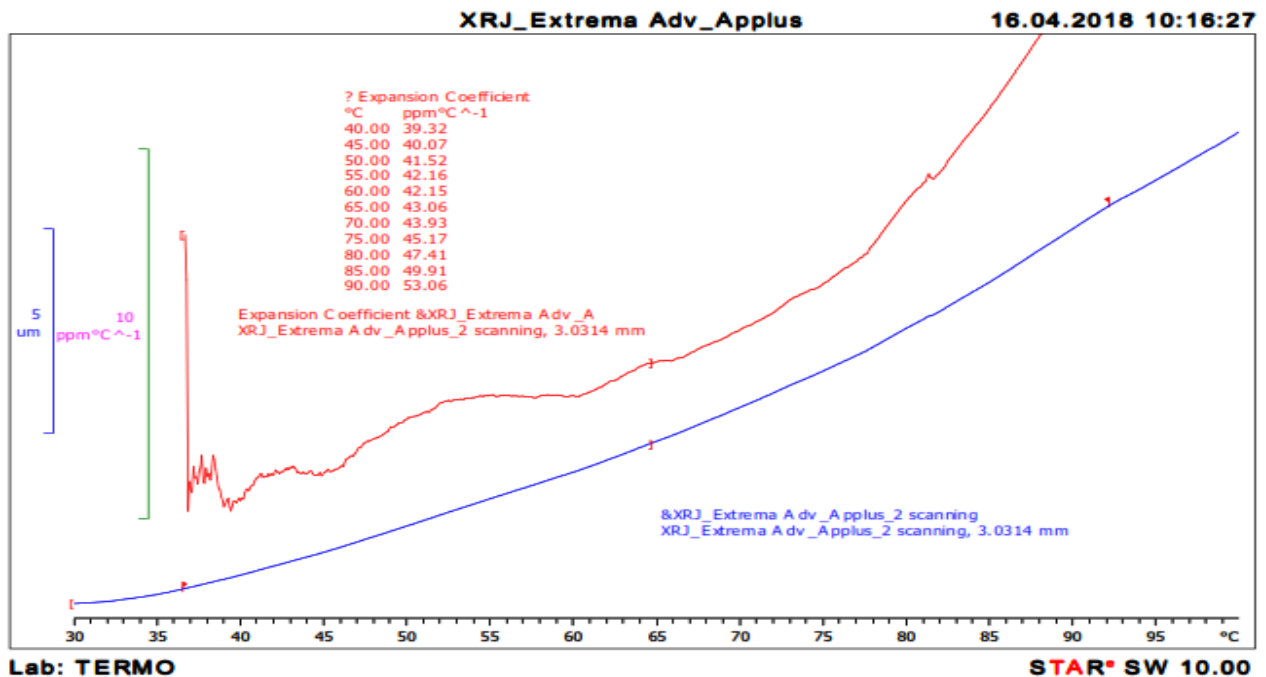
The coefficient of expansion has been determined in the direction perpendicular to the section of the sample.

Temperature range: 35°C – 90°C

Graph of values

Temperature	Coefficient of linear expansion PPM°C ⁻¹
40	39,32
45	40,07
50	41,52
55	42,16
60	42,15
65	43,06
70	43,93
75	45,17
80	47,41
85	49,91
90	53,06

Representation of thermal expansion as a function of temperature



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✓ **Determination of the modulus of elasticity in bending and bending strength of profiles, Annex A**

The test specimen rests on two supports and is deflected by means of loading head between the supports.

The test specimen is deflected at a constant rate at midspan until the maximum load is obtained or until rupture occurs. During the procedure, the force applied to the test specimen and the resulting deflection at midpoint is measured.

The test specimens shall be cut rectangular to the longitudinal direction of the profiles. The cross section of the test specimens shall be the full cross section of the profiles from which they are cut.

For the test under standard conditions, the length of the test specimen l_2 shall be 20 times the nominal thickness h plus 100 mm.

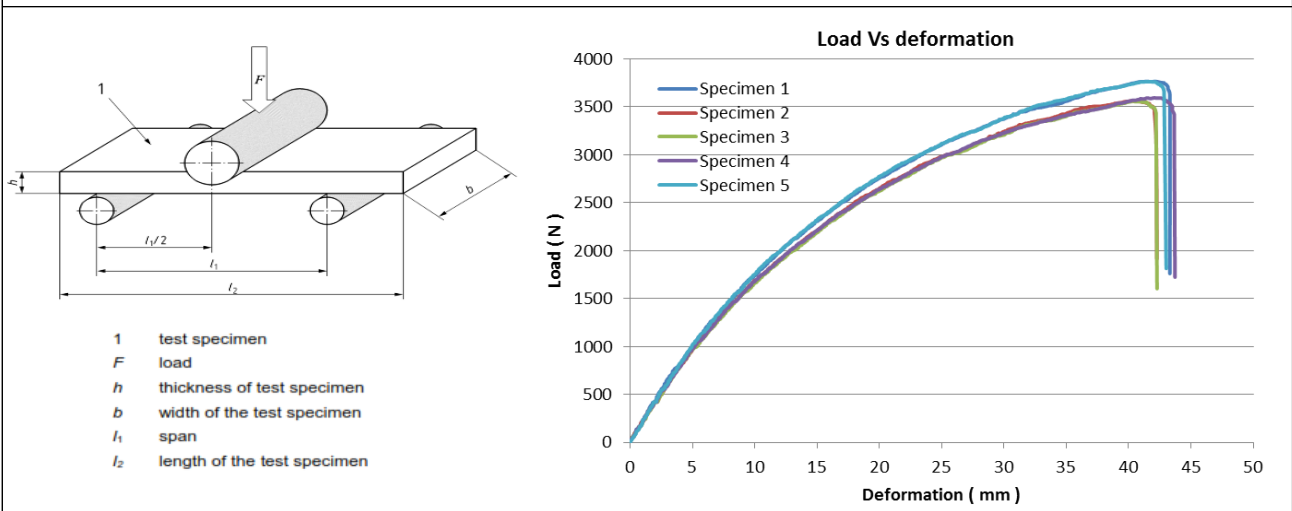
The test specimens shall be tested in the standard atmosphere 23/50.

The specimens shall be loaded at a constant strain rate of $1 \pm 0,1\%$ per minute.

Length of the specimens (l_2): 580 mm

Separation between support rollers (l_1): 480 mm

Specimen	Thickness (h) (mm)	Width (b) (mm)	Maximum load (F_{max}) (N)	Bending strength (MPa)	Modulus of elasticity (E_m) (MPa)
1	23,49	136,2	3764	36,1	3073
2	23,20	136,5	3562	34,9	3089
3	23,26	136,5	3560	34,7	3184
4	23,21	136,2	3594	35,3	3067
5	23,39	136,3	3762	36,3	3021
Average			3649	35,5	3087



Note: using a separation between support rollers of 406 mm, according to the interval of use declared by the petitioner, the deformation produced under load of 250N is 0,7mm.

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✓ **Density, according 6.2. Determined according to EN 323:1994**

The test pieces were conditioned in a laboratory environment at 20°C ± 2°C and 65% ± 5% HR up to constant mass.

Specimen	Mass (g)	Length (mm)	width (mm)	thickness (mm)	Density (kg/m ³)
1	51,32	50,8	50,8	19,651	1012
2	49,26	50,4	50,9	18,919	1015
3	48,02	49,1	50,7	19,205	1004
4	49,86	49,2	50,9	19,651	1013
5	47,96	48,4	50,9	19,267	1010
6	47,68	49,0	50,9	19,015	1005
Average					1010

✓ **Scratch resistance. Determined according to EN 15186, B method.**

According to the standard used as reference, the scratch resistance is the minimum load, in N, applied to a diamond tip of defined geometry that produces a visible and continuous superficial mark. Since these are samples with texture imitation wood grain, it is not possible for the tip to make a circle complete so that the visible mark is taken as a criterion in the four quadrants of the specimen that gives rise to an almost complete circle.

Increasing loads are applied from 1 N, with increments of 1 N, repeating twice the scratching with each load and, as a contrast for the valuation is used talcum powder.

The assessment has been carried out by three technicians.

The scratch resistance is calculated as the average of the ratings of three tested specimens rounding to the nearest N.

The classification for the scratch resistance is established according to the following table:

	Dashed stripes, weak surface marks, or non-visible marks	Continuous circle or clearly visible lines
Grade 5	6 N	> 6 N
Grade 4	4 N	> 4 N a 6 N
Grade 3	2 N	> 2 N a 4 N
Grade 2	1 N	> 1 N a 2 N
Grade 1	--	< 1 N

RESULT	Resistance index
3 ± 1 N	Grade 3

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✓ **Resistance to artificial weathering, according 8.1. Using the basic principles of EN 927-6:2007**

Artificial aging

The trial consists of a total of 12 exposure cycles with a total duration of 2016h. Each exposure cycle lasts one week and consists of a period of condensation followed by a phase of water spraying and exposure to UV-A340 radiation as indicated in the following table:

Step	Function	Temperature	Duration	Condition
1	Condensation	45 ± 3°C	24 h	--
2	Subcycle: step 3 followed by step 4	--	144 h consisting of 48 cycles of 3h, formed by steps 3 and 4	--
3	UV	60 ± 3°C	2,5 h	Irradiance set point 0,89 W/(m ² nm) at 340 nm
4	Pulverization	--	0,5 h	6l/min at 7l/min, UV off

The artificial aging test comprises the following evaluations:

✓ **Initial evaluation:**

- Evaluation of the superficial aspect
- Brightness measurement
- Color measurement

✓ **Exposure cycle artificial aging**

✓ **Evaluation after the test:**

- Evaluation of the superficial aspect
- Color variation
- Brightness variation

➤ **Brightness**

The brightness measurements before the exposure, are made with a glossmeter, an apparatus capable of measuring the specular reflection.

After the previous calibration of the glossometer, the specular brightness of the surfaces to be tested is measured, collecting values for incident light angles of 20°, 60° and 85°.

Several measurements are made in different areas of the surface. The 60° angle is used in any case, the 20° is used to study samples whose specular brightness at 60° is greater than 70% and 85° is used in the case that this measure is less than 30%.

After the aging of the samples, the brightness at the same points is measured again to determine the possible variation of this property.

The difference in brightness, ΔB, between the samples before and after the aging test is determined by the difference between the means of the values obtained, for each angle, before and after the test.

ΔB positive → brightness increase
ΔB negative → loss of brightness

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➤ **Color**

The color is measured before exposure in accordance with ISO 7724-2. The CIE 1976 color coordinates (L*a*b*) are determined for the standard illuminant D65 and 10° standard observer for each test panel, resulting in the average of a minimum of five individual measurements.

To define the color of the samples under test, the CIELAB chromatic system is used, which allows to characterize the colors of opaque samples through three chromatic coordinates:

- L* measures brightness (0 black - 100 white).
- a* measures the degree of red (+a*) or green (-a*).
- b* measures the degree of yellow (+b*) or blue (-b*).

The color measurements are made with a colorimeter. After the previous calibration of the same proceeds to the measurement of the color of the surfaces to be tested, performing 5 readings corresponding to 5 representative portions of the test sample.

After the aging of the samples, the color is re-measured in them points to determine if the exposure causes any variation in this property.

The difference between the values of the chromatic coordinates before and after after the aging test.

$$\begin{aligned}\Delta L^* &= L_2^* - L_1^* \\ \Delta a^* &= a_2^* - a_1^* \\ \Delta b^* &= b_2^* - b_1^*\end{aligned}$$

The results obtained tell us if there has been a change in the color of the Sample due to natural exposure:

ΔL^*	(+) clear	(-) dark
Δa^*	(+) red	(-) green
Δb^*	(+) yellow	(-) blue

The total color difference is calculated according to:

$$\Delta E = \sqrt{((L_2 - L_1)^2 + (a_2 - a_1)^2 + (b_2 - b_1)^2)}$$

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Test	Standard	Results		
		Δ (20°)	Δ (60°)	Δ (85°)
Brightness (difference) ΔB	UNE/EN ISO 2813	0,02 ± 0,02	0,07 ± 0,06	0,82 ± 0,28
Color (difference) ΔE	ISO 7724/2	ΔL^*	Δa^*	Δb^*
		-0,69 ± 0,32	0,05 ± 0,02	-0,23 ± 0,12
		$\Delta E = 0,73 \pm 0,32$		
Aspect	Visual assessment	The change in brightness and color is not significant. No type of superficial defect is observed. In the back part there is slight yellowing due to leachate of some substance of the wood fiber.		

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PHOTOGRAPH OF THE SURFACE AND THE TRANSVERSAL SECTION OF THE SAMPLE:



Applus+, ensures that this work has been done within the requirements of our Quality System and Sustainability, having fulfilled the contractual and legal regulations.

As part of our improvement program, please let us pass on any comments they consider appropriate, contact the person responsible for signing that letter, or the Director of Quality of Applus+, at: satisfaccion.cliente@applus.com