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Title: Proposal for a fiber cement panel with the addition of sugarcane bagasse

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Introduction

In recent years, environmental concerns have stimulated extensive research into environmentally friendly materials. Focusing attention on the use of fibers obtained from renewable plant sources for the manufacture of composite materials (Biagiotti, et al., 2008; John & Thomas, 2008; Faruk, et al., 2012).

The combination of these interesting mechanical and physical properties, in addition to the environmental benefits, has been the main driver behind its use as an alternative to traditional reinforcements (Ardanuy, et al., 2015).

Introduction

The applications of cement-based composites with vegetable fibers (VF) have been defined in the area of construction as non-structural elements, such as: thin walls, thin sheet products for partition walls, building envelopes or roofs, flat sheets, tiles and prefabricated components in general. (Roman, et al., 2008).

The implementation of a manufacturing methodology for coating elements with this type of fiber, saving half of the processes, would provide an opportunity in communities that have this type of agro-industrial waste; the project as such serves for future homologous projects with other VFs of similar characteristics in order to contrast the viability of the method and its limits.

Methodology

A series of tests were carried out to design, experiment and characterize the materials to be used, from the tools, mix composition, element thickness, casting, vibrating and curing, in order to obtain an adequate result that complies both in physical and mechanical characteristics according to the non-compressed fibrocement standard NMX-C-234-ONNCCE-2015.

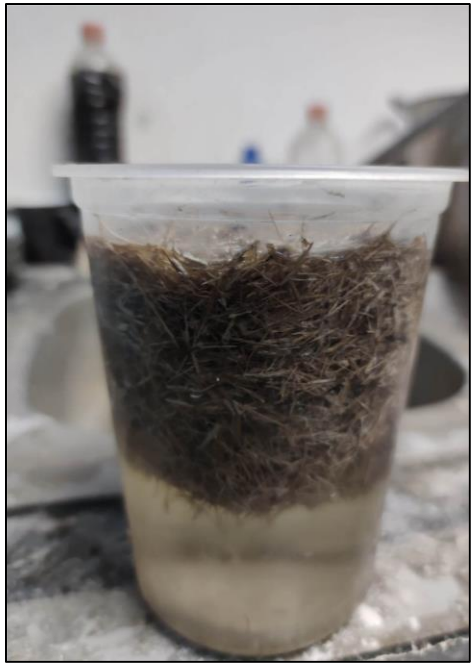
Materiales

- Cement CPC 30R RS.
- River sand with high silica content.
- Dry sugarcane bagasse with a relative humidity of 11.7%.
- Sodium silicate 20º Be with a concentration of 22% w/w.

Methodology

Fiber pretreatment

- BC screening.
- Rinsing of fibers.
- Impregnated with sodium silicate.



Methodology

Mixing

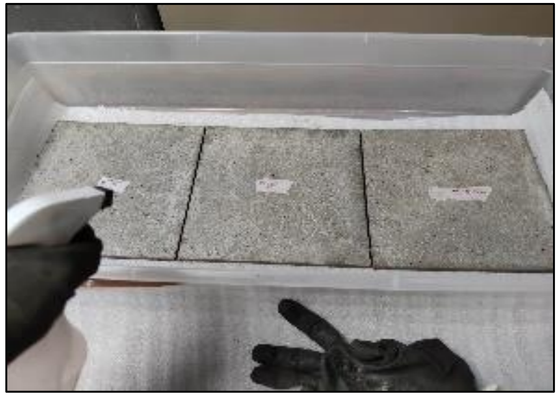
- 1. Cement + Sand - mix manually for 30 seconds with a spoon until the composition is homogeneous.
- 2. Addition of Water - 30 seconds at medium speed with the mixer with circular movements.
- 3. Addition of treated BC fiber - 30 seconds at medium speed with the same movement but with an up and down motion.
- 4. 20 seconds at fast speed with the same movement.
- 5. Check the consistency, making sure that there are no fiber clumps, if there are, repeat step 4.

Methodology

Casting, vibrating and curing

- The specimens were poured into previously greased disassembled metal molds.
- Compaction by impact vibration, tamping and screeding.
- Demolding in 24 h.
- Curing in an environment of favorable humidity and temperature.



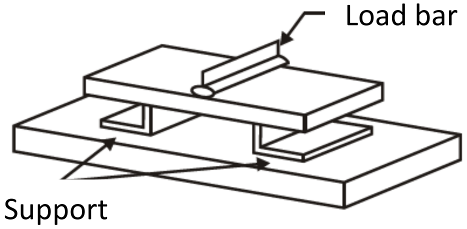
Methodology

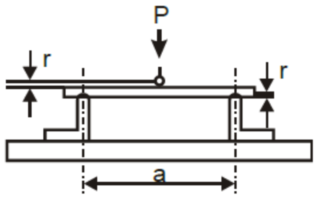
Rupture Module

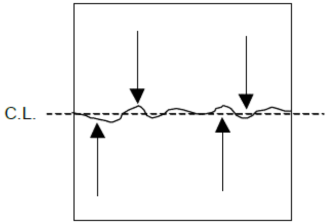
Five plates are subjected to obtain the modulus of rupture (MOR) in a universal machine, with a constant acceleration of 0.30 t/min supported on two smooth rods with a diameter of 20 mm and a separation between them of 200 mm for each of the four test groups in transverse and longitudinal direction, averaging the values and performing the test in a time of 30 seconds, the maximum load at the moment of rupture is recorded.

$$\boldsymbol{MOR} = \frac{eFl_s}{2be^2}$$

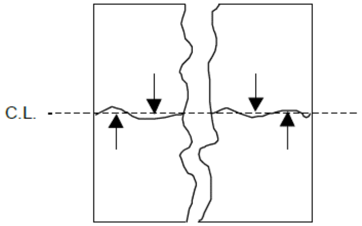
Where: F is the ultimate load (N); ls is the distance between the centerlines of the supports (mm); b is the width of the test specimen (mm) and e is the thickness where the failure occurs (mm).







a) first test



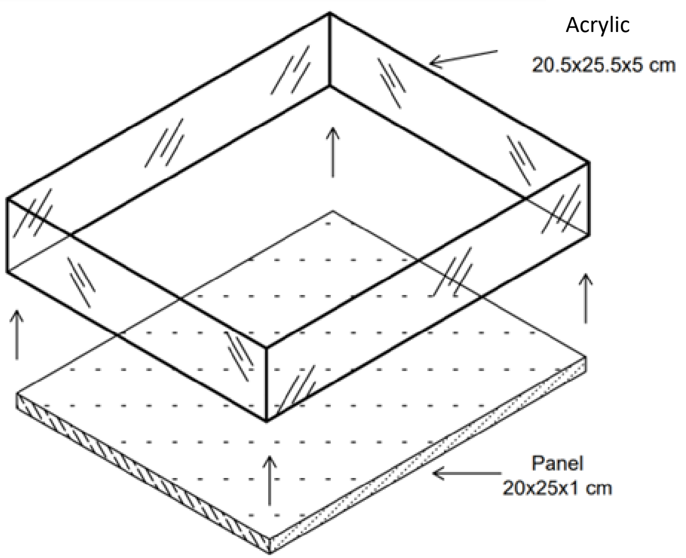
b) second test

Methodology

Permeability test

It is placed in an acrylic frame of 20.5 cm x 25.5 cm x 5.0 cm on top of a panel, for each test group, these were cut to a size of 25.0 cm x 20.0 cm according to the regulations and this was sealed at the top that makes contact with the frame, water is placed until obtaining a height of 20 mm, it was left for 24 hours. At the end of this time, if visually there were drops on the lower face.

In this test the panels may show traces of moisture on the underside of the plate, but in no case should be observed formation of water droplets.



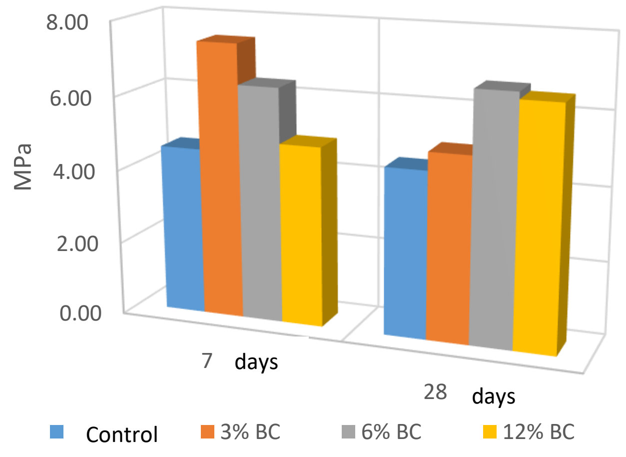
Results

After testing the specimens with the different dosages of BC, it is observed that the test group with 6% addition of fibers is the one that shows the highest modulus of rupture at 28 days, with respect to the values at 7 days, the specimen containing 3% of BC is the best, but its resistance shows a decrease of 32. 70% at 28 days, in addition to buckling and slight crumbling, being this the only test group that shows an abnormal and decreasing behavior, the remaining specimens with BC addition show an improvement in bending with respect to the control, none worsens or decreases below the value of the same once 28 days are reached, which indicates that the fibers fulfill their function as reinforcement without reducing the panel mechanically.

Results

Dosage to manufacture a panel				
Components	Testigo	3% BC	6% BC	12% BC
Cement (gr)	357	350	340	320
Sand (gr)	892	875	850	800
Water (ml)	339	332	323	304
Fiber (gr)	0	10.50	20.40	38.40

Average modulus of rupture of the different specimens and control specimen at 7 and 28 days.



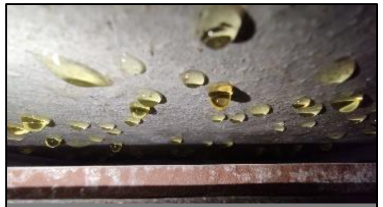
MOR results for the test groups		
Mixture	MOR avg. at 7 days (MPa)	MOR avg. at 28 days (MPa)
Control specimen	4.56	4.53
3% BC	7.46	5.02
6% BC	6.37	6.70
12% BC	4.90	6.51

Panel properties		
Mixture	Ambient density (kg/m^3)	Water absorption (%)
Control specimen	1812.51	14.78
3% BC	1672.77	17.62
6% BC	1556.78	20.96
12% BC	1430.80	26.83

24 h permeability test report	
Mixture	Droplet formation
Control specimen	None
3% BC	20 h
6% BC	12 h
12% BC	7 h

Control specimen (no drops)

3% BC (drops in 20 h)



6% BC (drops in 12 h)

12% BC (drops in 7 h)

Results

Applications and categories of NT flat plates for category B
Aplication
1. Substrate for internal walls or floor tiles.
2. Ceilings.
3. Interior substrate for walls to be painted or wallpapered.
4. Subfloors or floor underlayment (internal).

Minimum performance requirements	
Category B in ambient state (Mpa)	
Class 1	4
Class 2	7
Class 3	13

Conclusions

The fiber cement panel composed of BC and mortar, denotes adequate MOR values for its use, being supported by the marked in the NMX-C-234-ONNCCE-2015, with results above 4 MPa, which is designated as Class 1, getting very close to a class 2 panel of 7 MPa, having the possibility to perform as a standard panel category B with uses such as: substrate for internal walls or floor tiles, ceilings, interior substrate for walls to be painted or wallpapered and mezzanine or floor base (internal), but however by not successfully passing the permeability test, considered as a higher grade, which is below the flexural test, the objective is semi-complete, exposing a new problem: how to increase the impermeability, in order to guarantee its durability, which is implicit in the failed test of the test groups with BC.

Conclusions

It is remarked that even so, the mechanical values reflected in the method used, which leaves out several of the usual processes carried out for woody fibers, did not harm the final flexural performance of the panels, the general objective of the feasibility of being able to produce a fiber cement panel based on sugarcane bagasse and mortar using a smaller amount of resources and procedures for its production is partially confirmed, for which it is now necessary to modify the process, in such a way that it allows to improve the impermeability, to complete the control requirements that guarantee the permanence of the element.

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