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RESEARCH ARTICLE

TYPES OF TREATMENT AND FAILURE MODE OF CEMENTITIOUS MORTARS REINFORCED WITH SUGARCANE BAGASSE

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Abstract

The entire scientific community now agrees that sustainable development depends on environmentally friendly and renewable materials. Thus, all government policies are taking numerous steps to encourage research in this direction. The aim of the present work is to study the fracture mechanism of Sugarcane Bagasse (SCB) mortars as a function of the different treatments applied to the bagasse.To achieve this, two different types are applied toSCB. These were treatment in a sodium hydroxide solution and heat treatment at 200°C. Mortars reinforced with these different types of bagasse were then produced. The volume fractions of SCB used were 0%, 3% and 6%, giving M0 for reference mortar, MBr3 and MBr6 for mortars with untreated SCB reinforcement, MBt3 and MBt6 for mortars with heat-treated SCB reinforcement, MBc3 and MBc6 for mortars with sodium hydroxide-treated SCB reinforcement. Three-point bending tests at 28 days of age were carried out on specimens of dimensions 4×4×16cm3 obtained from the different formulations, to determine the flexural strengths. The fracture surfaces of the specimens were analyzed to understand the fracture mechanism as a function of the type of treatment applied to the SCB.The results of the studies show that all the formulations containing SCB have a flexural strength greater than that of the control mortar, with the highest strength found in the MBt6 mortar. Analysis of the fracture surfaces shows that mortars containing untreated and heat-treated SCB exhibit failure by ravelling. However, mortars containing SCB treated with sodium hydroxide break by fiber rupture.

Introduction:-

People's basic needs have changed over the years, but the way in which they are addressed has not. Although techniques evolve, the principle remains unchanged. The last two decades have seen the environmental aspect take centre stage in the search for solutions to human problems [1] [2]. The agricultural sector offers countless possibilities for achieving this objective. This explains why several authors are working to put agricultural waste to good use. For example, [3] has shown that the use of sugarcane bagasse improves flexural strength; [4] has even

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added that bagasse treatment improves fibre-matrix adhesion and therefore mechanical properties. In engineering, sugarcane bagasse can be used in several forms, the most common of which are raw, surface-treated and ash. On the other hand, authors have evaluated the possibility of combining sugarcane bagasse with other biomasses such as rice husk ash in cement mortars [5][4]. They have also shown that this combination leads to an improvement in both thermal and mechanical properties.

The use of sugarcane bagasse in construction is an alternative to the problems of managing agricultural waste [6]. At a population level, it is very easy to observe open-air burning of agricultural waste; this solution emits carbon monoxide and more carbon dioxide.

Of all the available reviews, there is little or no work that focuses on the influence of processing on the fracture mechanics of cementitious mortars reinforced with sugarcane bagasse. The aim of the present work is to show the effect of processing on the fracture mode of sugarcane bagasse-reinforced cementitious mortars.

Materials and Methods:-

Materials:-

Dans ce travail les matériaux utilisés sont : la bagasse de canne à sucre, le sable, le ciment, le mortier renforcé par la bagasse de canne à sucre.

Experimental design

Formulation of sugar cane bagasse mortars

Sugar cane bagasse reinforced mortars are obtained by replacing a volume fraction of the control mortar with sugar cane bagasse. The volume fractions are 0%, 3% and 6%. This gives the formulations M0, MB3, MB6 respectively. The control mortar is ordinary mortar complying with the recommendations of standard EN 196-1, with the exception that the sand is not standardised. The different formulations are summarised in the following table. The M0 mortar represents the ordinary mortar without sugarcane bagasse reinforcement.

Type of treatment	ID composites	OPC (%)	SCB ratio (% vol.)	S/C (wt.)	W/C
Reference	M0	100	-	3	0.6
Untreated SCB	MBr3	100	3	3	0.6
	MBr6	100	6	3	0.6
Heattreated SCB	MBt3	100	3	3	0.6
	MBt6	100	6	3	0.6
NaOHtreated SCB	MBc3	100	3	3	0.6
	MBc6	100	6	3	0.6

Sugar cane bagasse processing

Two types of treatment have been applied to sugar cane bagasse: sodium hydroxide treatment and heat treatment. Raw sugar cane bagasse is obtained after the sugar has been extracted from the cane. This is done in sugar production companies. This is the case of the Savè sugar company.

Treatmentwith sodium hydroxide

The BCS fibres were chemically treated using a 3% sodium hydroxide (NaOH) solution. Sugar cane bagasse was soaked in the sodium hydroxide solution for 48 hours. After this time, the sugarcane bagasse fibres were removed from the sodium hydroxide solution and rinsed with tap water to remove the dissolved sugar.

Heat treatment

For the heat treatment process we proceeded as follows: Pour the sugarcane bagasse fibres into a ceramic bowl and add water; place the ceramic bowl in the oven and heat to 200°C for the first hour; maintain the oven temperature for a further hour; turn off the oven and leave to cool; remove the fibres from the oven and rinse them with tap water to remove the sugar dissolved during heating.

Mechanical characterisation of mortars reinforced with sugarcane bagasse
The mechanical properties of these mortars are determined in accordance with standard EN 196-1. The aim is to determine the flexural strength of mortars reinforced with sugarcane bagasse.

Study of the fracture mechanism of mortars reinforced with sugarcane bagasse
The aim here is to study the influence of the type of sugarcane bagasse treatment on the fracture mode of sugarcane bagasse-reinforced composites. The method consisted of photographing the fracture surface using a high-resolution camera and analysing it.

Results and Discussion:-

Mechanicalcharacteristics

	Fm (KN)	FlexuralStrength(MPa)	Standard deviation	Improvement (%)
M0	2.40	5.63	0.04	0.00
MBr3	2.85	6.69	0.47	18.72
MBr6	3.00	7.02	0.48	24.69
MBc3	2.69	6.31	0.38	12.07
MBc6	2.59	6.07	0.21	7.77
MBt3	2.97	6.96	0.27	23.58
MBt6	3.03	7.10	0.15	26.07

Table 3: - 8 presents the bending test data carried out on mortars reinforced with sugarcane bagasse at 28 days.

From this table we can see that all the mortars reinforced with sugarcane bagasse have improved flexural strength compared with the M0 mortar. In addition, we can see from the standard deviation that there is little dispersion of the results around the mean. This leads us to believe that the tests were well conducted [7].

Whether for a volume replacement rate of 3% or 6% of the mortar, mortars reinforced with heat-treated sugarcane bagasse show a greater improvement in flexural strength compared with mortars reinforced with untreated sugarcane bagasse treated with sodium hydroxide [4].

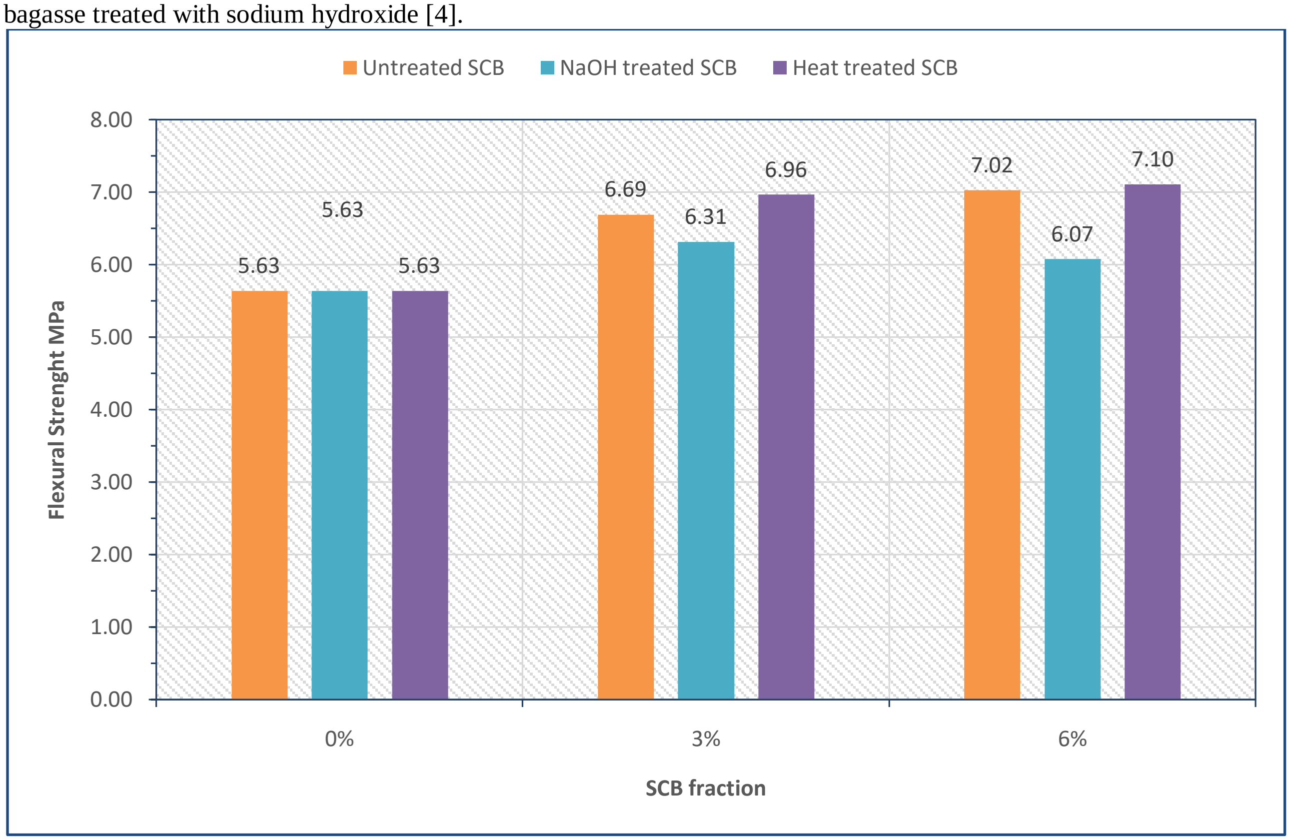

Figure 1:- Evolution of flexural strength as function of type of treatment and volume ratio.

Figure 3.39 shows the evolution of the flexural strength of mortar reinforced with treated or untreated sugarcane bagasse as a function of the fibre volume rate at 28 days.

Substituting 3% sugarcane bagasse for the mortar gives mortars whose flexural strength is higher than the reference at 28 days in all cases. The mortar reinforced with sugarcane bagasse, heat-treated at 200°C, has a higher flexural strength of 6.96 MPa.

With 6% substitution of the mortar by sugarcane bagasse, all the mortars reinforced with untreated or treated bagasse have a flexural strength higher than the reference; the mortar reinforced with heat-treated sugarcane bagasse has a maximum flexural strength of 7.10MPa at 28 days.

From the analysis of Figure 1, we can see that heat-treated sugarcane bagasse offers better flexural strength when incorporated into the mortar.

This is since it adheres better to the cementitious matrix than untreated bagasse. It should also be noted that heat treatment causes an increase in vapor pressure [8] according to the principle of thermodynamics, which results in a higher absorption of heat-treated sugarcane bagasse [9]. As a result, heat-treated sugarcane bagasse retains [10] more water than other bagasse, making it easier for chemical reactions to continue in the material.

We note that the best flexural strengths are obtained at low substitution rates.

Fracture mechanism of sugar cane bagasse mortars

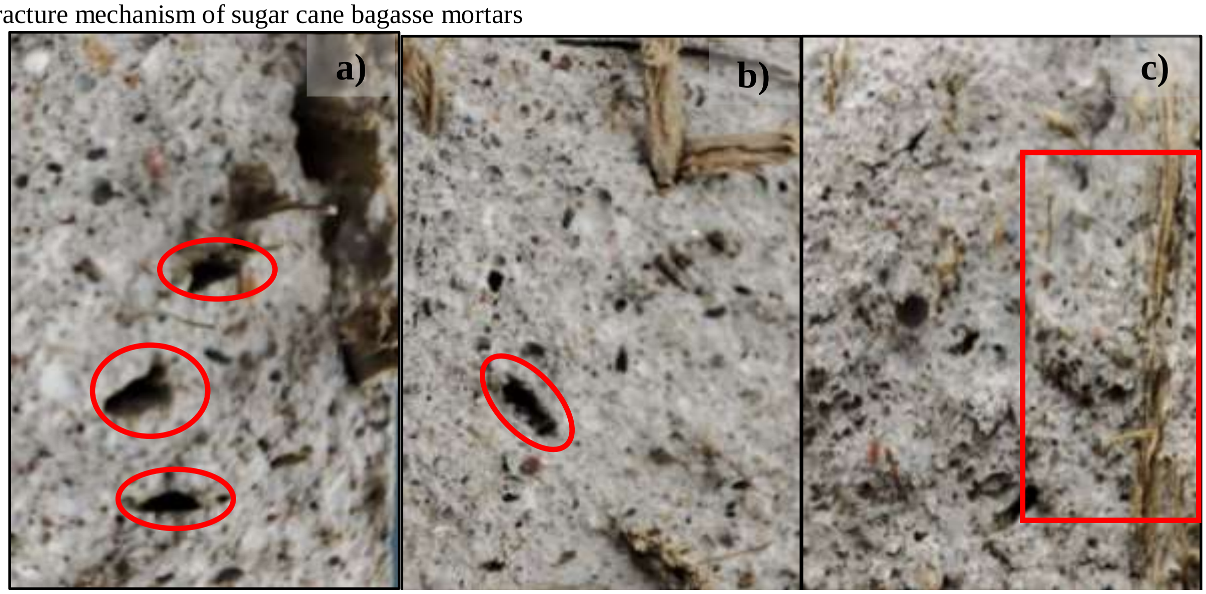

Figure 2:- Rupture surface of sugarcane-reinforced mortars.

Figure 2a) shows the fracture surface of mortars reinforced with untreated sugarcane bagasse. This figure shows the sugarcane bagasse loosening holes in the mortar mass surrounding it. This phenomenon indicates a lack of adhesion between the mortar and the untreated sugarcane bagasse [11]. As a result, the tensile stresses in the mortar are not properly absorbed by the bagasse [12].

Figure 2b) shows the fracture surface of mortars reinforced with heat-treated sugarcane bagasse. In this image, we can see a loosening hole in the heat-treated sugarcane bagasse inside the mortar. It can also be seen that there are fewer loosening holes in mortars containing heat-treated sugarcane bagasse compared with those containing untreated sugarcane bagasse. These findings show that the adhesion between heat-treated sugarcane bagasse and mortar is not perfect, although it is better than that between untreated sugarcane bagasse and mortar [13].

Figure 2c) shows the fracture surface of mortars reinforced with sugarcane bagasse treated with sodium hydroxide. This figure shows that there is no ravelling between the sugarcane bagasse treated with sodium hydroxide and the surrounding mortar. In addition, the sugarcane bagasse observed on the fracture surface has a smaller cross-section than the first two types of sugarcane bagasse. This information tells us that there is better adhesion between the mortar and the sugarcane bagasse treated with sodium hydroxide compared with the other types of bagasse. Nevertheless, the small fibre cross-section observed on the fracture surface means that sodium hydroxide treatment has modified the geometric structure of sugarcane bagasse fibre cross-sections [14].

Considering the information from the mechanical characteristics and that from the analysis of the fracture surface, we can say that sugarcane bagasse treated with sodium hydroxide has better adhesion with the mortar and lower flexural strength, compared with mortars containing untreated sugarcane bagasse and those containing heat-treated sugarcane bagasse. These results show that sodium hydroxide treatment is more effective as a surface treatment, provided that the fibre structure is not damaged [15]. Heat treatment offers the best compromise between adhesion and flexural strength of cementitious mortars.

Conclusion:-

This study made it possible to investigate the fracture mechanism of mortars reinforced with sugarcane bagasse. The work focused mainly on studying the bending strength at 28 days of age and analysing the fracture surface of the various mortars containing the different types of sugarcane bagasse. It enabled us to make the following observations:

1. Sugar cane bagasse treated with sodium hydroxide has better adhesion with the cementitious mortar compared with untreated sugar cane bagasse and heat-treated sugar cane bagasse.
2. The heat treatment affects the structure of the sugar cane bagasse fibers.
3. The heat treatment provides better adhesion to the mortar compared to untreated bagasse.
4. Mortar containing heat-treated sugarcane bagasse offers the best flexural strength.
5. Heat treatment is the best compromise between flexural strength and adhesion to cementitious mortar.

Heat treatment is the best compromise between flexural strength and adhesion to the cementitious mortar. As a result, heat treatment is the one that gives an acceptable surface roughness, without damaging the structure of the sugarcane bagasse fibres, to give greater flexural strength.

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