The environmental benefits of using sugarcane bagasse in cement mortars

Abstract

The promotion of ecological and renewable materials is gaining more and more interest. Some authors even maintain that the use of plant biomass helps to protect the environment, without giving any supporting values. The aim of this study is firstly to show how much carbon dioxide is saved by not burning sugar cane bagasse (SCB). Secondly, it highlights the structural advantages of using sugarcane bagasse in construction. To do this, we collected the carbon composition of sugarcane bagasse from the literature and evaluated the amount of carbon dioxide emitted during combustion using the carbon-to-carbon dioxide conversion equation. We then formulated an F0 control mortar. Volume fractions of this control mortar are replaced by sugarcane bagasse. For 0%, 3% and 6%rates of sugarcane bagasse, we obtained F0, F3 and F6 respectively.

The results of this study show that the use of sugarcane bagasse in the mortar makes it possible to lighten the loads on the structural elements while improving the flexural strength of the mortar for a rate of 3% of sugarcane bagasse. In addition, the combustion equation shows that, in the best-case scenario, one kilogram of burnt sugarcane bagasse releases 1.77 kg of carbon dioxide. Using mortar reinforced with sugarcane bagasse therefore helps to reduce greenhouse gas emissions. These mortars can also be used as infill elements such as joists.

Keywords: Combustion, Sugar cane bagasse, Mortar, Greenhouse gases, Carbon dioxide.

1 Introduction

The scientific community is evolving in the way it approaches problems to provide solutions for the benefit of society. Although techniques are evolving, the principle remains unchanged. For about two decades now[1], there has been a technological debate promoting materials that are both ecological[2][3] and renewable [4][5][6]. At present, there are many materials that can be used in this way, particularly in the agricultural sector. For these reasons, several authors are working to develop materials of agricultural origin, such as agricultural waste. For example, [7]have shown that the use of sugarcane bagasse improves flexural strength; [8]even added that bagasse treatment improves fiber-matrix adhesion and therefore mechanical properties. Some studies have even recommended the use of sugarcane bagasse ash as a pozzolan[9][10][11]. On the other hand, authors have studied the possibility of combining rice husk ash with sugarcane bagasse in cement mortars [12][8]. They have also shown that this combination leads to an improvement in both thermal and mechanical properties[13].

Some authors have reported that plant biomass poses a management problem[14][15]. The solution that people often opt for is to burn this waste indiscriminately[16]. This technique not only releases carbon dioxide but also carbon monoxide, a very dangerous greenhouse gas.

Finding a use for sugarcane bagasse, which will reduce the amount of bagasse burnt, is a very interesting solution to the problems of managing this waste.

However, there is little or no research describing the ecological benefits of using sugarcane bagasse as a material. The aim of this work is to show us the savings we make in terms of reducing carbon dioxide emissions.

2 Materials et method

2.1 Materials

The materials used in this research are sugarcane bagasse, sand, cement, and mortar reinforced with sugarcane bagasse.

2.2 Method

2.2.1 ***Structural interest in the use of sugar cane bagasse fibers***

To study the structural interest of using sugar cane bagasse, we made an ordinary F0 control mortar. This control mortar is the ordinary mortar complying with the recommendations of standard EN 196-1, with the exception that the sand is not standardized.

Mortars reinforced with sugar cane bagasse are obtained by replacing the mortar with 3% and 6% sugar cane bagasse; the result is mortars F3 and F6. We then compared the density and flexural strength of the mortars obtained with those obtained with the control mortar.

The sugar cane bagasse used in this work has a density of 625 Kg/m^3. It is therefore possible to estimate the mass of bagasse used for one cubic meter of mortar, and consequently the amount of carbon dioxide that would have been saved.

2.2.2 ***Estimating the CO_2 footprint gain***

To assess the amount of carbon dioxide saved by using sugarcane bagasse in the mortar, we proceeded as follows:

- Using a literature review, determine the carbon composition of sugarcane bagasse.

- Determine the mass of carbon dioxide emitted by the calcination of one kilogram of bagasse, assuming complete combustion.

Table 1 : Carbon composition of sugarcane bagasse

	Authors		
	[17]	[18]	[19]
Percentage of Carbon **C**	44.90	60.59	39.42

The Carbon proportion used is taken to be equal to the average of those shown in the table, i.e.: 48.33%

The assumption here is that we are in the case of complete combustion. This is the most favorable case, unlike incomplete combustion where carbon monoxide is emitted.

The following equation Eq1 expresses the relationship between the transformation of carbon into carbon dioxide during complete combustion:

$$C + O_2 \rightarrow CO_2 \qquad \text{Eq1}$$

This equation was used by [20]to estimate the rate of carbon dioxide emitted during the combustion of rice husks.This equation proved to be sufficient to give the maximum limit to be obtained for the combustion of sugarcane bagasse.

For a cubic meter of mortar, the mass of sugarcane bagasse used is given by the following equation:

$$m_b = V_b \times \rho \qquad \text{Eq2}$$

Where m_b is the mass of sugarcane bagasse and V_b its volume fraction.

3 Results and discussion

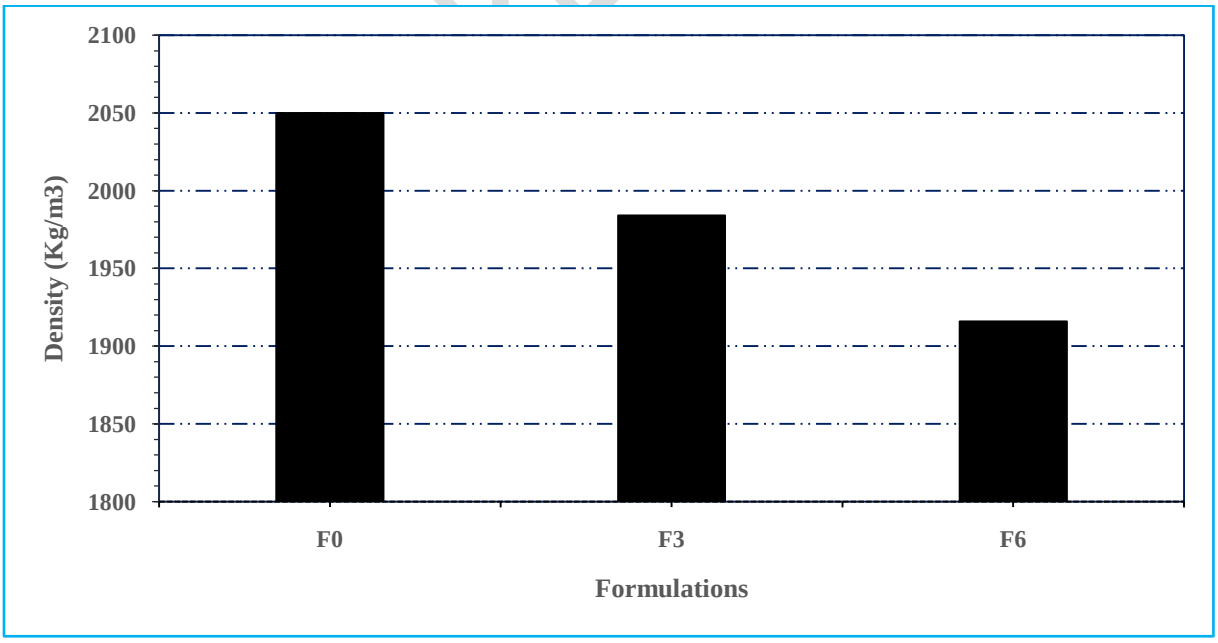

Figure 1 : Variation of density as function of SCB's rate

Figure 1 shows the evolution of the density of mortars reinforced with sugarcane bagasse.

This figure shows that mortar F0 has the highest density with a value of 2047kg/m3. The lowest value is that of mortar F6. This means that the densest mortar is F0, while the least dense mortar is F6. The density of the mortar therefore decreases as the sugarcane bagasse content increases. This is linked to the porosity of the sugarcane bagasse. Indeed, sugarcane bagasse has an intrinsic porosity [21]; consequently, the higher the bagasse content, the more pores there are in the mortar, making it lighter[22] than the reference. This observation has been made by several authors, both with sugarcane bagasse mortar and with other plant biomasses. Mortar reinforced with sugarcane bagasse therefore makes it possible to lighten structures and, consequently, save on structural materials.

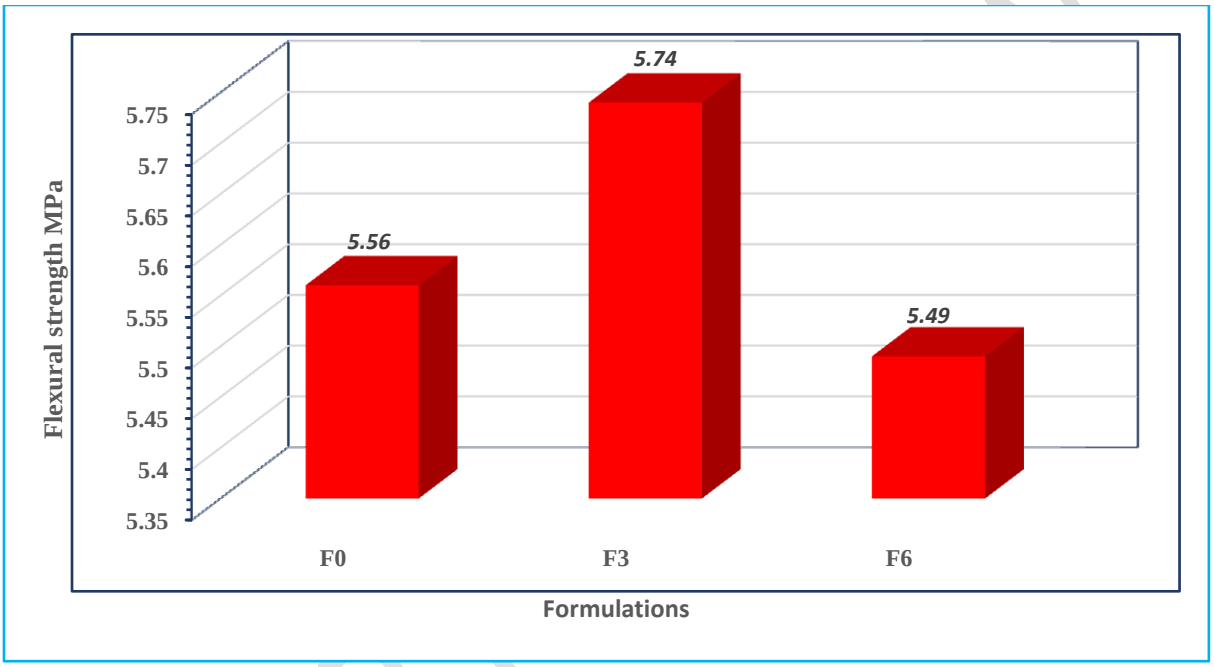

Figure 2 : Variation of flexural strength as function of SCB's rate

Figure 2 shows the evolution of the flexural strength of mortars reinforced with sugarcane bagasse. This figure shows that the flexural strength of F3 is greater than that of F0. On the other hand, the flexural strength of F6 is lower than that of F0. Flexural strength increases for low levels of sugarcane bagasse and falls for higher levels. This behavior has been observed by other authors. This can be explained by the fact that flexural strength is conditioned by good matrix-fiber cohesion [23]; however, for a higher proportion of fibers in the composite, there is a reduction in the quantity of matrix coating the fiber. This results in a reduction in fiber-matrix adhesion and, consequently, a reduction in flexural strength.

Table 2 :Quantity of carbon dioxide emitted per kilogram of sugarcane bagasse.

	Molar mass (mol/g)	Mass (Kg)
SCB	-	1
C	12	0.48
CO_2	44	1.77

Table 2 shows the quantity of carbon dioxide obtained per kilogram of sugarcane bagasse.

From this table we can see that in the best case, when there is complete combustion, with one kilogram of sugar cane bagasse burnt we obtain 1.77kg of carbon dioxide. Otherwise, incomplete combustion results in the release of carbon monoxide. Carbon monoxide is a dangerous greenhouse gas. This is the kind of combustion we see with the uncontrolled burning of agricultural waste. Even more reason to encourage the use of sugar cane bagasse in composites.

Table 3:Quantity of carbon dioxide to be reduced as a function of the volume fraction of sugar cane bagasse.

Formulations	F0	F3	F6
m_b (Kg)	0	18.75	37.5
CO_2 (Kg)	0	33.19	66.37

Table 3 shows the amount of carbon dioxide that could be reduced if sugarcane bagasse were used in the construction mortar.

From this table we can see that the mass of carbon dioxide reduced increases with the proportion of sugarcane bagasse in the mortar. This is quite normal, as the mass of bagasse also increases with its content in the mortar. Incorporating 6% of the volume fraction of bagasse in the mortar would reduce carbon dioxide from sugarcane bagasse combustion by almost 67Kg.

4 Conclusion

This study made it possible to evaluate the ecological and structural interest of using sugarcane bagasse in cement mortars. The following can be noted from this study:

- The mass of the mortar decreases as the sugarcane bagasse content increases.

- Structures are lightened with the use of sugarcane bagasse mortars.

- Flexural strength increases at low levels of sugarcane bagasse and decreases at high levels.

- The complete combustion of one kilogram of sugarcane bagasse releases 1.77Kg of Carbon dioxide.

- Incorporating 6% of the volume fraction of bagasse in the mortar would reduce carbon dioxide from sugarcane bagasse combustion by almost 67Kg.

As a result, using sugarcane bagasse in mortar reduces the quantity of greenhouse gases emitted during the uncontrolled combustion of sugarcane bagasse, while improving the mortar's flexural strength and reducing loads on structural elements.

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