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Influence of Sugarcane Bagasse Fibers on the Mechanical Strength and Porosity of Concrete Made with Forspak 42.5 N Cement in the Republic of Congo

Christ Ariel Malanda Ceti[1,2*], Alain Second Dzabana Honguelet[3,4,5], Ferland Ngoro-Elenga[3,4,5], Timothée Nsongo[3,4,5], Abel Dominique Eboungabeka[3,5], Hilaire Elenga[3,4], Nice Ngouallat Mfoutou[6]

[1]National Higher Polytechnic School, Marien Ngouabi University, Brazzaville, Congo
[2]Higher Institute of Architecture, Town Planning, Building and Public Works, Denis Sassou Nguesso University, Kintélé, Congo
[3]Faculty of Science and Technology, Marien NGOUABI University, Congo
[4]Geological and Mining Research Center, Ministry of Mining and Geology, Brazzaville, Congo
[5]Research Group of Physical Chemical and Mineralogical Properties of Materials, Brazzaville, Congo
[6]National Institute for Research in Engineering Sciences, Innovation and Technology, Brazzaville, Congo
Email: *cetimalanda@gmail.com, abeleboungabeka@gmail.com

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Abstract

The concrete mixed to sugarcane bagasse fibers and polypropylene fibers prepared with varied conditions were presented. The aim of our study is to formulate a concrete mixed with sugarcane bagasse fibers, which will gradually replace the conventional polypropylene fibers often used. We formulated all our concretes using the dreux gorisse method. We used an oven calibrated at 105˚C to dry the washed fibers. We also carried out tensile splitting and compression tests, at 28 and 112 days of age. The reinforcement mechanisms of sugarcane bagasse fibers and polypropylene fibers concretes were subjected to tensile splitting and compression tests after total immersion of the specimens in tap water at 28 and 112 days. Porosity at 28 days, mass loss and drying shrinkage at 80 days were also studied. The curing processes of concretes containing 0.10, 0.15, 0.17, 0.23 and 0.25% bagasse fibers were compared with those of ordinary concretes containing no fiber. The results showed that the addition of bagasse fibers reduces mechanical strength and porosity. In summary, specimens SBC-0.15 and SBC-0.17 showed the best results for all fibers. We plan to do the same work, but this time with raffia or palm nut fibers.

Keywords

Concrete, Bagasse Fiber, Polypropylene Fiber, Tensile Test, Compression Test

1. Introduction

The construction of bio-fibre concrete engineering structures in developing countries such as Congo Brazzaville and around the world is a major challenge for the 21st century. Congo Brazzaville is a forested country in the Congo Basin region, with variable rainfall and a number of climatic factors that interfere with ordinary concretes and the search for new concrete properties. Bagasse is found in large quantities in the south of the Republic of Congo. Its distribution in the Bouenza region, in the south of Congo Brazzaville, by the SARIS Congo group, a subsidiary of the multinational SOMDIAA (Organization, Management and Development company for the Agricultural and food Industries), shows just how much Congo Brazzaville has to offer in terms of expanding sugarcane-growing areas. This plant is of major socio-economic interest because of the fineness, strength and flexibility of its fibers. The fiber has been grown for over half a century by the Saris CONGO group, with whom we have signed a research partnership on bagasse. The sugar business covers an area of 12,000 hectares of sugar cane. What's more, the Moutela plant has a crushing capacity of 5000 tonnes of sugarcane a day for the duration of the sugar campaign, which runs from June to November, giving an annual production of almost 70,000 tonnes of sugar. Its abundance and influence in the region have led Ngouallat *et al*. to work on its by-product, molasses [1] [2]. Several works have been already done on composite materials in Congo Brazzaville, particularly with wood chips, plant waste, etc. [3]-[5]. One tonne of sugar cane generates 280 kg of bagasse waste [6]. This creates economic and environmental problems. The incorporation of plant fibers is an alternative for the manufacture of composite or biosourced concretes in order to address both the issue of construction comfort and the environment. The fibers normally used in construction have the disadvantage of being derived from non-renewable resources (steel, polypropylene, glass fiber, etc.). Each type of fibers has a particular influence on the mechanical behaviour of concrete. Among the plant fibers used are sugarcane, palm nut, coconut and bamboo fibers. These fibers are renowned for their high mechanical performance. Sugar production is currently rising sharply worldwide, with almost 1500 million tonnes of sugar produced worldwide. Around 40% - 45% of bagasse remains after the juice has been extracted. Normal annual bagasse production is therefore estimated at 600 million tonnes, a bulky waste product from the sugar industry [7]. Cement is the most widely used material in infrastructure development. The environmental issue of cement has become a growing concern, as the cement industries are responsible for around 2.5% of total industrial waste emissions worldwide [8]. Cement production requires considerable energy and is also responsible for 5% of global anthropogenic CO_2 emissions (each tonne of cement produces around 01 tonne of CO_2) [9]. The advantage of cement composites reinforced with plant fibers lies in their improved mechanical and thermal properties, as well as their reasonable cost [10] [11]. The use of abundant waste materials in the construction industry is an important motivation for this study [3] [4] [12] [13]. The results of the study of these concretes in the fresh and hardened states are compared with concretes reinforced with polypropylene fibers [14]. Ideally, the combination of two components, the matrix and the fiber, results in a material that performs better than the matrix alone [15]. Incorporating fibers into concrete increases flexural strength, controls changes in cracking, impact resistance, fracture toughness and tensile strength. It increases adhesion and modifies the rheological characteristics of concrete [16]. Steel fiber is the most commonly used [12]. Plant fibers are preferred to synthetic fibers because of their biodegradability, recyclability, wear resistance and environmental friendliness [17]. From an economic point of view, they offer the possibility of stimulating economic activities in isolated regions, and from a social point of view, they help to support agriculture in these regions [18]. As far as plant fibers are concerned, it is important to take into account their disadvantages, notably their inherent variability in terms of physical and mechanical properties, their lower durability and their resistance to wear. In recent years, researchers and industrialists have taken a keen interest in the development of new plant fiber-reinforced composites for use in the construction and public works sectors. In this work, we designed concretes with different formulations reinforced with SBC sugarcane bagasse and PC polypropylene fibers. We then subjected them to tensile splitting and simple compression tests at 28 days and 112 days. Finally, a study of the porosity at 28 days of the different concretes was carried out.

2. Experimental Details

2.1 Materials

The cement used in this study is portland cement with strength class 42.5 N (CEM I 42.5 N according to standard EN 197-1) from the Forspak cement works in the Niari department of Congo Brazzaville.The superplasticizer (SP) Dynamon Easy 738 is a modified acrylic polymer-based admixture, which is specifically suited to the ready-mixed concrete sector. The superplasticizer is incorporated into the mix when the concrete is mixed with a standard mixer. All the aggregates come from the Djoué river quarry on the outskirts of Brazzaville. They are hard and non-reactive to alkali-reaction. The 0/4 mm sand has a density of 2652 kg/m^3 and a water absorption coefficient of 0.76% (by mass). Aggregates (04/12 mm and 12/20 mm) with a density of 2673 kg/m^3 and a water absorption coefficient of 0.72% (by mass). The polypropylene fibers used (**Figure 1**) in this study are fibers manufactured from propylene. They are Sikafibre-force 54. It has a length of 54 mm, a diameter of 0.34 mm, a tensile strength of 689 MPa and a tensile modulus of elasticity of 5.75 GPa. **Figure 2** shows sugarcane bagasse fiber sieved through a 4 mm sieve.

The untreated sugarcane bagasse was sieved with a 4 mm sieve to extract elements smaller than 4 mm, then immersed in water for two hours before being dried again in a Controlab oven at 40˚C to prevent the mixing water from being absorbed by the fibers when the concrete was made. The mass of the sample was taken as a function of time. We also used Origin Pro software to process our data.

Figure 1. Sieved sugarcane bagasse fiber.

Figure 2. Unscreened sugarcane bagasse fiber from Saris Congo after extraction at the factory.

2.2. Formulation of Different Types of Concrete

Our objective is to obtain a structural concrete with a compressive strength class of C30/37 in accordance with standard NF EN 206-1. To achieve this, several types of concrete were formulated using the Dreux-Gorisse method, of which seven typical concretes were selected [14]. These were five concretes based on sugarcane bagasse fibers (SBC: Sugar Bagasse Concrete), namely SBC-0. 1, SBC-0.15, SBC-0.17, SBC-0.23, SBC-0.25, containing respectively 0.1, 0.15, 0.17, 0.23, and 0.25 % sugarcane bagasse fibers (by volume), a concrete based on Polypropylene fibers (PC: Polypropylene Concrete) incorporating 0.1 % by volume of polypropylene fibers and an ordinary concrete (OC: Ordinary Concrete), taken as the reference concrete. Using the dreux-gorisse method, we started from the principle of making 21 specimens of concrete using cylindrical steel moulds with a diameter of 16 × 32 mm. And for the dosage of admixture in the matrix, depending on the quantity of fibers introduced, we carried out different dosages at 0.6, 0.54 and 1.20 %.

For each concrete formulation, concrete specimens with cylindrical moulds (Ø: 16 cm, height: 32 cm) were made. To carry out the experiments on the concretes, we began by weighing the quantities according to the mix code using a 30 kg Kern precision balance. The materials were then mixed in a Controlab C0198/3 vertical shaft mixer with a mixing capacity of 300 liters and a tank volume of 600 liters. The coarse and fine aggregates were dry-mixed for one minute. Water was then added gradually while the mixer was in motion. The polypropylene fibers were also gradually introduced into the mixer. The same process was repeated when mixing concrete with sugarcane bagasse fibers. The remaining admixture and water were then added to the still-running mixer. We estimated the total mixing time to be around five minutes for both the ordinary concrete and the sugarcane bagasse fiber concrete. In the case of mixes reinforced with polypropylene fibers and bagasse fibers, the fibers were added progressively in the middle and at the end of the mixing period, by placing them slowly and manually into the mix. To prevent the fibers from 'balling up', the addition of the fibers added two minutes to the total mixing time. The Abrams cone slump test was carried out at the end of the mixing process. All the moulds were first oiled and then filled in two layers and vibrated using a Heberth-type portable electric concrete vibrator for approximately one minute. Cylindrical moulds measuring 16 × 32 mm were cast vertically. The compacted specimens were covered with a rubber sheet to limit water loss for the first 24 hours after casting. The following day, the specimens were demoulded and weighed on a 30 kg kern precision balance. The specimens were then immediately placed in water tank with a temperature of 20˚C ± 2˚C and a relative humidity of over 60˚C ± 5˚C to determine the tensile and compressive strengths at 7, 14, 28 and 112 days, *i.e.*, an average of 3 specimens per age of concrete. Also, 9 specimens were withdrawn from the batch for drying shrinkage and loss of mass and porosity tests.

3. Characterization of the Different Types of Concrete

We carried out the following characterization tests on fresh and hardened concrete.

3.1. Fresh State: Abrams Cone Workability

Consistency classes (slump classes) are used to characterise the workability of concrete and to classify it according to standard NF 18-451 using the Abrams cone [19]. The classes of concrete from firm to very fluid are given in **Table 1**. We used control brand equipment to carry out the Abrams cone test. For the last class, the Abrams cone slump test is not accurate enough, so the Abrams cone spread test is used.

Table 1. Slump classes for different types of concrete [19].

Class	Slump in mm	Type of concrete
S1	10 to 40	Farm
S2	50 to 90	Plastic
S3	100 to 150	Very plastics
S4	160 to 210	Fluid
S5	220 or more	Very fluid and self-placing concrete

3.2. Hardened State

The following formula was used to obtain percentage values for drying shrinkage

$$\mathrm{Mr} = \left(\frac{Dd - Da}{Dd}\right) \times 100 \quad (1)$$

With Mr: Measurement of the dimension, Dd = Starting dimension, corresponds to the dimension on the 1st day, *i.e.*, the first measurement, Da = Ending dimension, corresponds to the dimension on the 2nd day, i.e. the following day.

The total porosity (N_{tot}) of a concrete sample is given by:

$$N_{tot} = 100 \times \left[\frac{(\mathrm{Ww} - \mathrm{Dw})}{\mathrm{Ww}}\right] \quad (2)$$

Ww: wet weight, Dw: dry weight.

The following formula was used to find the compressive strength value:

$$\mathrm{Fcj} = \frac{\mathrm{P}}{S} \quad (3)$$

Where Fcj is the compressive strength of a cylindrical concrete specimen measuring (16 × 32) cm. P is the breaking load obtained on the compression press and S is the surface area of the specimen.

4. Results and Discussion

4.1. Slump Test for Fresh Concrete

The values of the different classes of the Abrams cone slump test are presented in **Table 2** below. Two classes of concrete can be distinguished.

- S_3 (110 - 140 mm; OC, SBC-0.10, SBC-0.15 et PC),
- S_2 (60 mm; SBC-0.17, SBC -0.23 et SBC-0.25).

Among S3 concretes, the SBC-0.10 and SBC-0.15 differ in that the workability of the SBC-0.15 decreases due to the increase in sugarcane bagasse fibers. Both types of concrete have practically the extreme values of class S3. For class S2 concretes, it can be seen that as the amount of sugarcane bagasse fibers increases, the workability and workability of the mix in the fresh state decreases. These results are in agreement with those found in the literature [20]-[22]. This is due to the high porosity of the bagasse fibers: despite being impregnated in the alkaline solution before mixing, the bio-fibers of bagasse still continue to absorb some of the mixing water during the making of the composite, which reduces the workability of the concrete, hence the use of the superplasticizer, which made it possible to maintain a level of workability similar to classes S2 and S3 and to obtain a structural concrete that is easy to place.

Table 2. Mix proportions for 1 m^3 and slump values for the different concretes.

Proportion of mixture per 1 m^3	Mixing code						
	OC	SBC-0.1	SBC-0.15	SBC-0.17	SBC-0.23	SBC-0.25	PC
Cement (kg)	16.20	16.20	16.20	16.20	16.20	16.20	16.20
Water (l)	10.46	10.46	10.46	10.46	10.46	10.46	10.46
Sand (kg)	26.11	26.11	26.11	26.11	26.11	26.11	26.11
Gravel 4 - 12 (kg)	28.61	28.61	28.61	28.61	28.61	28.61	28.61
Gravel 12 - 20 (kg)	32.33	32.33	32.33	32.33	32.33	32.33	32.33
Wet sugar cane bagasse fibre (kg)	0.00	0.10975	0.15365	0.17560	0.24145	0.2634	0.00
Polypropylene fibres (kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.10975
Superplasticizer (kg)	0.0972	0.06804	0.0972	0.0972	0.0972	0.1944	0.06804
Slump test (m)	0.12	0.115	0.142	0.065	0.070	0.082	0.122
Standard class NFP 18-451	S3 Very plastic	S3 Very plastic	S3 Very plastic	S2 Plastic	S2 Plastic	S2 Plastic	S3 Very plastic

Fibers (sugarcane bagasse and polypropylene) are additive and do not substitute components for cement, sand, or aggregates. They are considered as sewing fibers and their contribution in mass is negligible compared to the percentages of the aggregates. In the case of bagasse and polypropylene fibers concretes (SBC and PC), the fibers are mixed with the cement and aggregates before the water is added to ensure a better distribution of the fibers throughout the mix and to prevent the fibers from agglomerating and sticking together. We can add that problems of agglomeration or the formation of "sea urchin" balls can occur when fibers are introduced into the mix. The fibers could then disrupt the granular arrangement and thus reduce the workability and compactness of the mix.

4.2. Compressive Strength and Splitting Tensile Strength

Compressive strength and splitting tensile strength were tested on cured cylindrical specimens stored in a damp room (100% RH at 20˚C) at 7, 14, 28 and 112 days.

Each value is the average of three specimen values per concrete age. Compression and tensile tests were carried out in accordance with standard NF P15-471.

The simple compression tests were carried out on the 16 × 32 cm cylindrical specimens. The results obtained are shown in Figure 3 below.

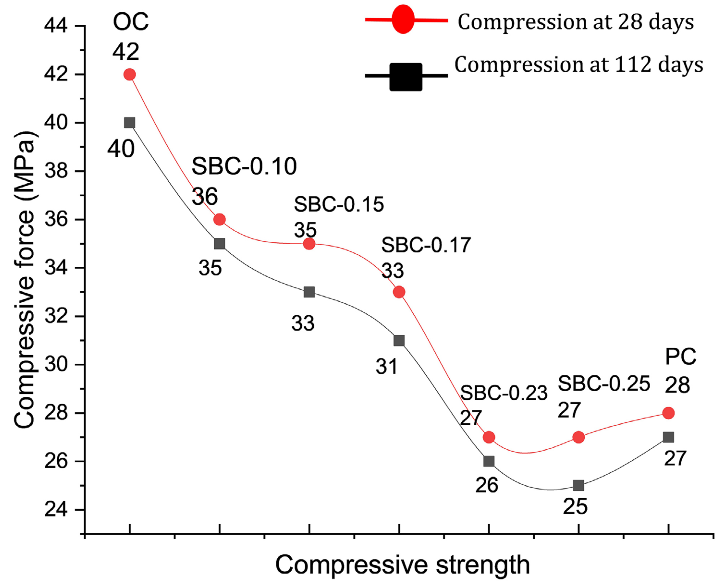

Figure 3. compressive force vs compressive strength.

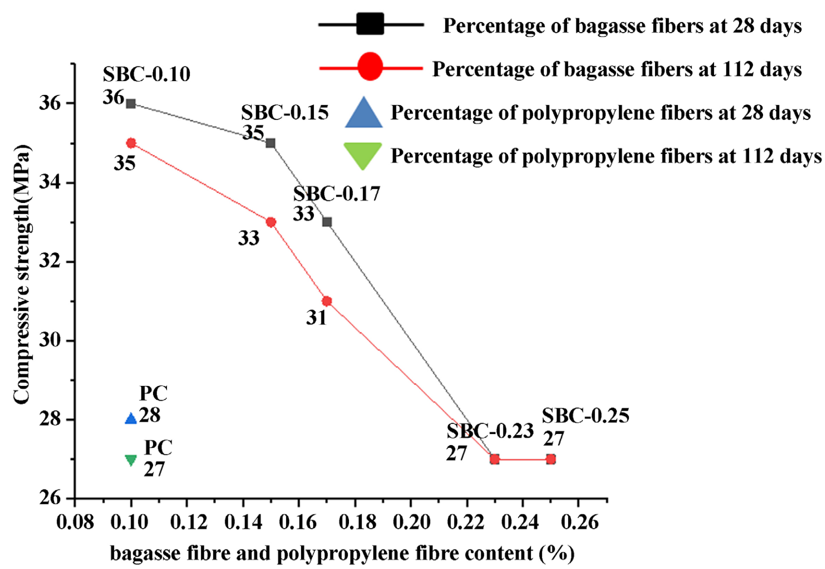

Figure 4. Compressive strength vs fibers content.

Figure 4 above shows the compressive strength as a function of fibers content. This clearly shows that as fibers content increases, compressive strength decreases.

Whatever the number of days, the compressive strength decreases with the compressive strength and shows a minimum function of the percentage of fibers incorporation at 28 and 112 days. The highest compressive strength is that of OC. There is no significant difference between the compressive strengths at 28 and 112 days, but although those of SBC-0.15, SBC-0.17 and PC decrease by 20% compared to OC, they remain within the strength values of ordinary structural concrete, whose strength is limited to between 25 and 50 MPa as stipulated in standard EN 206-1. We also note that there is a strong correlation between sugarcane bagasse fibers content and compressive strength for both maturities. As the sugarcane bagasse fibers content increases, the compressive strength of the concrete decreases. This relationship is in line with several research studies carried out on plant fiber-reinforced concrete. The use of plant fibers does not improve the compressive strength of concrete, as they increase the volume of voids and reduce the compactness of the composite [20]-[24]. These results are in agreement with those obtained by other authors [25]-[29]. It should be noted here that for both maturities (at 28 days and 112 days), compressive strength decreases progressively with increasing fiber content.

4.3. Splitting tensile strength

Tensile splitting tests (Brazilian test) were carried out on samples of cylindrical concrete (16 × 32) cm, as shown in **Figure 5** below. The results of the tensile splitting test are shown after 28 and 112 days in water at 20˚C ± 2˚C.

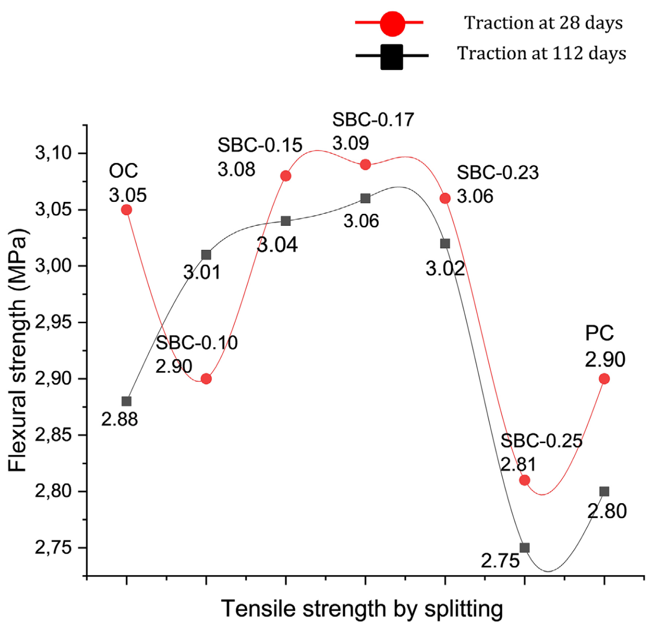

Figure 5. Split tensile force vs tensile strength.

Figure 6 below shows the tensile strength as a function of fibers content.

At 28 days, the strengths of bagasse fibers SBC-0.10 (2.90 MPa), SBC-0.25 (2.81 MPa) and PC (2.9 MPa) are lower than those of the reference concrete OC (3.05 MPa). On the other hand, SBC-0.15 (3.08 MPa), SBC-0.17 (3.09 MPa) and SBC-0.23 (3.06 MPa) have higher strengths than OC. At 112 days, all the fiber-reinforced concretes still show very good results compared with ordinary OC concrete (2.88 MPa). SBC-0.25 concrete (2.75 MPa) is the exception, remaining lower than the OC reference concrete. The best values are those of concretes SBC-0.15 (3.08 MPa at 28 days and 3.04 MPa at 112 days) and SBC-0.17 (3.09 MPa), which increased by almost 7% at 28 days and up to 6% at 112 days (3.06 MPa). For both 28 and 112 days, we note that above 0.17% incorporation of sugarcane bagasse fibers, the tensile strengths of the concretes decrease. And the coefficient of variation (the ratio between the standard deviation and the mean) of the concretes subjected to tensile strength at 28 days and 112 days gives us a value close to 100%. This gives us a homogeneous distribution for the concretes at 28 days and 112 days, so in terms of mechanical tensile strength by splitting, the resistance of all the concretes underwent a homogeneous variation.

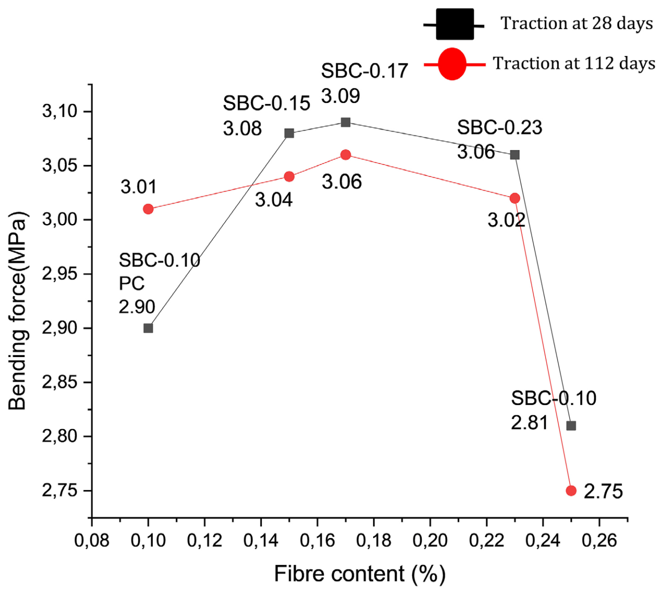

Figure 6. Split tensile strength vs fibers content.

Sugarcane bagasse fibers improve the tensile strength of concrete and reduce crack propagation, particularly in the early stages. This phenomenon depends on the quantity of fibers incorporated into the concrete, up to a certain threshold where the effect is reversed, as is the case with other types of natural fibers [30] [31]. In our case, the threshold not to be exceeded is 0.17%. We can also say that the improvement in tensile strength is due to the stitching effect of the fibers in the matrix [32] [33].

The ability of sugarcane bagasse fibers to stretch, given their remarkable tensile strength, delays the cracking of concrete, thus preventing its sudden ruin, as in the case of a low-magnitude earthquake [32].

However, once the fiber percentage threshold is exceeded, the tensile strength of the concrete decreases, probably as a result of the superposition of two potential phenomena: the effect of non-uniformly dispersed fibers in the matrix and the weakening of the cementitious matrix caused by the reduction in cement volume [28] [29] [34]. Taking into account the compressive and tensile strengths, we can conclude that the concretes SBC-0.15 and SBC-0.17 are the two composites with the best sugarcane bagasse fibers content in terms of mechanical properties. These results are in agreement with those found in previous work by other authors [25] [26]-[29].

4.4. Porosity

We measured the porosity over 24 hours of immersion in water. The specimens were manufactured and demoulded after 24 hours. The dry weight (Ps) was measured using a 30 kg Kern precision balance. The test tubes were then immediately and completely immersed in the water tank. The results of the different samples are shown in **Figure 7** below.

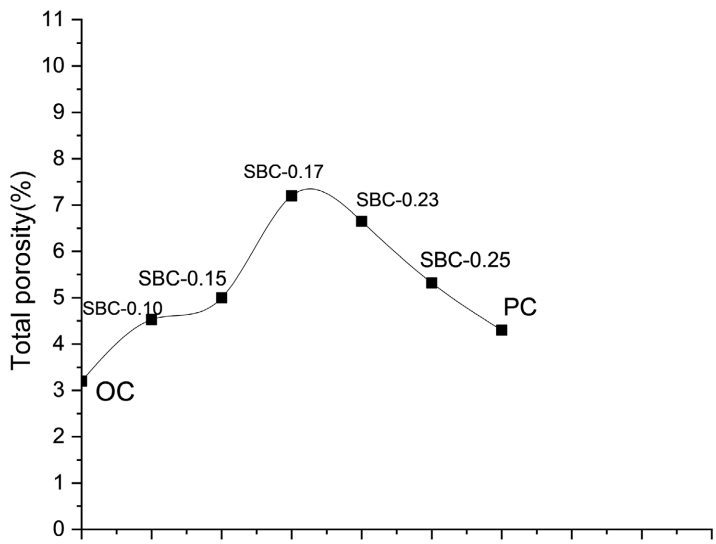

Figure 7. Porosity at 28 days vs fibers content.

The varies between 3.2 and 7.2%. Ordinary concrete (OC) is the least porous and SBC-0.17 concrete is the most porous. It can be seen that the total water porosity increases when the sugarcane bagasse fibers content varies between 0.10 and 0.17% (from SBC-0.10 to SBC-0.17) and decreases when the sugarcane bagasse fibers content varies between 0.17 and 0.25% (from SBC-0.17 to SBC-0.25). For propylene fibers concrete (PC), the porosity is close to that of SBC-0.10. Previous research studies confirm our results regarding the increase in total porosity in fiber-reinforced concrete [28] [29]. It is the fibers dispersed in the concrete that retain some of the water.

With the exception of SBC-0.23 and SBC-0.25, we can state that the total porosity values are proportional to the percentage of sugarcane bagasse fibers added. This exception, which is inconsistent with the literature, may be due to the poor dispersion of the sugarcane bagasse fibers in the concrete when they are added at a rate greater than 0.17%. Above this value, balls of sugarcane bagasse form, causing heterogeneous parts in the concrete samples, preventing water from entering certain parts of the composite by making it less porous. The unexpected results for SBC-0.23 and SBC-0.25 are probably distorted by the concentration of sugarcane bagasse fibers in certain parts of the composite. We can therefore say that the mechanism of variation is as follows: porosity increases with the addition of fibers up to 0.17% or it tends to stabilise, and drops after 0.17%.

5. Conclusions

We incorporated sugarcane bagasse fibers to produce a biosourced concrete. The results show that the workability of sugarcane bagasse fibers concrete decreases above the threshold of 0.17% of sugarcane bagasse fibers (*i.e.*, SBC-0.17) in the mix. The incorporation of sugarcane bagasse fibers into the matrix reduces the simple compressive strength of the concrete. Above 0.17%, this resistance even decreases considerably. Concretes with 0.15% and 0.17% sugarcane bagasse can be used as structural concrete. Bagasse fibers improve the tensile strength of concrete, which exceeds that of ordinary concrete and polypropylene concrete. Incorporating sugarcane bagasse fibers into concrete increases its total porosity to water. Above a certain threshold (0.17% sugarcane bagasse fibers in our case), porosity decreases. We can also say that 0.15% sugarcane bagasse fibers is the optimum contribution for reinforcing concrete.

Also, sugarcane bagasse fibers considerably improves the tensile strengths of the concretes compared with those of ordinary concrete (OC), with the exception of the percentages of 0.10% and 0.25% (SBC-0.10 and SBC-0.25).

In short, sugarcane bagasse fibers can be used for concrete reinforcement, just like polypropylene, but it also offers the possibility of having an environmentally-friendly mix that complies with the United Nation's Sustainable Development Goals (SDGs) for 2030, as well as the 3Rs process (reduce, reuse, recycle), which can make a significant contribution to the creation of what we might call green, sustainable and optimised buildings and infrastructures, for the well-being of people and nations.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Ngouallat, N.M., Malanda, N., Malanda, C.A.C., Maniongui, K.B., Madila, E.E.N. and Louzolo-Kimbembe, P. (2024) Comparative Analysis of Statistical Thickness Models for the Determination of the External Specific Surface and the Surface of the Micropores of Materials: The Case of a Clay Concrete Stabilized Using Sugar Cane Molasses. *Geomaterials*, **14**, 13-28. https://doi.org/10.4236/gm.2024.142002

[2] Mfoutou, N.N. (2023) Study of the Internal Mechanisms Involved in Stabilisation of Fine Clay Soils Using Sugar Cane Molasses, Materials and Construction. Master's Thesis, Marien Ngouabi University.

[3] Ngoro-Elenga, F., Elenga, H., Nsongo, T. and Tamo Tatietsé, T. (2016) Experimental Study on the Effect of Wood Sawdust and Sand on the Clay Slabs Resistance to Compression. *Research Journal of Engineering Sciences*, **5**, 13-16.

[4] Silouantonda Kouamissa, P. and Nsongo, T. (2023) Influence of Wood Chip on Concrete Characteristics. *American Journal of Materials Science and Engineering*, **11**, 16-21.

[5] Ganga, G., Nsongo, T., Elenga, H., Mabiala, B., Tatsiete, T.T. and Nzonzolo, (2014) Effect of Incorporation of Chips and Wood Dust Mahogany on Mechanical and Acoustic Behavior of Brick Clay. *Journal of Building Construction and Planning Research*, **2**, 198-208. https://doi.org/10.4236/jbcpr.2014.23018

[6] Barroso, J., Barreras, F., Amaveda, H. and Lozano, A. (2003) On the Optimization of Boiler Efficiency Using Bagasse as Fuel. *Fuel*, **82**, 1451-1463. https://doi.org/10.1016/s0016-2361(03)00061-9

[7] Srinivasan, R. and Sathiya, K. (2010) Experimental Study on Bagasse Ash in Concrete. *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship*, **5**, 60-66. https://doi.org/10.24908/ijsle.v5i2.2992

[8] Jayminkumar, A.P. and Raijiwala, D.B. (2015) Experimental Studies on Strength of RC Concrete by Partially Replacing Cement with Sugar Cane Bagasse Ash. *International Journal of Innovative Research in Science, Engineering and Technology*, **4**, 2228-2232.

[9] Abd Elhameed Hussein, A., Shafiq, N., Fadhil Nuruddin, M. and Ahmed Memon, F. (2014) Compressive Strength and Microstructure of Sugar Cane Bagasse Ash Concrete. *Research Journal of Applied Sciences, Engineering and Technology*, **7**, 2569-2577. https://doi.org/10.19026/rjaset.7.569

[10] Campbell, M.D. and Coutts, R.S.P. (1988) Wood Fibre-Reinforced Cement Composites. *Journal of Materials Science*, **15**, 1962-1970.

[11] Arsene, M.A., Savastano Jr., H., Allameh, S.M., Ghavami, K. and Soboyejo, W. (2003) Cementitious Composites Reinforced with Vegetable Fibers. *Proceedings of the First Interamerican Conference on Non-Conventional Materials and Technologies in the Eco-Construction and Infrastructure*, Joao-Pessoa, 13-16 November 2003, 1-27.

[12] Brandt, A.M. (2008) Fibre Reinforced Cement-Based (FRC) Composites after over 40 Years of Development in Building and Civil Engineering. *Composite Structures*, **86**, 3-9. https://doi.org/10.1016/j.compstruct.2008.03.006

[13] Zafindro, M. (2014) Contribution to the Valorization of Bagasse—Application to the Manufacture of Fiber Concrete. Bachelor's Thesis, University of Antananarivo.

[14] Khelifa, M.R. (2017) Formulation and Characterization of Eco-Concretes Reinforced with Esparto Fibers for Green and Sustainable Buildings. Master's Thesis, University of Paris Seine.

[15] Chavan, S. and Rao, P. (2016) Utilization of Waste PET Bottle Fibers in Concrete as an Innovation in Building Materials. *International Journal of Engineering Research*, **5**, 304-307.

[16] Zakaria, M., Ahmed, M., Hoque, M.M. and Islam, S. (2016) Scope of Using Jute Fiber for the Reinforcement of Concrete Material. *Textiles and Clothing Sustainability*, **2**, Article No. 11. https://doi.org/10.1186/s40689-016-0022-5

[17] Kumar, A. and Srivastava, A. (2017) Preparation and Mechanical Properties of Jute Fiber Reinforced Epoxy Composites. *Industrial Engineering & Management*, **6**, Article ID: 1000234. https://doi.org/10.4172/2169-0316.1000234

[18] Mohammadhosseini, H., Tahir, M.M., Mohd Sam, A.R., Abdul Shukor Lim, N.H. and

Samadi, M. (2018) RETRACTED: Enhanced Performance for Aggressive Environments of Green Concrete Composites Reinforced with Waste Carpet Fibers and Palm Oil Fuel Ash. *Journal of Cleaner Production*, **185**, 252-265. https://doi.org/10.1016/j.jclepro.2018.03.051

[19] (2007) Slump Test, Consistency and Workability of Concrete Using the Abrams Cone. French Standards, NFP 18-451.

[20] El-Hilali, A. (2009) Experimental Study of the Rheology and Behavior of Self-Compacting Concrete (SCC): Influence of Fine Limestone and Plant Fibers. Ph.D. Thesis, University of Cergy-Pontoise.

[21] Bourzam, A. (1999) Effect of Palm Fibers on the Mechanical Performance of Concrete Reinforced with Natural Fibers. Master's Thesis, National School of Public Works of Algiers.

[22] Bouchekouk, M. (1992) Study of Concrete Reinforced with Glass Fibers Coated with Thermoplastic Polymers. Master's Thesis, INSA Lyon.

[23] Neville, A.M. (1997) Properties of Concrete. 4th Edition, Pearson Education Limited.

[24] Hussien, N.T. and Oan, A.F. (2022) The Use of Sugarcane Wastes in Concrete. *Journal of Engineering and Applied Science*, **69**, Article No. 31. https://doi.org/10.1186/s44147-022-00076-6

[25] Mboungou Londe, G.H., Mwero, J.N., Kanali, C. and Abuodha, S.O. (2024) Investigating the Influence of Raw and Treated Coconut Fibre Obtained from Agricultural Residue on the Strength and Durability Characteristics of High-Strength Concrete. *Advances in Civil Engineering*, **2024**, Article ID: 8275876. https://doi.org/10.1155/2024/8275876

[26] Rumbayan, R., Sudarno, and Ticoalu, A. (2019) A Study into Flexural, Compressive and Tensile Strength of Coir-Concrete as Sustainable Building Material. *MATEC Web of Conferences*, **258**, Article No. 01011. https://doi.org/10.1051/matecconf/201925801011

[27] Thyavihalli Girijappa, Y.G., Mavinkere Rangappa, S., Parameswaranpillai, J. and Siengchin, S. (2019) Natural Fibers as Sustainable and Renewable Resource for Development of Eco-Friendly Composites: A Comprehensive Review. *Frontiers in Materials*, **6**, Article 226. https://doi.org/10.3389/fmats.2019.00226

[28] Valizadeh Kiamahalleh, M., Gholampour, A., Ngo, T.D. and Ozbakkaloglu, T. (2024) Mechanical, Durability and Microstructural Properties of Waste-Based Concrete Reinforced with Sugarcane Fiber. *Structures*, **67**, Article ID: 107019. https://doi.org/10.1016/j.istruc.2024.107019

[29] Kumar, N. and Barbato, M. (2022) Effects of Sugarcane Bagasse Fibers on the Properties of Compressed and Stabilized Earth Blocks. *Construction and Building Materials*, **315**, Article ID: 125552. https://doi.org/10.1016/j.conbuildmat.2021.125552

[30] Aggarwal, L.K. (1995) Bagasse-Reinforced Cement Composites. *Cement and Concrete Composites*, **17**, 107-112. https://doi.org/10.1016/0958-9465(95)00008-z

[31] Ali, M.A. and Singh, B. (1975) The Effect of Porosity on the Properties of Glass Fibre-Reinforced Gypsum Plaster. *Journal of Materials Science*, **10**, 1920-1928. https://doi.org/10.1007/bf00754481

[32] Wang, Y., Wu, H.C. and Li, V.C. (2000) Concrete Reinforcement with Recycled Fibers. *Journal of Materials in Civil Engineering*, **12**, 314-319. https://doi.org/10.1061/(asce)0899-1561(2000)12:4(314)

[33] Keyvani, A.S. (1997) Behavior of Fiber Concrete Composites Using Recycled Steel Shavings. *The Journal of Solid Waste Technology and Management*, **24**, 1-8.

[34] Desta, A. (2019) Investigation on Production of Light Weight High Tensile Strength Concrete Using Sugarcane Bagasse Fiber. *Saudi Journal of Engineering and Technology*, **4**, 78-122.