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Behavior of Sugarcane bagasse Fiber Reinforced Concrete

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Abstract: Research on improving the mechanical and physical characteristics of concrete is one possibility. Fiber-reinforced concrete is one of the innovations that provides affordable, useful, and practical solutions for overcoming tiny fractures and other flaws. Since the tension in concrete is weak; fiber helps to overcome this deficiency. There are various kinds of fiber that fulfill this. With such in mind, this paper explores the suitability of sugarcane bagasse fibers. Sugarcane bagasse is considered as a waste material in most parts of the world and is a common constituent found in municipal waste streams which cause environmental issues. Sugarcane fibers, an alternative biodegradable material, is widely accessible and at a very low price. This paper compares the strength and durability of Portland pozzolana concrete with sugarcane fiber reinforced concrete, as per the BIS code, with 0%, 1%, 2% 3%, 4% addition of sugarcane by weight of cement. The outcome demonstrates that the addition of sugarcane fibers enhances the binding properties, microcracks control, imparts ductility and also increases the spalling resistance. The experimental findings in overall studies would encourage further research in this direction for long term performance to extend this cost-effective type of fibers for use in structural application.

Keywords: Fiber Reinforced Concrete, Sugarcane bagasse Fiber, Compressive Strength, Flexural Strength and Crack Resistance.

I. INTRODUCTION

Concrete consists of Portland cement, water, and stone aggregate, with low tensile strength, limited ductility, and minimal resistance to cracking. Due to the low tensile strength of concrete, it is necessary to take certain steps to address this weakness. Therefore, adding fiber to the concrete enhances properties such as tensile strength, and decreases air and water voids, as well as the natural porosity of gel, ultimately improving the durability of the concrete.

Fiber is a small reinforcing material with specific properties. The behavior of concrete is greatly affected by the type and quantity of fibers added to it. The characteristics of fiber reinforced concrete are primarily determined by the material and composition.

A quality fiber needs strong adhesion in the matrix and flexible elastic modulus. It has to work with the binder, which must not be damaged or broken in the future. It needs to be brief, smooth, and adaptable for blending, carrying, and laying while also durable enough to endure the blending operation. Fibers
are commonly utilized in concrete to regulate plastic and dry shrinkage cracking, decrease permeability, and enhance impact, abrasion, and shatter resistance. Fiber reinforced concrete is a convenient, practical, and cost-effective way to address micro-cracks and other similar imperfections. It is a successful approach for building earthquake-resistant structures that are lightweight.

Sugarcane fiber

Sugarcane bagasse has tensile strength, making it suitable for use as a material to reinforce fibers. Sugarcane Fiber is a readily available degradable material that is abundant and inexpensive. Sugarcane bagasse is typically seen as a waste product globally and is a frequent component in municipal waste, leading to significant environmental issues during its decomposition. Additionally, the fiber's high tensile strength and unique chemical composition make it appropriate for use as a reinforcing material. This research aims to blend the natural sugarcane fiber into concrete as a reinforcement to investigate improvements in its long-term properties. This is an effort to explore how sugarcane can be utilized as fiber reinforcement in concrete, offering a different approach to handling sugarcane waste. Current research is being conducted to investigate the impact of sugarcane fiber on conventional cement concrete in terms of compressive and flexural strengths, aiming to economically manage cracking.

Properties and composition

Bagasse is the solid residue resulting from the juice extraction from the sugarcane stalks and contains the fibrous lingo-cellulosic material of the stalks. The fineness of fiber varies between 25tex and 35tex. The moisture regain of fiber lies between 13% and 18%. The tenacity of the fiber lies between 12 g/tex and 18 g/tex and the percentage breaking elongation varies between 2.5% and 3.5%. The fiber possesses a moderate amount of elastic recovery at 50% of breaking extension. The flexural rigidity of fiber is quite low ranging from 0.015 g cm2 to 0.032 g cm2. Dry sugarcane bagasse consists mostly of cellulose, hemicellulose, and lignin, with only a little amount of ash and wax (around 40–50% and 28.–55%, respectively)

II. MATERIAL PROPERTIES:

Ingredients used are Portland pozzolana cement (PPC), coarse aggregate, fine aggregate, water and sugarcane fibers.

A) Portland Pozzolana Cement:

UltraTech cement PPC, conforming to the BIS code, was used.

B) Aggregate:

The coarse aggregates had nominal maximum size of 12.5 mm and specific gravity of 2.58. The fine aggregate used in this investigation was crushed sand, with fineness modulus of 2.78.

C) Sugarcane Fiber:

Table 1: Properties of Sugarcane Fibers

Property	Value
Density	1.2 g/cm3
Tensile Strength	290 MPa
Torsional rigidity	95 dyne-cm2 to 330 dyne-cm2
Young's modulus	27.1 Gpa

III. SPECIMEN PREPARATION:

The concrete mix design is done in accordance with IS 10262-2009. The mortar cubes were mixed by using 3:1 proportion to determine its compressive strength, where three parts of sand were mixed with one part of cement and the W/C was 0.5. In the present experimental investigation, the total number of specimens casted was 90. The cubes casted were total of 75 in number, of which each set of 3 cubes were meant for different percentage of sugarcane(i.e., 0%, 1%, 2%, 3% and 4%) Similarly, 15 beams were casted with varying percentages of sugarcane by weight of cement. All the specimens were tested for 28-day strength.

IV. TEST PERFORMED:

Various cubes and beams are tested and analyzed for determining the effect of sugarcane as fiber in concrete. The following tests were performed.

A) Compressive strength test

The test was conducted as per IS 516-1959. The test is carried out on specimens cubical in shape of the size of 150mmx150mmx150 mm. Specimens were placed on the bearing surface of the compression testing machine. A uniform rate of loading was applied till the failure of the cube. The maximum load was noted and the compressive strength was calculated.

B) Flexural Strength Test

This test was carried out as per IS 516-1959 specifications. Normal concrete beams and sugarcane fiber reinforced concrete beams of size 150mm×150mm× 700mm are tested using a flexure testing machine. The specimen is simply supported on the two rollers of the machine which are 600mm apart, with a bearing of 50 mm from each support. The load shall be applied on the beam from two rollers which are placed above the beam with a spacing of 200mm. The load is applied at a uniform rate such that the extreme fibers stress increases at 0.7N/mm2/min i.e., the rate of loading shall be 4kN/min. The load is increased till the specimen fails. The maximum value of the load applied as noted down.

C) Rebound Hammer Test

Rebound hammer test is done to out the compressive strength of concrete by using rebound hammer as per IS 13311(part 2)-1992 Rebound hammer test was conducted on cubes and beams (without crack) at 25 selected points, with the instrument in vertically downward direction and in horizontal direction. In order to take readings in horizontal direction, a load corresponding to 20% of design strength was applied. In cubes, the points were marked on each of its faces. In case of beams, three sections were selected accordingly (say A, B, C) and points were marked on each face along the length of the beam.

D) Water Absorption Test

The procedure for the water absorption test is as described. Cubes shall be completely immersed in clean water at room temperature for 24 hours. The blocks shall then be removed from the water and allowed to drain for one-minute, visible surface water being removed with a damp cloth. The saturated and surface dry blocks are immediately weighed. After weighing all blocks shall be dried in a ventilated oven at 100 degrees Celsius to 1150 degree Celsius for not less than 24 hours.

E) Sulphur Attack Test:

The resistance of concrete to sulphate attacks was studied by determining the loss of compressive strength of variation in compressive strength of concrete cube immersed in sulphate water having 5%
of sodium sulphate (Na_2SO_4) and5% of magnesium sulphate ($MgSO_4$) by weight of water and those which are not immersed in sulphate water. The concrete cubes of 150mm size after 28 days of water curing and dried for one day were immersed in 5%$Na_2SO_4$and 5% $MgSO_4$ added water for 28 days. The concentration of sulphate water was maintained throughout the period, after 28 days immersion period, the concrete cubes were removed from the sulphate waters and after wiping out the water from the surface of cubes tested for compressive strength following the procedure prescribed in IS 516-1959.

V. RESULTS AND DISCUSSIONS:

The mechanical properties of concrete are tested on the specimens, with and without sugarcane as fiber reinforcement. The percentage of sugarcane fiber is varying from 1% to 4% with an increase of 1% in each iteration. During the casting of test samples, it was observed that mixing of sugarcane bagasse in the concrete to achieve homogeneity is a problem at concentration above 3% of sugarcane bagasse, resulting in balling and lumping of sugarcane fibers which will ultimately affect the mechanical properties of the concrete. The results are briefly tabulated and comparison between sugarcane fiber reinforced concrete and plain cement concrete were shown below.

A) Strength Test:

a) Compression Test

With 1% addition of sugarcane fibers an increase of 8.79% was observed and a further 1% addition enhances it to 15%. With further increase the strength reduces. The results are shown below:

Table 2: Average Compressive Strength of Sugarcane Fiber Concrete

Sr No.	Percentage of sugarcane fibers	Compressive Strength (N/mm2)
1	0	27.3
2	1	29.7
3	2	31.4
4	3	27.8
5	4	24.1

b) Flexural Strength Test

With 1% addition of sugarcane fiber an increase of 5.8% was observed and a further 1% addition enhances it to 23.1%.

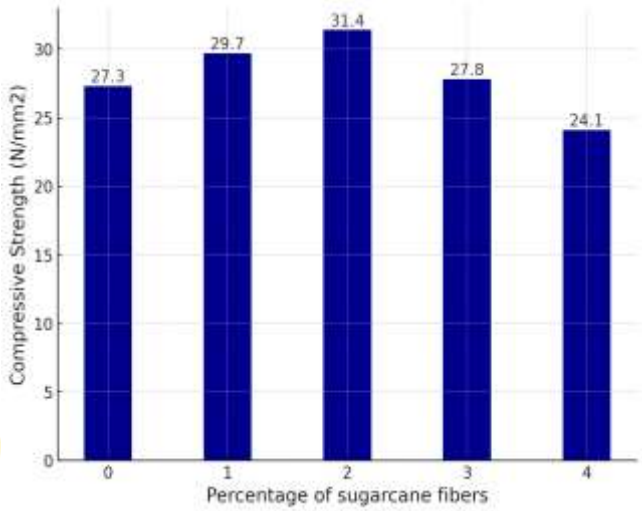


Figure 1: Compressive Strength of Sugarcane Fibers

Table 3: Average Flexural Strength of Sugarcane Fiber Concrete

Sr No.	Percentage of sugarcane fibers	Flexural Strength (N/mm2)
1	0	5.2
2	1	5.5
3	2	6.4
4	3	6. 3
5	4	5.7

c) Rebound Hammer Test

From the non-destructive test done vertically downwards, the compressive strength was obtained from the rebound hammer test. The result proves that addition of sugarcane does affect the strength of concrete.

Table 4: Rebound Number on Sugarcane Fiber Concrete

Sr No.	Percentage of sugarcane fibers	Compressive Strength (N/mm2)	Rebound Number
1	0	34	34.09
2	1	35	34.67
3	2	37	35.24
4	3	37	35.59
5	4	38	36.72

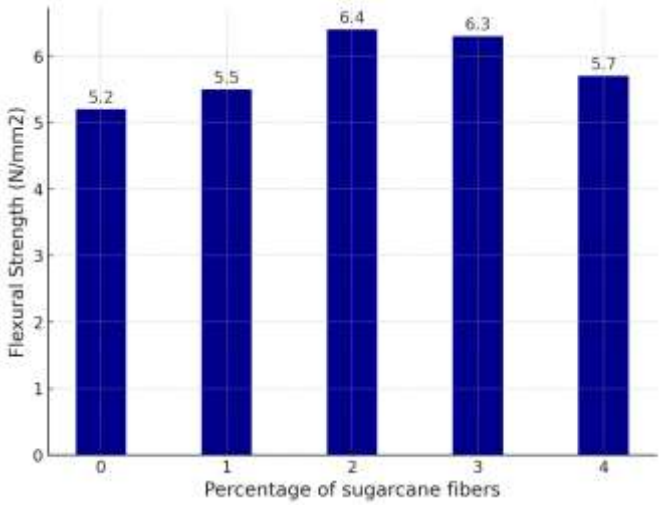
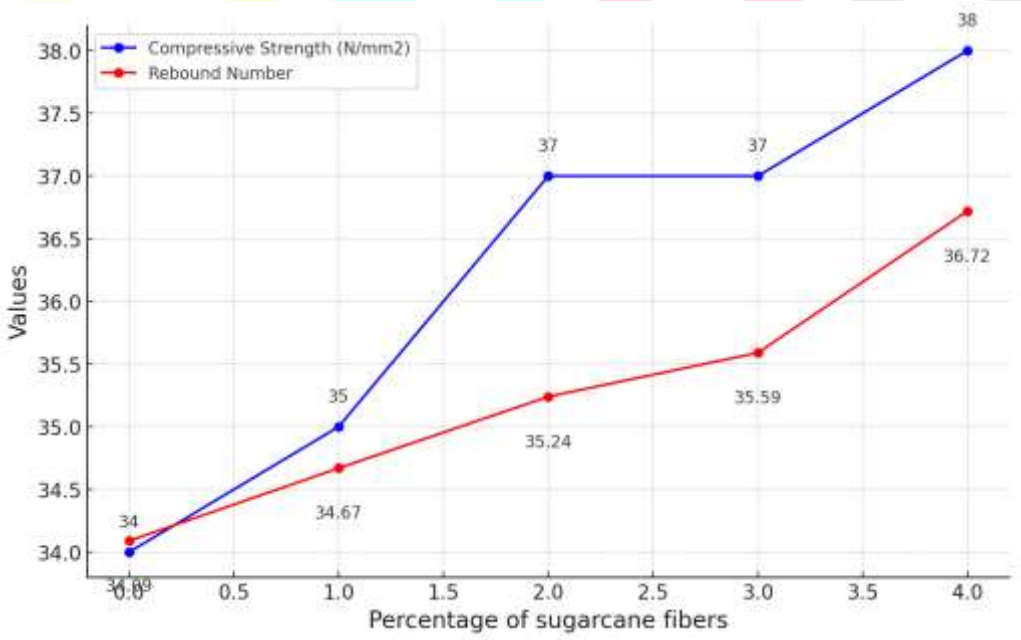


Figure 2: Flexural Strength of Sugarcane Fibers



B) Durability Tests

a) Water Absorption Test

If the percentage of water absorbed by the concrete increases, the durability of the concrete decreases. From the tests conducted, it is observed that there is a decrease in the amount of water absorbed when incorporating sugarcane as reinforcement in concrete and the minimum value of 1.81% is obtained when adding 4% sugarcane by weight of cement.

Table 5: Percentage of Water Absorption

Sr No.	Percentage of Sugarcane fibers	Dry Weight (kg)	Wet Weight (kg)	Percentage Absorption
1	0	8.830	9.125	3.23
2	1	8.590	8.873	3.19
3	2	8.620	8.814	2.20
4	3	8.895	9.092	2.17
5	4	8.910	9.075	1.81

Figure 3: Variations between rebound number with % Sugarcane

b) Sulphur Attack Test

In the Sulphur attack test, the percentage of weight loss and percentage of strength loss will decrease with increasing the percentage of sugarcane fiber. From the observations it is found that minimum percentage of strength loss and weight loss is obtained for 2% and 3% of sugarcane fiber by weight of cement respectively.

Table 6: Sulphate Attack on Sugarcane Fiber Concrete

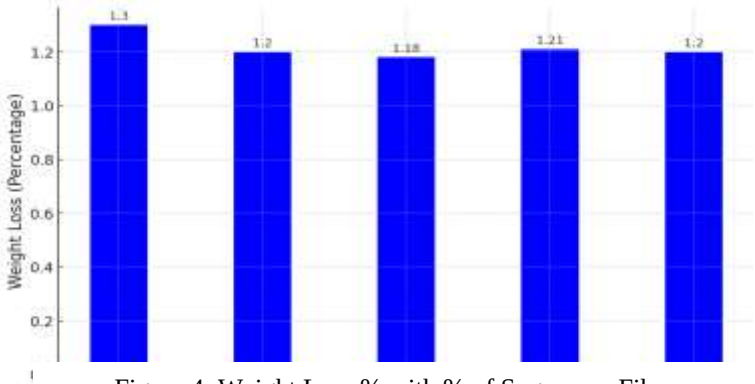


Figure 4: Weight Loss % with % of Sugarcane Fibers

Sr No.	Percentage of sugarcane fibers	Weight Loss (Percentage)	Strength Loss (Percentage)
1	0	1.3	14.3
2	1	1.2	14
3	2	1.18	12
4	3	1.21	11.5
5	4	1.2	13

V. CONCLUSION:

Sugarcane is used as an additive in various percentages by weight of cement in concrete. Strength and durability tests were conducted on sugarcane fiber reinforced concrete and the results showed that there is an increase in compressive strength by 15% and 23.1% increase in flexural strength by adding 2% of sugarcane fiber by weight of cement. Increase in flexural strength indicates the reduction in micro-cracks, which is a threat to durability. Addition of 2% sugarcane fiber by weight of cement shows better result in strength as compared to other percentages. Further addition shows declination in result even though there is no loss less than the target strength. Normal reinforced concrete will be adversely affected by the effect of moisture and other corrosive agents. The attack is due to the generation of micro cracks in the later stages of the concrete structures. The test result shows that due to the incorporation of sugarcane fiber, the durability characters can be elevated slightly. From the durability tests, it is observed that loss of strength is reduced by addition of 2% sugarcane by weight of cement. Hence,we can conclude that sugarcane fibers are a profitable additive to concrete, which diminishes the crack formation, enabling the long life of structures.

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