Comparative Study of Concrete & Fibre Reinforced Concrete with use of Hair & Sugar-Cane as Fibre

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***Abstract*—Concrete is an important constituent in construction. It is difficult to find an alternative option of concrete in thefield of civil engineering. A lot of advancement has been achieved in its properties such as strength, workability etc. Fibre reinforced concrete is one of them. Fibre reinforced concrete contains discontinuous, discrete, firmly dispersed suitable fiber other than mixtures of concrete. We are making use of hair and sugar cane as fiber to examine the effect on properties of concrete after addition of these materials. The test to be conducted on concrete and Fibre reinforced concrete are acompressive strength, workability. This fiber helps in improvisation quality of concrete and reduces of the cost of construction. Also, the concrete so developed will use hair and sugarcane thus it solves theproblem of its disposal and will be eco-friendly.**

Keywords*—Concrete, fiber reinforced concrete, hair, sugarcane, fiber, non-conventional concrete, fiber, compressive strength, human hair,compacting factor, green concrete.

I. INTRODUCTION

Concrete, a mixture of cement, sand, aggregate and water which hardens when placed in skeleton form and cured. It is widely used and well-known construction material in thefield of civil engineering. Concrete which contains a hydraulic cement, water, aggregate, and discontinuous discrete fiber is called fibre-reinforced concrete. It may also contain pozzolans and other admixtures commonly used with conventional concrete. Fibre of various shapes and sizes produced from steel, plastic, glass and natural materials are being used. Steel fiber is most commonly used for all fibers. French gardener Joseph Monier invented Fibre Reinforced Concrete in 1849. He patented fiber reinforced concrete in 1867.

Background:

"And Pharaoh commanded the same day the taskmasters of the people, and their officers, saying,-"Ye shall no more give the people straw to make brick, as therefore: let them go and gather straw for themselves"

Horneros, a tiny bird native to Argentina, Chile, Bolivia, and other South American countries. Professor Alberto Fava of the University of La Plata in Argentina points out, the bird had been painstakingly building straw-reinforced clay nests on treetops since before the advent of humans. According to Exodus 5:6, Egyptians used astraw to reinforce mud bricks. There is evidence that asbestos fiber was used to reinforce clay pots about 5000 years ago. Fibres have been used as reinforcement since ancient times. Historically, horsehair was used in mortar and straw in mud bricks. In the 1900s, asbestos fibers were used in concrete. In the 1950s, the concept of composite materials came into being and fibre-reinforced concrete was one of the topics of interest. Once the health risks associated with asbestos were discovered, there was a need to find a replacement for the substance in concrete and other building materials. By the 1960s, fibers such as steel, glass, and synthetic fibers such as polypropylene fibers were used in concrete. Research into new fibrereinforced concretes continues today.

Origin of Idea: Concrete is weak in tension so fiber is introduced to overcome this deficiency[1]. Hair and Sugarcane are a different type of material based on their degradability. Hair is non-bio-degradable whereas sugarcane is bio-degradable which are available in abundance in India at acheap cost. We used these two materials as fiber to improve its physical properties. Concrete is an important and integral part of theconstruction. Nowadays as construction is increasing day by day requirement of cheaper, greener and better concrete is required which fulfills the current demand of theindustry.Therefore, the idea of research has originated from the idea of creating an option for conventional concrete[2].

Advantages of fiber reinforced concrete: Use of fiber reinforced concrete has been started in construction. Fiber reinforced concrete is useful in repairing as well as in increasing durability. Fiber Reinforced has the advantage of increased strength and also, better energy absorbing characteristics. Fiber concrete can be used in thevarious field such as road pavement, airfield, refractory lining, low-cost building, precast fabrication, explosive-resistant structure, etc. In the areas of severe earthquake zone, the fiber reinforced concrete can be used to decrease the loss of life or property. Fibers reduce stresses generated in concrete by checking microscopic cracks forming inside concrete.

Disadvantages of fiber Reinforced Concrete: The main disadvantage of using fiber in concrete is its mixing. Uniformly distribution of fiber will be difficult in the field. Thus, it increases cost and labor in comparison to plain concrete. But the advantages are so much, it overrides the disadvantage.

Utilization of Fiber in concrete:

a) To check cracking due to plastic shrinkage as well as drying shrinkage.

b) Fibers also make concrete more resistant to impact and abrasion.

c) The fiber also reduces the permeability of concrete and thus reducing bleeding of water in concrete.

II. METHODOLOGY

The methodology adopted to compare the Concrete & Fiber Reinforced Concrete is done by testing compressive strength and slump.

Various cubes with different proportion of hair and sugarcane are analyzed for finding the effect of fiber.

Materials: The Ordinary Portland Cement Grade 43 (OPC) which is in accordance with IS 8112:2013 was used. The cement is in dry powdery form with the good chemical compositions and physical characteristics. Locally available and crushed stone were used as fine and coarse aggregates, respectively. The fine and coarse aggregates were tested as per IS: 383-1970 and 2386-1963 (Part I, II and III) specifications [12, 13]. The properties of fine and coarse aggregates are given in following Table 3. Water available on the college campus conforming to the requirements of water for concreting and curing as per IS: 456-20009.

Hair: Human hair was used for experiment having properties given in Table 2.

Mix Proportion: Mix design is carried out as per Indian Standard Code Method (IS 10262 – 2009) for concreting the test specimen. The grade of concrete which we adopted is M20 with the water cement ratio of 0.5.

Percentage of fiber: Optimum percentage given in table 4 of fiber was determined by literature review. For each ratio, 6 numbers of cubes were cast.

Whereas 2 numbers of thebeam for thehighest percentage of respective fiber were cast.

Fiber replaces cement by mass according to their percentage used.

Test Performed: For determining the effect of fiber in concrete following tests were performed:

i) Compression test: It is the most common test performed on concrete. Also, it is an easy test to perform and most of the desired properties of concrete can be qualitatively related to its compressive strength. The compression test is done on cubical shape specimens sized 150 × 150 × 150 mm. The test is done in the following steps: The cast iron mold (preferred), is used to prepare the cubes of size 150 × 150 × 150 mm. Then these molds are placed on the vibrating table and are compacted until the specified condition is attained. After 24 hours the specimens are removed from the molds and immediately submerged in clean fresh water. After 28 days the specimens are tested under the load in a compression testing machine.

ii) Slump Test: Slump test is amethod to measure workability of fresh concrete. It is amost common method for measuring theconsistency of fresh concrete. Slump test can be performed either in laboratory or site. However, it does not measure all the factors contributing workability. Concrete too dry or too wet cannot be examined by slump test.

iii) Compacting Factor Test: Compacting factor test is more precise and sensitive than the slump test. It's generally used when concrete is to be compacted by vibration and is of low workability.

$$\text{Compacting Factor} = \frac{\text{Weight of partially compacted concrete}}{\text{Weight of fully compacted concrete}}$$

TABLE I. PROPERTIES OF FIBERS

Type Of Fibre	Tensile Strength (Ksi)	Young's Modulus (10^3Ksi)	Ultimate Elongation (%)	Specific Gravity
Polypropylene	80-100	0.5	~25	0.90
Acrylic	30-60	.3	25-45	1.1
Asbestos	80-140	12-20	~0.6	2.2
Cotton	60-100	0.7	3-10	1.5
Glass	150-550	10	1.5-3.5	2.5
Nylon	110-120	0.6	16-20	1.1
Polyester	105-125	1.2	11-13	1.4
Rock Wool	70-110	10-17	~0.6	2.7
Rayon	60-90	1.0	10-25	1.5
Polyethylene	100	0.02-0.06	~10	0.95
Steel	40-400	29	0.5-35	7.8

TABLE II. PROPERTIES OF HAIR

S. No.	Properties	Values
1.	Cross-Section	Circular
2.	Diameter	18-100μm
3.	Elongation	1.6 times its dry length
4.	Length	II-50 m

TABLE III. PROPERTIES OF AGGREGATE

Properties	Fine Aggregate	Coarse Aggregate
Max size of aggregate (mm)	4	20
Specific gravity	2.53	2.85
Bulk Density (kg/cu.m)	1718.5	1564.2
Fineness Modulus	2.65	7.63
Water Absorption (%)	1.2	1.15

TABLE IV. PERCENTAGE OF FIBER USED

Concrete		Percentage of fiber		
Hair FRC		0.5%, 1%, 1.5 %		
Sugarcane FRC		1%, 1.5%, 2%		
Mixed	Hair	0.75%	1%	1%
	Sugarcane	1.5%	1.5%	2%

III. RESULT AND DISCUSSIONS

i) Workability

Following observation were made with help of slump test and compacting factor test:

- Normal concrete can be compacted manually as well as mechanically.
- Hair FRC also can be compacted by both manually as well as mechanically.
- While in sugarcane FRC and hair + sugarcane FRC plasticizer is needed for increasing workability or W/C can be increased up to 0.6 without compromising with strength.

a. Slump Test:

Values of aslump of different concrete and FRC is given in Table 6.

b. Compacting factor test

Values of aslump of different concrete and FRC is given in Table 6.

TABLE V. SLUMP VALUE

Concrete		Slump Value
PCC		57 mm
Hair	0.5%(A)	53 mm
	1%(B)	49 mm
	1.5%(C)	46 mm
Sugarcane	1%(A)	49 mm
	1.5%(B)	42 mm
	2%(C)	36 mm
Mixed	(0.75+1.5)% (A)	48 mm
	(1+1.5)%(B)	41 mm
	(1+2)%(C)	34 mm

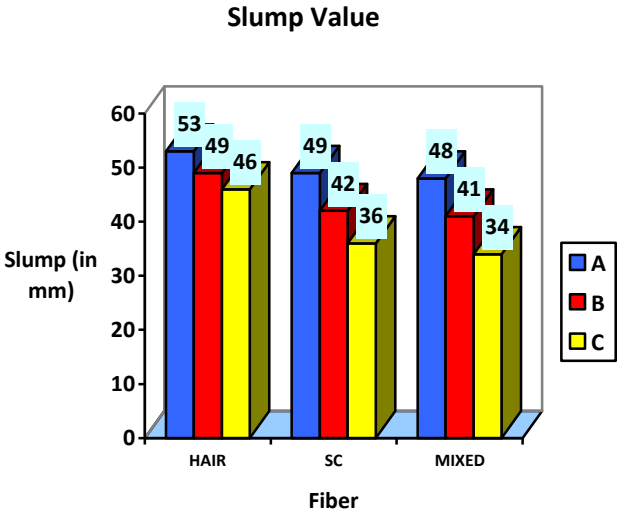


Fig. 1. Slump value

TABLE VI. COMPACTING FACTOR VALUE

Concrete		Compacting Factor Value
PCC		0.92
Hair	0.5%(A)	0.91
	1%(B)	0.90
	1.5%(C)	0.88
Sugarcane	1%(A)	0.88
	1.5%(B)	0.87
	2%(C)	0.845
Mixed	(0.75+1.5)% (A)	0.89
	(1+1.5)%(B)	0.87
	(1+2)%(C)	0.84

ii) Compressive Strength Test

Compressive test was done on 7 and 28 days after curing in compressive testing machine (CTM). With help of this test the optimum percentage of fiber among chosen by us is determined as follow:

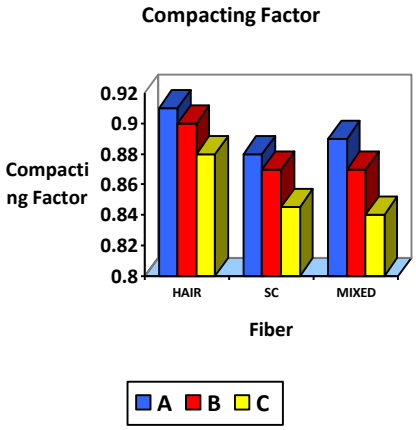
a) Hair FRC – 1.5%

b) Sugar cane FRC – 2%

c) Hair + Sugar cane FRC – 1%+2%

TABLE VII. RESULTS OBTAINED FROM COMPRESSION TEST AND THE CORRESPONDING COMPRESSIVE STRESS

S. No.	Concrete	Percentage	7 days						28 days					
			Maximum load (KN)			Compressive Stress (N/mm^2)			Maximum load (KN)			Compressive Stress (N/mm^2)		
			Cube no. 1	Cube no. 2	Cube no. 3	Cube no. 1	Cube no. 2	Cube no. 3	Cube no. 1	Cube no. 2	Cube no. 3	Cube no. 1	Cube no. 2	Cube no. 3
1.	PCC	-	290	305	320	12.88	13.55	13.77	510	545	530	22.66	24.22	23.55
2.	Hair	0.5%(A)	340	355	325	15.11	14.88	14.44	625	620	610	27.77	27.55	27.11
		1%(B)	345	360	350	15.33	16	15.55	650	640	635	28.88	28.44	28.22
		1.5%(C)	370	365	385	16.44	16.22	17.11	680	650	675	30.22	29.53	30
3.	Sugar cane	1%(A)	310	325	330	13.77	14.44	14.66	565	565	560	25.11	25.11	24.85
		1.5%(B)	340	340	335	15.11	15.11	14.88	575	580	575	25.55	25.77	25.56
		2%(C)	345	350	330	15.33	15.55	14.67	620	610	640	27.55	27.11	28.44
4.	Mixed	(0.75+1.5)% (A)	370	365	355	16.44	16.22	15.77	635	640	645	28.22	28.44	28.67
		(1+1.5)%(B)	385	380	380	17.11	16.88	16.88	655	650	660	29.11	28.88	29.33
		(1+2)%(C)	390	390	390	17.33	17.55	17.33	720	690	710	32	30.67	31.55



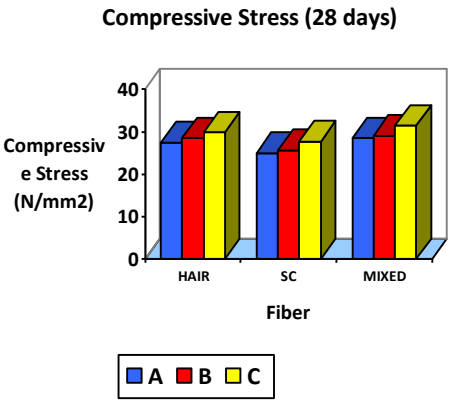


TABLE VIII. COMPRESSIVE STRENGTH

Concrete		Compressive Stress (N/mm^2)	
		7 days	28 days
PCC		13.4	23.48
Hair	0.5%(A)	14.81	27.48
	1%(B)	15.63	28.51
	1.5%(C)	16.59	29.92
Sugarcane	1%(A)	14.29	25.02
	1.5%(B)	15.03	25.63
	2%(C)	15.18	27.7
Mixed	(0.75+1.5)% (A)	16.14	28.44
	(1+1.5)%(B)	16.96	29.10
	(1+2)%(C)	17.40	31.41

IV. CONCLUSION

a) With help of fiber compressive strenth is increased upto 33%.

b) It can revolutionized area of pavement conctruction.

c) It can be used in area where reinforcement requirement is low.

d) Also it is eco-friendly as well as it solves the problem of solid waste.

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