An Experimental Evaluation of Compressive Strength and Flexural Strength of Bamboo Fiber Reinforced Concrete

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Abstract:– *This study presents the consideration of the use of bamboo fiber to get better performance of bamboo fiber reinforced concrete. To check the compressive and flexure strength, concrete cubes reinforced with bamboo fiber, cubes and prism have been casted and tested after 3 days, 7 days and 23 days respectively by changing the percentage of fiber. The observation of slump value, compressive strength and flexural strength were note. With respect to its result, further comparison has been shown between plain concrete and BFRC(Bamboo Fiber Reinforced Concrete . The flexural strength of bamboo fiber reinforced concrete is found to be increased remarkably.*

Key Words: Concrete Cubes, Bamboo Fiber, Compressive Strength, Flexure Strength, Slump Value, BFRC.

1. INTRODUCTION

Production of iron, steel, glass etc has led to environment pollution. While the natural, clean and biodegradable resources like plant and fiber have recently replaced steel.

Concrete having brittle property with less value of tensile strength and strain capacities, hence is preferred with fibers. Fiber reinforced concrete (FRC) had overcome this problem since 1960s. In past fibers were widely used in many types of mortar and concrete for providing stability. Steel, organic polymers, glass, carbon, asbestos, and cellulose are most commonly used fibers.

The fibers can be categorized into Synthetic fiber and Natural fibers. Synthetic fiber was obtained by chemical means while natural fibers are taken from parts of the minerals, plants and animals.

Table 1. Fibers with different characteristic values

Fibers	Density (gr/cm3)	Tensile Strength (MPa)	Elastic Modulus (MPa)
Carbon	1.8	3500	200
Glass	2.5	2500	70
Sisal	1.5	600	10
Kenaf	1.5	900	50
Cotton	1.5	400	10
Bamboo	1.5	700	10

1.1 BAMBOO

Bamboo is a natural source of fiber and one of the fastest growing giants plants with great economic potential. Bamboo gets fully mature within 4years consuming less energy to harvest and transport. For constructions of bridges and houses and for scaffolding bamboo has been used for thousands of years in Asia.

Due to its superior properties like low weight to strength ratio, high tensile strength and factors like low cost, easy availability and environment friendly during service, bamboo has constantly attracted the attention of scientists and engineers for use as reinforcement in concrete in construction industries. Recently, many researchers have tried to use bamboo as substitute of steel in reinforced concrete

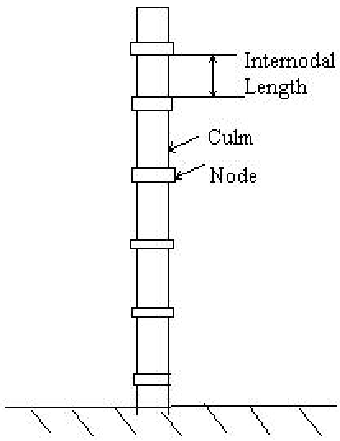


Fig 1.1- Bamboo Culm

Fig 1.2-Bamboo Fiber

Table 1.1: Properties of Bamboo

Properties	Standard Value
Average weight	0.625 kg/m
Modulus of rupture	610 to 1600 kg/cm2
Modulus of Elasticity	1.5 to 2.0 x105 kg/cm2
Ultimate compressive stress	794 to 864 kg/cm2
Safe working stress in compression	105 kg/cm2
Safe working stress in tension	160 to 350 kg/cm2
Safe working stress in shear	115 to 180 kg/cm2
Bond stress	5.6 kg/cm

2. LITERATURE REVIEW

[1] Jigar K. Sevalia et al[1990] Performed tension test on Bamboo strip which revealed elastic behavior. Both Singly and Doubly Reinforced Beam showed elastic behavior while performing flexural tests. Doubly Reinforced Beam performed more elastically than Singly Reinforced Beam. Also load carrying capacity in Doubly Reinforced Beam increased by 29.31 % as compared to Singly Reinforced Beam. Vertical cracks developed, on failure of the beam, within middle third region of the beam. Modulus of Elasticity of the Doubly Reinforced Beam was found more than twice the Modulus of Elasticity of the Singly Reinforced.

[2] Avula Ganesh Reddy et al[2015] made study on Short columns of two different lengths (1m and 1.3).Ultimate load carrying capacity of conventional concrete steel reinforcement was found to be16% more than concrete made by coconut shell aggregate and steel reinforcement and 38% more than coconut shell with bamboo reinforcement. Ultimate load carrying capacity decreased with increase in length of column. Stiffness of the columns decreased with the replacement of aggregate and reinforcement.

[3] Anurag Nayak et al(2013) replaced steel reinforcement by bamboo reinforcement. Designed one way slab of size 3000 x 7000 mm^2 providing beam of 7000 mm length and 250 x 250 mm^2.Bamboo reinforcement were used for both main and distribution reinforcement. Bamboo reinforced is three times cheaper then steel reinforcement and cheaper especially for single storey structure.

[4] Sani Harunaet al[2015] performed tension test on bamboo strip revealed elastic behavior and its ultimate strength was 112.05N/mm^2. The modulus of elasticity of coconut shell concrete was found to be 12075.2N/mm2 which represents 54%, 57%, 43.88% and 60.36% that of modulus of elasticity of conventional concrete. The load carrying capacity of the NWC beams were slightly higher than CSCS, BCSC, and BCSCB beams. The stiffness behavior of CSC beam showed similar trend as that of NWC up to failure. Deflections are higher in BCSC and BCSCB beams when compared to NWC and CSCS beams and by wrapping the split bamboo with binding wire the deflections were slightly reduced in BCSCB beams compared to BCSC beams.

[5] Masakazu TERAI & Koichi MINAMI(2011) compared experimental results of bamboo reinforced concrete members with reinforced concrete members and investigated the fracture behavior and the mechanical properties of Bamboo Reinforced Concrete members. Constructed 9 pull - out and 4 slab specimens and carried, pull-out tests and 3 point in the bending tests. The tensile strength of concrete made with cement paste (w/c=80%) increased with time. The behavior of pull-out test with bamboo is almost the same as the plain steel bar.

[6] BINDU M et al studied the characteristics strength properties of Bamboo Fibers Reinforced Concrete (BFRC).Bamboo Fiber showed good potential and increased strength. The fibers acts as a crack resistor, hence bears more load as compared to the conventional concrete. The specimens made from conventional concrete broke immediately at failure, whereas the BFRC specimen remains intact even at failure. Workability decreases with the increase in the length of the fiber.

[7] Dr. Shakeel Ahmad et al made bamboo reinforced Concrete cubes and compared the results with plain concrete cubes. Casted singly and doubly reinforced beam with bamboo sticks and tested them in flexure. Flexural strength and Modulus of elasticity increased as compared to conventional concrete. The strength of concrete cubes with fibers doesn't show much improvement up to 28 days but doubled in 50 days. Bamboo fiber in reinforced concrete beam reduced crack.

[8] Sri Murni Dewi et al used concrete beam of 15 cm x 20 cm x 160 cm with reinforcement of bamboo and pumice stone aggregate. Coated bamboo reinforcement with sand to make rough surface and used a type of bamboo known as Ori bamboo. The fiber was coated with paint and covered with sand to prevent the hygroscopic properties. Result showed that bamboo fiber reduced crack-width and deflection of concrete, increased beam post-cracking load-carrying capacity and increased workability and quality of concrete.

[9] Zhao Weifeng1 et al Concluded that bamboo reinforced concrete can be applied in building elements such as bamboo reinforced concrete columns, beams, slabs and walls. Mechanical properties with good vibration damping and workability increased. Bamboo can be used as a partial substitute for steel bars in concrete elements.

[10] M. M. Rahman et al performed tensile strength test and flexural strength on bamboo sticks of 1m and of varying cross sections having three and five nodes are performed. Singly and double bamboo reinforced beams of 750 mm length having 150 mm width and depth are compared with plain concrete beam.Stress-strain curves of bamboo showed that bamboo possesses low modulus of elasticity compared to steel. Bamboo as reinforcement in concrete increased the load carrying capacity of beam having the same dimensions. For singly beam, the load carrying capacity increased about 2 times and that for doubly beam about 2.5 times than that of plain concrete beam.

[11] Dr. Nayanmoni Chetia et al used a species called *Bamboosa Tulda.* Bamboo showed high tensile strength of about 440 N/mm^2 which actually depends on the species, cross sectional area, better flexural performance and reduction in the mid span deflection when provided with bamboo reinforcements. Flexural strength of maximum of 1.81times and a minimum of 1.19 times to that unreinforced beam sections observed in 28 days strength test.

[12] P. Sharma et al observed thatbamboo for foundation is rather restricted since timber when in contact with damp ground; they deteriorate and decay very quickly unless treated with effective preservatives. The most extensive use of bamboo in construction is for the walls and partitions. Bamboo is ideal as a roofing material as it is strong, resilient and light weighted.

[13] Leena Khareet al conducted tensile tests on three types of bamboo- Solid, Moso and Tonkin. Tests specimens were made by cutting the bamboo in 13 mm wide strips of 228 mm to 305 mm in length. Samples showed node failure, end tap failure and failure at the vicinity of the end-tap. Beam with 4% Bamboo reinforcement gave an over-reinforced failure. Tensile tests indicated that presence of nodes in Solid Bamboo samples did not affect the behavior.

3. METHODOLOGY

3.1 Mix Design:

There are various methods of mix design. In the present work, Indian Standard method (IS: 10262 - 2009) is used for Concrete mix design of grade, M30.

Table No. 3.1– Ingredients used per cubic meter of concrete

S.No.	Materials	Proportions
1	Water (L)	193.44
2	Cement (kg/m3)	413.33
3	Fine Aggregate (kg)	831
4	Fine Aggregate (kg)	987
5	Calculated Proportions	1: 1.807:2.568

3.2. Preliminary Data Required For Mix Design:

Exposure Condition of the structure: The general environment, to which the concrete will be exposed during its service life, is categorized into five class to severity, as per IS 456.

Table 3 Environmental Exposure Conditions

(*Clauses* 8.2.2.1 *and* 35.3.2)

Sl No. (1)	Environment (2)	Exposure Conditions (3)
i)	Mild	Concrete surfaces protected against weather or aggressive conditions, except those situated in coastal area.
ii)	Moderate	Concrete surfaces sheltered from severe rain or freezing whilst wet
		Concrete exposed to condensation and rain
		Concrete continuously under water
		Concrete in contact or buried under non-aggressive soil/ground water
		Concrete surfaces sheltered from saturated salt air in coastal area
iii)	Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation.
		Concrete completely immersed in sea water
		Concrete exposed to coastal environment
iv)	Very severe	Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet
		Concrete in contact with or buried under aggressive sub-soil/ground water
v)	Extreme	Surface of members in tidal zone
		Members in direct contact with liquid/ solid aggressive chemicals

Fig 3.1: Environmental Exposure Condition (source: IS 456:2000)

- Minimum thickness of member: Size of aggregate should not be more than one-fourth of the minimum thickness of member, mostly 20 mm nominal size aggregate is suitable for most works. It is always suggested to go the maximum nominal size of aggregate to save on quantity of cement per unit of concrete.
- Cement Grade: Cement type/grade locally available that can be made available throughout construction period.
- Workability: Placing condition of concrete governs its workability, low – slump of 25-75 mm (lightly reinforced sections in slab, beam, and column) to high – slump of 100-150 mm (slip form, pumped concrete).

Illustrated Example Of M30 Grade Concrete, Concrete Exposed To Severe Exposure Conditions.

(i) Stipulation for Proportioning Concrete Ingredients

(a) Characteristic compressive strength required in the field at 28 days grade designation:M30

(b) Type of Cement : OPC 43 Grade confirming to IS-12269-1987

(b) Maximum Nominal size of aggregate : 20 mm

(c) Shape of CA : Angular

(d) Workability required at site : 80 mm (slump)

(e) Type of exposure the structure will be subjected to (as defined in IS: 456) : Severe

(ii) Test data of material

The following materials are to be tested in the laboratory and results are to be ascertained for the design mix

(a) Cement Used : OPC 43 Grade Confirming to IS 12269

(b) Specific Gravity of Cement : 3.15

(c) Specific gravity

Specific gravity of Fine Aggregate (sand) : 2.71

Specific gravity of Coarse Aggregate : 2.68

(d) Water Absorption

Coarse Aggregate : 0.8%

Fine Aggregate : 1.0%

(e) Free (surface) moisture

Coarse Aggregate : Nil

Fine Aggregate : Nil

Aggregate are assumed to be in saturated surface dry condition usually while preparing design mix.

(f) Seive Analysis

Fine aggregates : Confirming to Zone I of Table 4 IS – 383.

Procedure for Concrete Mix Design of M30 Grade Concrete

Determining the Target Strength for Mix Proportioning

F'ck = fck + 1.65 x S

Where,

1.65 is tolerance factor (1 in 20)

F'ck = Target average compressive strength at 28 days

Fck = Characteristic compressive strength at 28 days

From IS 10262-1982

Value of S = 5 (M30 good quality concrete)

S = Assumed standard deviation in N/mm2 = 5 (as per table -1 of IS 10262- 2009)

= 30 + 1.65 x 5.0 = 38.25 N/mm2

Table 1 Assumed Standard Deviation
(*Clauses* 3.2.1.2, A-3 *and* B-3)

Sl No. (1)	Grade of Concrete (2)	Assumed Standard Deviation N/mm² (3)
i)	M 10	3.5
ii)	M 15	
iii)	M 20	4.0
iv)	M 25	
v)	M 30	5.0
vi)	M 35	
vii)	M 40	
viii)	M 45	
ix)	M 50	
x)	M 55	

Fig 3.2: Standard Deviation (source: IS 456:2000)

Selection of Water-Cement Ratio:-

From Table 5 of IS 456, Maximum water-cement ratio = 0.45

Table 5 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal Maximum Size
(*Clauses* 6.1.2, 8.2.4.1 *and* 9.1.2)

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	–	300	0.55	M 20
iii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

NOTES

1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in **5.2**. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.

2 Minimum grade for plain concrete under mild exposure condition is not specified.

Fig 3.3: Water-Cement Ratio (source: IS 456:2000)

Selection of Water Content

Maximum water content for 20 mm aggregate = 186 Kg (for 25 to 50 slump)

Table 2 Maximum Water Content per Cubic Metre of Concrete for Nominal Maximum Size of Aggregate
(*Clauses* 4.2, A-5 *and* B-5)

Sl No. (1)	Nominal Maximum Size of Aggregate mm (2)	Maximum Water Content [1] kg (3)
i)	10	208
ii)	20	186
iii)	40	165

NOTE — These quantities of mixing water are for use in computing cementitious material contents for trial batches.

[1] Water}content corresponding to saturated surface dry aggregate.

Fig 3.4 : Maximum water-cement ratio (source: IS 456:2000)

We are targeting a slump of 80mm, we need to increase water content by 3% for every 25mm above 50 mm i.e. increase 6% for 100mm slump

So taking increase in water content = 4%

i.e. Estimated water content for 80 Slump = 186+(4*186/100)= 193.44 litre

Water content = 193.44 liters.

Calculation Of Cement Content

Water cement Ratio = 0.45

Water content from step-3 i.e. 193.44 liters

Cement Content = Water content/W-c ratio" = (193.44/0.45) = 413.33 kg/m^3

From Table 5 of IS 456,

Minimum cement Content for severe exposure = 250 kg/m^3

413.33 kg/m^3 > 250 kg/m^3, hence, OK.

As per clause 8.2.4.2 of IS: 456

Maximum cement content = 450 kg/m^3, hence Ok.

Proportion of volume of Coarse Aggregate and Fine Aggregate Content

From Table 3 of IS 10262- 2009, Volume of coarse aggregate corresponding to 20 mm size and fine aggregate (Zone II) = 0.62

Table 3 Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate
(*Clauses* 4.4, A-7 *and* B-7)

Sl No.	Nominal Maximum Size of Aggregate mm	Volume of Coarse Aggregate[1] per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate			
		Zone IV	Zone III	Zone II	Zone I
(1)	(2)	(3)	(4)	(5)	(6)
i)	10	0.50	0.48	0.46	0.44
ii)	20	0.66	0.64	0.62	0.60
iii)	40	0.75	0.73	0.71	0.69

[1] Volumes are based on aggregates in saturated surface dry condition.

Fig 3.5 : Volume of coarse aggregate per unit volume of total aggregate for different zones of fine aggregate (source: IS 456:2000)

Note 1: In the present case water-cement ratio is 0.45.So there will be change(upto 10% reduction for angular aggregate) in coarse aggregate volume i.e. 0.60 .

Estimation of concrete mix proportion calculations

The mix calculations per unit volume of concrete shall be as follows:

1. Volume of concrete = 1 m^3
2. Volume of cement = (Mass of Cement) / (Sp. Gravity of Cement)x1000 = (413.33) / (3.15 × 1000) = 0.131 m^3
3. Volume of water = (Mass of Water) / (Sp. Gravity of Water)x1000 = (193.44) / (1 × 1000) = 0.1934 m^3
4. Total Volume of Aggregates = 1- (b+c) = 1- (0.131 + 0.1934) = 0.6756 m^3
5. Mass of coarse aggregates = d X Volume of Coarse Aggregate X Specific Gravity of Coarse Aggregate X 1000 = 0.6756 x 0.60 x 2. 71 x 1000 = 1099 kg/ m^3
6. Mass of fine aggregates = d x Volume of Fine Aggregate x Specific Gravity of Coarse Aggregate X 1000 = 0.6756 x 0.40 x 2.68 x 1000 = 724 kg/ m^3

4.3.2. M30 Concrete Mix Design: The following table is prepared As per IS 10262-2009 and IS 456:2000

Table No. 4.5: Mix Design of concrete sample under conventional proportion.

A-1	Stipulations for Proportioning	
1	Grade Designation	**M30**
2	Type of Cement (confirming to IS-12269-1987)	PPC 43 Grade
3	Maximum Nominal Aggregate Size(IS 456:2000)	20 mm
4	Minimum Cement Content (MORT&H 1700-3A)	310 kg/m3
5	Maximum Water Cement Ratio (MORT&H 1700-3A)	0.45
6	Workability (MORT&H 1700-4)	100 mm (Slump)
7	Exposure Condition(IS 456:2000)	Normal
8	Degree of Supervision(IS 456:2000)	Good
9	Type of Aggregate(IS 2386 Part-I) & (IS 456:2000)	Crushed, Angular
A-2	**Test Data for Materials**	
1	Cement Used (IS-12269-1987)	PPC 43 Grade
2	Sp. Gravity of Cement (IS 456:2000)	3.15
3	Sp. Gravity of Water (IS 456:2000)	1
4	Sp. Gravity of Coarse Aggregate (IS 456:2000)	2.71

5	Sp. Gravity of Sand (IS 456:2000)	2.605
6	Water Absorption of Coarse Aggregate (IS 456:2000)	.97%
7	Water Absorption of Sand (IS 456:2000)	1.23%
8	Free (Surface) Moisture of Coarse Aggregates	Nil
9	Free (Surface) Moisture of Sand	Nil
10	Sieve Analysis of Individual Coarse Aggregates	Separate Analysis Done
11	Sieve Analysis of Combined Coarse Aggregates	Separate Analysis Done
12	Sp. Gravity of Combined Coarse Aggregates (IS 456:2000)	2.882
13	Sieve Analysis of Fine Aggregates	Separate Analysis Done
A-3	**Target Strength for Mix Proportioning**	
1	Target Mean Strength (IS10262-2009)	38.25 N/mm²
2	Characteristic Strength @ 28 days	30 N/mm²
A-4	**Selection of Water Cement Ratio**	
1	Maximum Water Cement Ratio (MORT&H 1700-3A)	0.45
2	Adopted Water Cement Ratio	0.44
A-5	**Selection of Water Content**	
1	Maximum Water content (10262-table-2)	1.86 Lit
2	Estimated Water content for 100 mm Slump, (Reduction water content because of plasticizer)	191.58 Lit
A-6	**Calculation of Cement Content**	
1	Water Cement Ratio	0.44
2	Cement Content (160/0.42)	413.09 kg/m3
A-7	**Proportion of Volume of Coarse Aggregate & Fine Aggregate Content**	
1	Vol. of C.A. as per table 3 of IS: 10262	62.00%
2	Corrected Vol. of Coarse Aggregate for 0.42 W/C ratio (increased by 0.01 for every 0.05 decrease in W/C ratio)	63.00%
3	Adopted Vol. of Coarse Aggregate (10% reduction for angular aggregates)	57.2% - 0.57
4	Adopted Vol. of Fine Aggregate	42.8% - 0.43
A-7	**Mix Calculations**	
1	Volume of Concrete in m³ =(Mass of Cement) / (Sp. Gravity of Cement)x1000 (380) / (3.15x1000)	0.1424
2	Volume of Water in m³= (Mass of Water) / (Sp. Gravity of Water) x 1000 = (160) / (1 × 1000)	0.1735
3	Volume of Coarse Aggregate in m³= Sr. no. 5 × 0.57 = 0.718 × 0.62	0.3914
4	Volume of Fine Aggregate in m³= Sr. no. 5 × 0.43 = 0.718 × 0.38	0.2940
A-8	**Mix Proportions for One Cum of Concrete (SSD Condition)**	
1	Mass of Cement in kg/ m³	413.09
2	Mass of Water in kg/ m³	173.5
3	Mass of Fine Aggregate in kg/ m³ (Vol.× sp.Gr.×1000)	746.76
4	Mass of Coarse Aggregate in kg/ m³ (Vol.× sp.Gr.×1000)	1060.423
5	Water Cement Ratio	0.42

4. TESTING OF SPECIMEN

4.1 Compression Strength Test:

Tables no. 4.1: The following table is prepared using the different % of fiber

Traditional Concrete								
Fiber %	Age Of Loading	Mould No.S	Fiber g	Cement Kg	F.A. Kg	C. A. Kg	Water L	Fck Mpa
0	3	P1.1	0	1.39	2.44	3.71	0.65	38.3
	7	P1.2	0	1.39	2.44	3.71	0.65	38.4
	28	P1.3	0	1.39	2.44	3.71	0.65	38.2

Parameter 1

Fiber %	Age Of Loading	Mould No.S	Fiber g	Cement Kg	F.A. Kg	C. A. Kg	Water L	Fck Mpa
0.5	3	P2.1	7	1.45	2.8	3.33	0.66	39.5
	7	P2.2	7	1.45	2.8	3.33	0.66	39.5
	28	P2.3	7	1.45	2.8	3.33	0.66	39.4

Parameter 2

Fiber %	Age Of Loading	Mould No.S	Fiber g	Cement Kg	F.A. Kg	C. A. Kg	Water L	Fck Mpa
1	3	P3.1	14	1.45	2.76	3.28	0.66	38.5
	7	P3.2	14	1.45	2.76	3.28	0.66	38.6
	28	P3.3	14	1.45	2.76	3.28	0.66	38.5

Parameter 3

Fiber %	Age Of Loading	Mould No.S	Fiber g	Cement Kg	F.A. Kg	C. A. Kg	Water L	Fck Mpa
1.5	3	P4.1	21	1.44	2.78	3.311	0.64	38.5
	7	P4.2	21	1.44	2.78	3.311	0.64	38.4
	28	P4.3	21	1.44	2.78	3.311	0.64	38.5

Parameter 4

Fiber %	Age Of Loading	Mould No.S	Fiber g	Cement Kg	F.A. Kg	C. A. Kg	Water L	Fck Mpa
2	3	P5.1	28	1.44	2.78	3.3	0.64	38.2
	7	P5.2	28	1.44	2.78	3.3	0.64	38.4
	28	P5.3	28	1.44	2.78	3.3	0.64	38.5

4.2 Flexural Strength Test:

Tables no. 4.2: The following table is prepared using the different % of fiber

Traditional Concrete

Fiber %	Age Of Loading	Mould No.S	Fiber g	Cement kg	F.A. kg	C. A. kg	Water L	Fcr (Mpa)
0	3	P1.1	0	3.04	6.50	0	11.40	17.3
	7	P1.2	0	3.04	6.50	0	11.40	17.3
	28	P1.3	0	3.04	6.50	0	11.40	17.30

PARAMETER 1

Fiber %	Age Of Loading	Mould No.S	Fiber g	Cement kg	F.A. kg	C. A. kg	Water L	Fcr (Mpa)
0.5	3	P2.1	7	3.04	6.77	0.02	13.09	15.5
	7	P2.2	7	3.04	6.77	0.02	13.09	15.5
	28	P2.3	7	3.04	6.77	0.02	13.09	15.5

PARAMETER 2

Fiber %	Age Of Loading	Mould No.S	Fiber g	Cement kg	Sand kg	C. A. kg	Water L	Fcr (Mpa)
1	3	P3.1	14	3.04	6.77	0.05	12.9	15.3
	7	P3.2	14	3.04	6.77	0.05	12.9	15.3
	28	P3.3	14	3.04	6.77	0.05	12.9	15.3

PARAMETER 3

Fiber %	Age Of Loading	Mould No.S	Fiber g	Cement kg	Sand kg	C. A. kg	Water L	Fcr (Mpa)
1.5	3	P4.1	21	3.01	6.70	0.08	13.01	15.4
	7	P4.2	21	3.01	6.70	0.08	13.01	15.4
	28	P4.3	21	3.01	6.70	0.08	13.01	15.4

Parameter 4

Fiber %	Age Of Loading	Mould No.S	Fiber g	Cement kg	Sand kg	C. A. kg	Water L	Fcr (Mpa)
2	3	P5.1	28	3.01	6.6	0.11	12.9	15.42
	7	P5.2	28	3.01	6.67	0.11	12.9	15.42
	28	P5.3	28	3.01	6.67	0.11	12.9	15.42

5. OBSERVATION

5.1 Slump test:

Table no 5.1: Showing test result of slump for different % of fiber added.

Specimen sample	Bamboo fiber %	Slump (mm)	Avg Slump (mm))
S1	0	81	81
S2		82	
S3		80	
S1	0.5	79	78
S2		77	
S3		78	
S1	1	74	76
S2		73	
S3		79	
S1	1.5	72	73
S2		72	
S3		74	
S1	2	68	70
S2		71	
S3		71	

Graph showing Comparison between tested slump of Traditional concrete and tested slump of bamboo fiber cube concrete

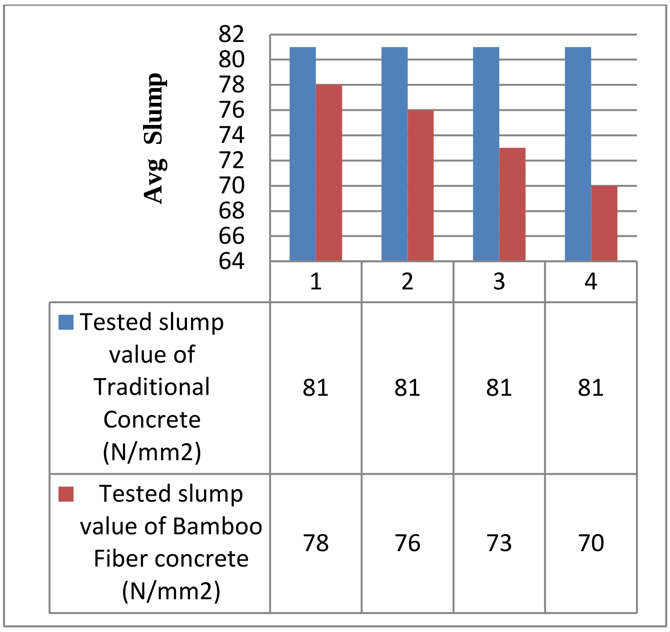


Chart -1: : Tested Slump of Traditional concrete VS tested Slump of bamboo fiber cube concrete

5.2 Compressive Strength Test Results:

Table no.5.2: Showing test results of Fck test done on cube of size 15mm x 15 mm x 15mm

Specimen sample	Bamboo fiber %	Fck (N/mm2)	Avg Fck (N/mm2)
S1	0	38.3	38.3
S2		38.4	
S3		38.2	
S1	0.5	39.5	39.43
S2		39.54	
S3		39.44	
S1	1	38.56	38.58
S2		38.65	
S3		38.54	
S1	1.5	38.5	38.5
S2		38.49	
S3		38.51	
S1	2	38.21	38.36
S2		38.45	
S3		38.5	

Graph showing Comparison between tested Fck of Traditional concrete and tested Fck of bamboo fiber cube concrete

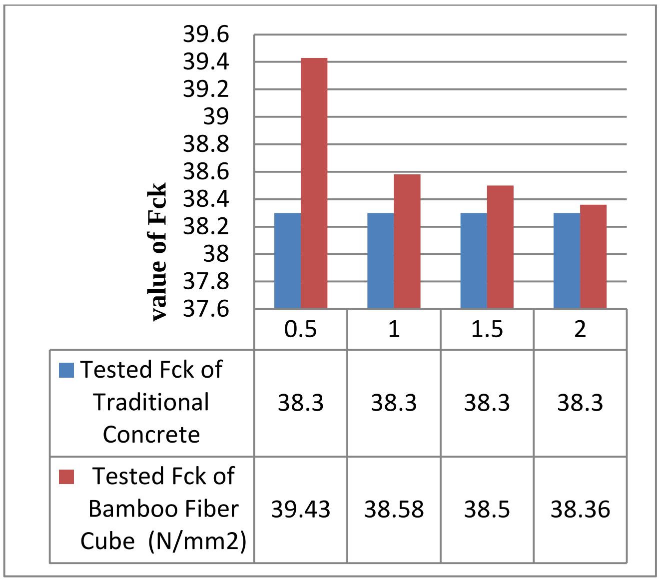


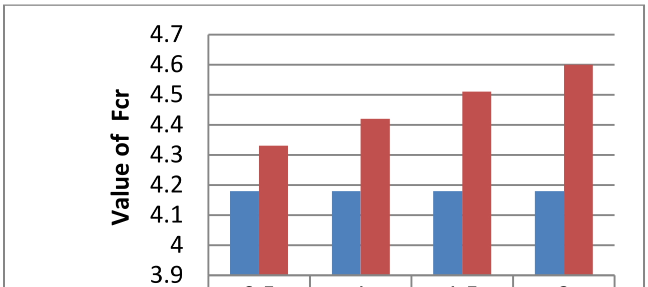
Chart 2: Tested Fck of Traditional concrete VS tested Fck of bamboo fiber cube concrete

5.3 Flexural Strength Data:

Table no.:5.3: Showing test results of Fcr test done on prism of size 15mm x 15 mm x 70 mm.

Bamboo fiber %	Flexural Strength (N/mm2)	Average Flexural Strength (N/mm2)
0	4.12	4.18
	4.22	
	4.2	
0.5	4.35	4.33
	4.32	
	4.31	
1	4.42	4.42
	4.43	
	4.41	
1.5	4.5	4.51
	4.53	
	4.51	
2	4.58	4.6
	4.61	
	4.61	

Graph showing Comparison between tested Fcr of Traditional concrete and tested Fcr of bamboo fiber cube concrete



	0.5	1	1.5	2
Flexural Strength of Traditional concrete	4.18	4.18	4.18	4.18
Flexural Strength (N/mm2)	4.33	4.42	4.51	4.6

Chart 3: Tested Fcr of Traditional concrete VS tested Fcr of bamboo fiber cube concrete

6. RESULT

- The test result and graph of slump test shows that the addition of bamboo fiber in concrete results in decrease in slump value.
- The test result and graph of compressive strength test shows that the addition of bamboo fiber in concrete initially results in increase in compressive strength upto 0.5 % but further addition of bamboo fiber shows falls in compressive strength.
- The test result and graph of flexural strength test shows that the addition of bamboo fiber in concrete results in continuous increase its strength.

7. CONCLUSIONS

- The addition of bamboo fiber in concrete decreases slump value.
- The flexural strength of concrete with the addition of bamboo fiber increases nearly 10% of traditional concrete.
- The compressive strength with bamboo fiber in concrete initially the strength with very small quantity of fiber (0.5 %) but further addition of fiber results in decrease in strength.
- Since tensile strength is proportional to flexural strength, hence experiment result shows that increase in flexural strength increases tensile strength of concrete.

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