Toughness Study on Bamboo Fibre Reinforced Concrete

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***Abstract*—Generally fibres are used to arrest cracking and strengthening of concrete. Usually various fibres are used in the concrete mix to attain the desired strength and resistance. Recently, in response to global warming issues and sustainable society, usage of natural fibres materials has become active in the developing countries. Bamboo which is low cost, fast growing, and having broad distribution of growth, is expected to contribute significantly to earthquake-resistant construction and seismic retrofit technology in the developing countries. Concrete is strong in compression but weak in tension. Properties of concrete can be improved by using natural fibres. The extent of progress depends on the type, length and diameter of fibre. The present study investigated the toughness properties, compressive strength and tensile strength of Bamboo Fibre Reinforced Concrete (BFRC). The investigation was done using 3 aspect ratios of bamboo fibre and M20 grade of concrete. The results indicate that, Toughness increase with decrease in fibre length. The optimum fibre length and diameter were found to be 36 mm and 1.2 mm**

Keywords—Bamboo fibre,fresh properties,Toughness studies

I. INTRODUCTION

As we know that the building construction indirectly plays a major role in environmental damages, and it's our responsibility to find more environmental techniques of construction for developments. And a solution for that is to search for a new material that can be sustainably recycled and reused. Therefore, it become necessary to go for new materials that is naturally available such as bamboo, coconut shell, glass, crump rubber, agricultural product, rice husk, ceramic, silica etc. We know that bamboo is one of the renewable, sustainable natural resources. But sufficient care has not been given to investigation and change in bamboo. Due to the beneficial physical and mechanical characteristics of bamboo, researches have been made of bamboo as fibre material in concrete. With the development of science and technology, new technologies are implemented for treating of bamboo to make it durable, strength, and more working in terms of construction materials. In this project bamboo will be used in concrete to study of strength characteristics.

In most countries commonly concrete is used as the base of construction of infrastructure. Concrete has got the important of requisite construction properties, such as its ability to withstand large compressive stresses. Concrete is widely used because it is cheap, easy to work and readily available. Many buildings are only made of concrete mainly cement concrete or mud-bricks in certain parts of the world. When considering about seismic activity, this is very risky. In the case of an earthquake, these structures have highly possible for collapse. An ideal solution for that structure would be steel reinforcement, but its cost is a major issue. For structural structures, scientists and engineers are constantly searching for new and sustainable materials. As a potential reinforcement the concept of using bamboo fiber has gained popularity.

The concrete possesses a very low tensile strength, little resistance to cracking and limited ductility. In plain concrete and similar like brittle materials, the structural cracks (micro cracks) develop even before into loading, particularly due to drying shrinkage or low elasticity or other causes of volume changes. Hence to overcome to all of these problems the alternate sustainable way like fibre reinforced concreting method has been used. The fibre reinforced concrete is a natural or unnatural composite material containing fibres in the cement matrix in an orderly manner or randomly distributed manner. Its properties would be obviously depend upon the efficient transfer of stress between matrix and the fibres, which is largely dependent upon the type of fibres, fibre contents, fibre geometries, orientation, and distribution of the fibres, mixing and compaction techniques of concrete, size and shape of the aggregate. Bamboo is a very strong in its longitudinal direction due to strong fibre bundles. Bamboo grows in the tropical and subtropical area. Due to the cheaper cost, bamboo houses are commonly built in the world. Because of the successful construction of bamboo houses, researcher sand companies have observed for using bamboo in the foam of raw or fibre as structural element of industries, such as bamboo reinforced concrete and bamboo fibre reinforced concrete. Bamboo plants have the potential to develop of innovations in the construction industries. Several research studies have been carried out on the use of raw bamboo and bamboo fibre as reinforcing material to replace conventional steel. Usually, bamboo was used for construction works and home furnishings and this furniture manufacturing process produces waste in the form of bamboo fibre is taken for bamboo fiber reinforced concrete. And this bamboo fiber reinforced concrete is taken for several strength studies and Toughness studies for determine the crack resistance. Therefore, bamboo fibre will be observed for repairing cracks in concrete.

So, in this context we studied about the toughness of bamboo fiber reinforced concrete (BFRC).Toughness studies is the ability to absorb energy and partially deform without rupturing. In this study we determined flexural strength, absolute toughness, post crack toughness, residual toughness, split tensile strength and compressive strength of the bamboo fiber reinforced concrete. And we got the result is the influence of bamboo fibre in flexural strength of concrete is superior than tensile and compressive strength and the fibres act as a crack resistor and reduce crack-width and deflection of concrete.

A. Advantages og BFRC

Bamboo fibres are natural fibres that are extracted from the bamboo. In response to global warming issues and sustainable society, the manufacturing, using natural materials has become actively in the developing countries. The advantages of using bamboo fibres in concrete specimens are:

- Addition of bamboo reduces crack width of concrete.
- It improves post - cracking load - carrying capacity.
- BFRC has more tensile strength when compared to Conventional concrete.
- Specimens made from Conventional concrete breaks immediately at failure whereas BFRC specimens remain intact even at failure.
- Bamboo fibres can be used as innovative fibres in concrete to increase the strength of the concrete and improve the ductility of concrete.

B. Significance of study

The cost of construction materials including reinforcement is increasing continuously over the past years and houses are becoming unaffordable for common peoples. Therefore, in order to provide shelter to economically backward peoples of the society it is necessary to go either for alternate construction materials with conventional construction technique or to adopt conventional materials with alternate construction technique to reduce crack on the structure and the cost of structure. It has been seen that bamboo fibre can be an alternative of steel reinforcement. Bamboo fibres are natural and sustainable fibres that's are extracted from the natural bamboo. In response to global warming issues and sustainable society, the manufacturing and using natural materials has become actively in the developing countries. The paper is intended to investigate the toughness properties of bamboo fibre in concrete. Bamboo fibre acts as reinforcement for improving physical and mechanical properties of concrete. In doing so, bamboo fibre will enhance concrete to be resistant to tensile cracks, bending and fracture. Thus, it's important to extend the concept of bamboo fibre addition into the conventional reinforced concrete as it saves percentage of reinforcement bars used in steel reinforced concrete construction.

II. MATERIALS AND PROPERTIES

A. Cement

Portland Pozzolana Cement (PPC) conforming to IS 12269-1987 was used in the study. Laboratory tests were conducted to determine the various properties like fineness, specific gravity, standard consistency, initial and final setting time. Table 2.1 shows the properties of cement tested.

Table 2.1 *Properties of cement*

Properties	***Results***
Standard Consistency	31%
Specific Gravity	3.08 gr/cm3
Initial Setting Time	30 minutes
Final Setting Time	580 minutes
Compressive Strength	3 days – 16 N/mm2 7 days – 22 N/mm2 28 days – 33 N/mm2

B. Fine Aggregate

M-Sand passing through 4.75mm IS sieve was used in the study. Specific gravity, fineness modulus, uniformity co-efficient and moisture content of the fine aggregate were tested as per IS 2386 (Part III)-1963. Details of sieve analysis were presented in Table 2.2. The properties of fine aggregate are given in Table 2.3.

Table 2.2 *Sieve analysis results of fine aggregate*

Sieve size	***Weight retained in each sieve (kg)***	***% Weight retained***	***Cumulative % weight***	***Percentage weight passing***
4.75	0	0	0	100
2.36	0.047	4.7	4.7	95.3
1.18	0.169	16.9	21.6	78.4
0.6	0.364	36.4	58	42
0.3	0.266	26.6	84.6	15.4
0.15	0.138	13.8	98.4	1.6

Fineness modulus=(sum of cumulative % weight retained)/100

= 267.3/100

= 2.673

Table 2.3 *Properties of fine aggregate*

Sl.No.	***Property***	***Value***
1	Fineness modulus	2.673
2	Specific gravity	2.61
3	Bulk density (g/cc)	1.85
4	Porosity (%)	0.26
5	Void ratio	.35

C. Course Aggregate

Crushed granite stones obtained from local quarries were used as coarse aggregate. The maximum size of coarse aggregate used was 20 mm. Laboratory tests were conducted on coarse aggregate to determine various physical properties as per IS 2386 (Prat III)-1970.Details of sieve analysis are presented in Table 2.4. The properties of coarse aggregate are given in Table 2.5.

Table 2.4*Sieve analysis results of coarse aggregate*

Sieve size	***Weight retained in each sieve (kg)***	***% Weight retained***	***Cumulative % weight***	***Percentage weight passing***
80	0	0	0	100
40	0	0	0	100
20	2290	45.8	45.8	54.2
10	2070	41.4	87.2	12.8
4.75	510	10.2	97.4	2.6
Pan	130	2.6	100	0

Fineness modulus of course aggregate = (Sum of cumulative % weight retained)/100

= 330.4/100

= 3.30

Table 2.5 *Properties of coarse aggregate*

Sl.No.	***Property***	***Value***
1	Fineness modulus	3.30
2	Specific gravity	2.77
3	Bulk density (g/cc)	1.438
4	Water absorption	0.555

The crushing valve obtained for coarse aggregate was 26 % and the impact value obtained was 27 %. As per IS 383-1970, the impact value and crushing value must be less that 45 %. The coarse aggregate used in the study confirms to IS 383-1970.

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D. Bamboo Fibre

Locally available bamboos were taken and bamboo fibres were taken out by mechanical method. Bamboo fibres of three different lengths and 1.2 mm diameter were taken. The lengths of fibres are 36, 46 and 56 mm and corresponding aspect ratios are 30, 38.3, and 48.6.

Fig 2.1 *Bamboo Fibre*

Table 2.6 *Properties of bamboo fibre*

Sl.No.	Property	Value
1	Tensile Strength (Mpa)	350-500
2	Elastic Modulus (Mpa)	10
3	Density (g/cm3)	1.1
4	Elongation at Break (%)	11
5	Specific Gravity	0.87
6	Water absorption (%)	104.2
7	Thickness (mm)	1.2

E. Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Water fit for drinking is generally considered fit for making concrete. Water should be free from acids, oils, Alkalies, vegetables or another organic impurity. The pH of water should be between 6-7. Portable water free from sulphates and chlorides were used for mixing as well as for curing the concrete.

III. EXPERIMENTAL METHODOLOGY

This chapter deals with the mix design and the various experimental methods adopted in the present study.

A. Methodology

- Materials collection
- Assessment of physical properties of materials used
- Tests to determine the fresh and hardened properties
- Tests to determine the Toughness of Bamboo Fibre Reinforced Concrete
- Analysis of results

B. Mix Design

The mix design used for the present study was taken from the literature review [11]. The details of concrete ingredients are given in the table 3.1.

Table 3.1 *Mixture proportions of the concrete mixes*

Sl. No.	Materials	Proportions
1	Cement (kg)	256.62
2	Fine Aggregate (kg)	382.93
3	Coarse Aggregate (kg)	769.86
4	Water (L)	141.14
5	Fibre (%) Length of Fibre = 36,46,56mm Diameter of Fibre = 1.2mm Aspect ratio = 30,38.3,46.6	1

C. Specimens

For compressive strength cubes of size 100x100x100 mm were casted and tested on compressive strength testing machine. For split tensile strength cylinder of height 300 mm and diameter 150 mm were casted. For flexural strength beam of size 100x100x500mm specimens were casted. The specimens were prepared in laboratory using hand mixing. The casting surface was levelled and finished using a trowel, after filling the mould. The Specimens were remoulded after 24hrs and are immersed in water for curing under controlled Environment until tested.

D. Fresh Properties

When concrete is in its plastic state it is known as a fresh concrete. Fresh concrete can be easily moulded to a durable structural member. Workability indicates the ease or difficulty with which the concrete is handled, transported and placed. The amount of water present in concrete should be in proper ratio. Workability of concrete can be measured using slump cone test. For each mix of different aspect ratio slump test were conducted.

1. Slump Test

Slump test is the most simple and common test used for finding the flow ability of the concrete. Flow ability of concrete is defined as the ability of the concrete to flow freely in a horizontal surface in the absence of obstacles without segregation. It also gives an assessment of filling ability. The apparatus consists of Abrams cone, which is a truncated cone having a base diameter of 200mm, top diameter of 100mm and a height of 300mm, a base plate, measuring tape and a trowel. The procedure consists of firstly the inside portion of the cone made wet and is placed at the centre of base plate Then the concrete is filled inside using a trowel with compaction to concrete. Concrete is filled in 4 layers and after each layer compaction is given. When the concrete is fully filled the cone is vertically lifted up. If there is no deformation the slump value will be zero. The schematic diagram of slump obtained shown in fig 3.1.

Fig 3.1 *Slump test*

E. Hardened Properties

The strength of concrete is obtained when it gets hardened. Compressive strength test, split tensile strength test and flexural strength test methods are mainly used to measure the strength of concrete. All the specimens were tested for 7,14 and 28 days of water curing. For each mix, nine specimens were casted and tested to obtain the average value.

1. Compressive Strength

The desirable properties of hardened concrete are related to the compressive strength. Compression strength test is the important and most common test conducted. Compressive strength of concrete is a measure of its ability to resist static load. As per IS: 516-1959, the compression test can be carried out on cube of size 100mm x 100mm x 100mm using compressive testing machine. The ultimate load divided by the area gives the cube compressive strength. The test setup is shown in Fig.3.2.

Fig 3.2 *Compressive strength testing on compression testing machine*

2. Split Tensile Strength

Split tensile strength is a method of determining the tensile strength of concrete using a cylinder which splits across the vertical diameter. It is an indirect method of testing tensile strength of concrete. As per IS: 5816 (1999), the split tensile strength test conducted on cylinder of height 300 mm and diameter 150 mm using compressive strength testing machine

Fig 3.3 *Tension testing on compression testing machine*

3. Flexural Strength

Flexural strength is defined as the maximum stress in the outermost fibre and is calculated the surface of the specimen on the tension side and flexural strength of the specimen shall be expressed as the modulus of rupture. Flexural strength test was carried out as per IS 516: 1959 in beam specimen having dimension 100mm x 100mm x 500mm. The specimens are tested after 7,14 and 28 days of water curing and 9 specimens were tested for each aspect ratio mix. The test was carried out in universal testing on a third point loading arrangement. The test setup for flexural strength test is shown in fig 3.4 and fig 3.5.

Fig 3.4 *Flexural strength testing on UTM*

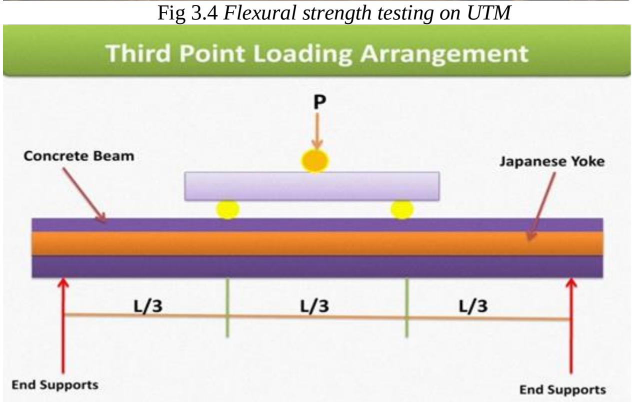

Fig 3.5 *Third point loading arrangement*

IV. RESULTS AND DISCUSSIONS

The experimental program was designed to investigate the toughness study of the bamboo fibre reinforced concrete at 1% by the weight of concrete. In this investigation compressive strength of cubes, split tensile strength of cylinders and flexural strength of beam were tested. For this experimental programs M20 grade of concrete is used.

1. Fresh Properties Test Results

a. Slump Test

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore, the ease with which concrete flows. Slump test carried on apparatus consists of Abrams cone, which is a truncated cone having a base diameter of 200mm, top diameter of 100mm and a height of 300mm, a base plate, measuring tape and a trowel. The procedure consists of firstly the inside portion of the cone made wet and is placed at the centre of base plate Then the concrete is filled inside using a trowel with compaction to concrete. Concrete is filled in 4 layers and after each layer compaction is given when the concrete is fully filled the cone is vertically lifted up. If there is no deformation the slump value will be zero. The schematic diagram of slump measurement and slump obtained are shown in fig 3.1. The tests were conducted on all the mixes before casting of specimens and the result of slump test is given in Table 4.1.

Table 4.1 *Slump test results*

Aspect ratio	***Fibre content (%)***	***Water cement ratio***	***Slump (mm)***
30	1	0.5	0
38.3	1	0.5	0
46.6	1	0.5	0

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2. Hardened Concrete Test Results

a. Compressive Strength Test

Compressive strength test was carried out in cube specimens of size 100mm after 7, 14 and 28 days of water curing. It was done in compression testing machine and the failure was noted to calculate the compressive strength. For each mix, 9cubes were casted to take the mean value. Table 4.2 shows the compressive strength of BFRC containing 1% of bamboo fibre and fig 3.2 shows the test setup for compressive strength test. Table 4.3 shows compressive strength result of Conventional concrete.

Table 4.2 *Compressive strength test results of BFRC*

Aspect ratio	*Age of specimens (days)*	*Compressive strength (Mpa)*
30	7	12.5
	14	16
	28	18.5
38.3	7	13
	14	17
	28	19
46.6	7	11
	14	14.5
	28	16.5

Table 4.3 *Compressive strength test result of Conventional Concrete*

Age of specimens (days)	*Compressive strength (Mpa)*
7	13.5
14	18
28	20

b. Split Tensile Strength Test

Concrete cylinder having diameter 100mm and height 300mm was used to study the split tensile strength. Test was conducted on compressive strength testing machine. Test was carried out after 7, 14 and 28 days of water curing and nine specimens were casted for each aspect ratio mix. Table 4.4 shows the split tensile strength of different aspect ratio of bamboo fibre and fig 3.3 shows the test setup for split tensile strength test. Table 4.5 shows result of split tensile strength test of Conventional concrete.

Table 4.4 *Split tensile strength test results of BFRC*

Aspect ratio	*Age of specimens (days)*	*Split tensile strength (Mpa)*
30	7	2.4
	14	2.69
	28	2.91
38.3	7	2.26
	14	2.55
	28	2.78
46.6	7	2.12
	14	2.26
	28	2.53

Table 4.5 *Split tensile strength test results of Conventional Concrete*

Age of specimen (days)	*Split tensile strength (Mpa)*
7	2.18
14	2.43
28	2.67

F. Toughness Studies

1. Absolute Toughness

Absolute toughness represents the area under the load deflection curve up to failure load.

2. Post Crack Toughness

Post crack toughness is defined as the area under the load-deflection curve from the ultimate load to the load at failure.

3. Residual Toughness

Residual toughness is measured from the area between the first drop after ultimate load to 3mm from first drop in load-deflection curve.

4. Flexural Strength Test

Concrete beams having dimension 100mm x 100mm x 500mm was used to study the flexural strength. Test was conducted on universal testing machine (UTM). Test was carried out after 7,14 and 28 days of water curing and nine specimens were casted for each aspect ratio mix. Table 4.6 shows result of split tensile strength test of Conventional concrete Table 4.7 shows the flexural strength at different aspect ratio of bamboo fibre and fig 3.4 and fig 3.5 shows the test setup for flexural strength test. The flexural strength was calculated using Equation below.

Fb = PL/(bd2)

P = Flexural strength in N/mm2

P = Maximum Load in KN

L = length of the specimen between supports in mm

B = Width of the specimen in mm

D = Depth of the specimen in mm

Table 4.6 *Flexural strength test results of Conventional Concrete*

Age of specimens (days)	*Flexural strength (Mpa)*
7	1.03
14	1.56
28	1.84

Table 4.7 *Mechanical results of three-point loading test*

Aspect ratio	*Age of specimen (days)*	*Flexural strength (Mpa)*	*Absolute toughness (Nm)*	*Post crack toughness (Nm)*	*Residual toughness (Nm)*
30	7	1.15	243.65	157	16.94
	14	1.65	466.38	325.05	20.91
	28	1.95	703.75	551	21.42
38.3	7	1.2	407.35	332.95	16.94
	14	1.5	589.5	474.25	18.08
	28	1.75	533.3	391.5	19.125
46.6	7	1.2	207.75	141.25	14.44
	14	1.35	347.45	254.55	14.75
	28	1.3	230.6	149.3	13.5

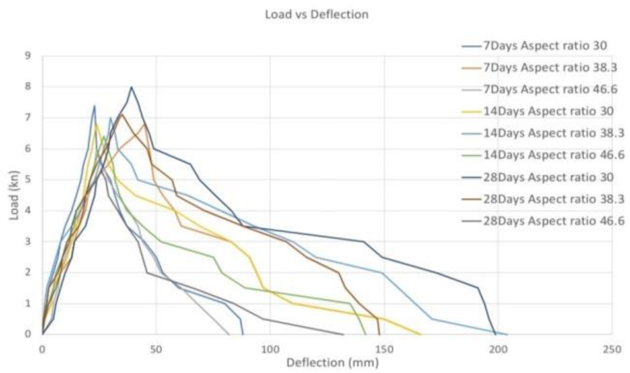

Fig 4.1 *Influence of fibre reinforcement on bending behaviour at various ages of concrete*

5. Toughness properties of BFRC (Aspect ratio 30)

a) Load-Deflection at various ages of concrete

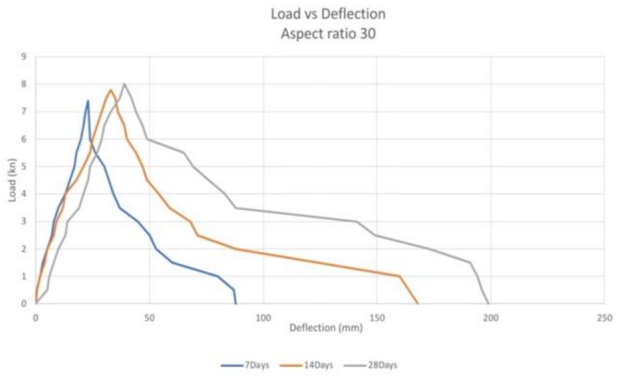

Fig 4.2 *Load-Deflection curve*

i. *Absolute toughness at 28th day*

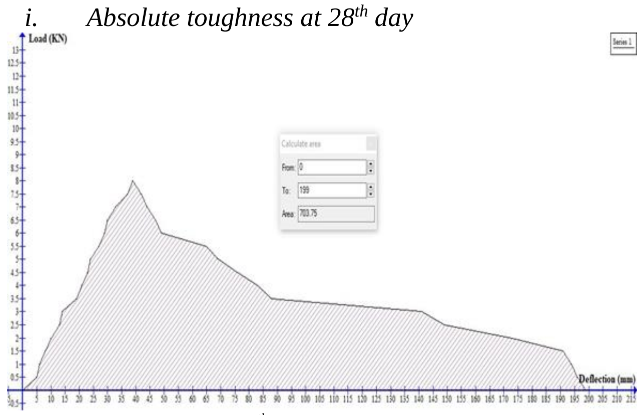

Fig 4.3 *28th day Absolute toughness*

ii. *Post crack toughness at 28th day*

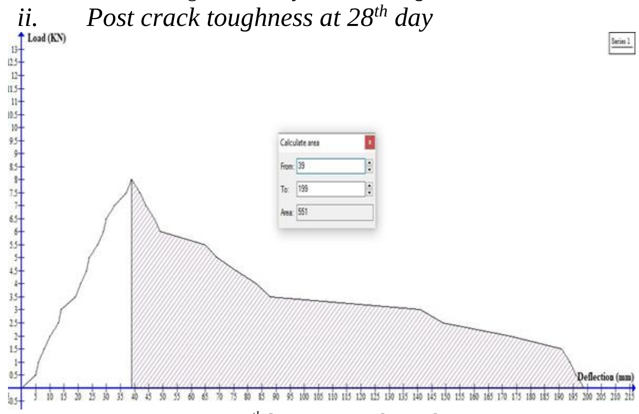

Fig 4.4 *28thday Post crack toughness*

iii. *Residual toughness at 28th day*

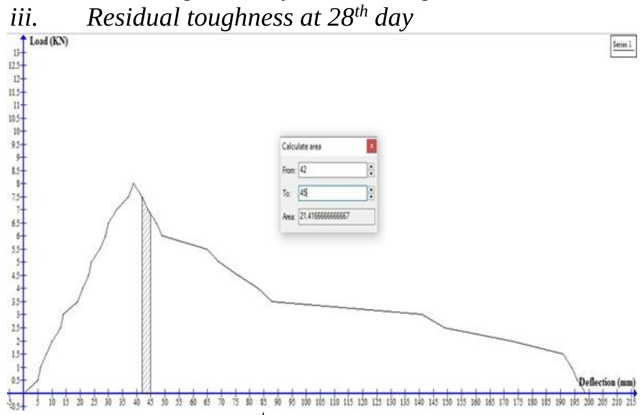

Fig 4.5 *28th day Residual toughness*

iv. *Comparison of toughness with ages of concrete*

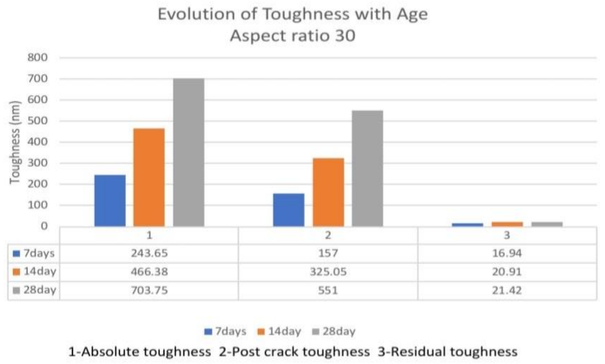

Fig 4.6 *Comparison of toughness with ages of concrete*

From the comparison of absolute, post crack and residual toughness, the following conclusions were made:

- Absolute and post crack toughness increases with age of concrete.
- Residual toughness was maximum at 14th day.

6. *Toughness properties of BFRC (Aspect ratio 38.3)*

a. *Load-Deflection at various ages of concrete*

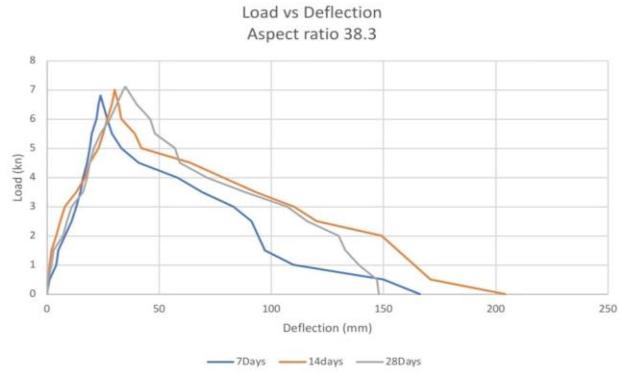

Fig 4.7 *Load-Deflection curve*

i. *Absolute toughness at 28thday*

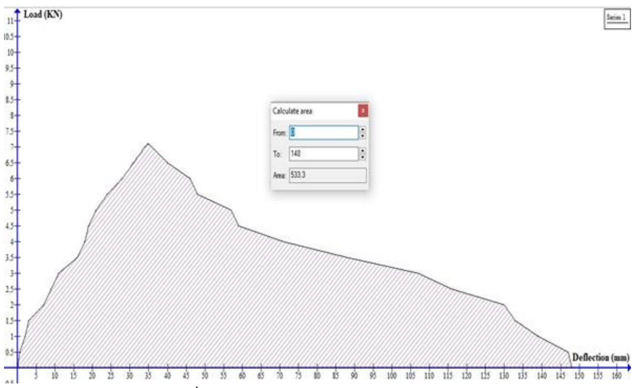

Fig 4.8 *28th day Absolute toughness*

ii. Post crack toughness at 28th day

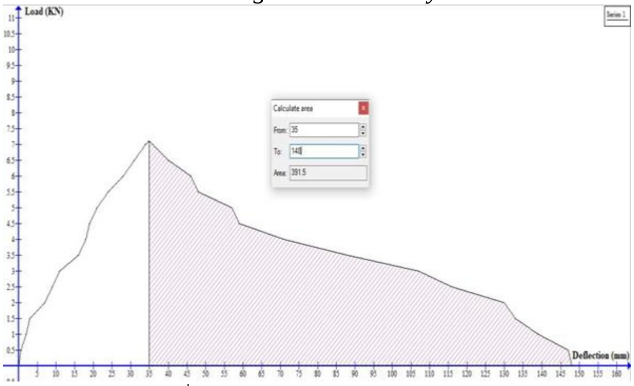

Fig 4.9 *28th day Post crack toughness*

iii. Residual toughness at 28th day

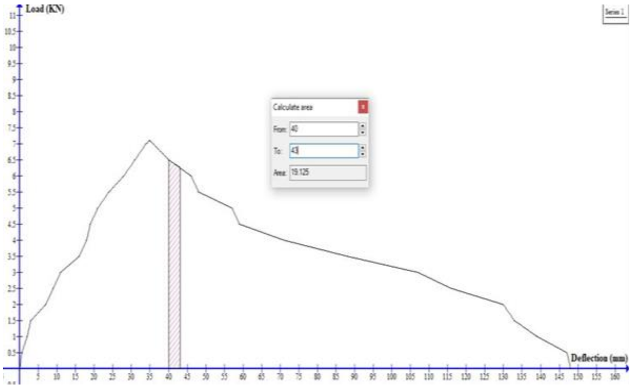

Fig 4.10 *28th day Residual toughness*

iv. Comparison of toughness with ages of concrete

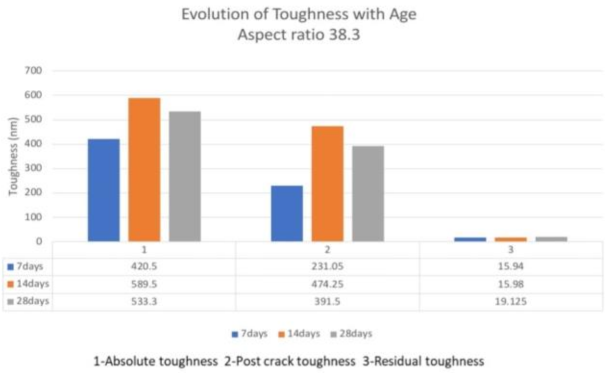

Fig 4.11 *Comparison of toughness with ages of concrete*

From the comparison of absolute, post crack and residual toughness, the following conclusions were made:

- Absolute toughness was maximum at 14th day and 9% decrease occur at 28th day.
- Post crack toughness was maximum at 14th day and 17% decrease occur at 28th day.
- Residual toughness increases with age of concrete.

7. Toughness properties of BFRC (Aspect ratio 46.6)

a. Load-Deflection at various ages of concrete

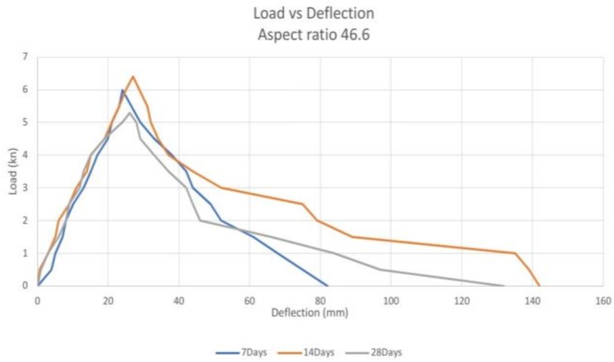

Fig 4.12 *Load-Deflection curve*

i. Absolute Toughness at 28th day

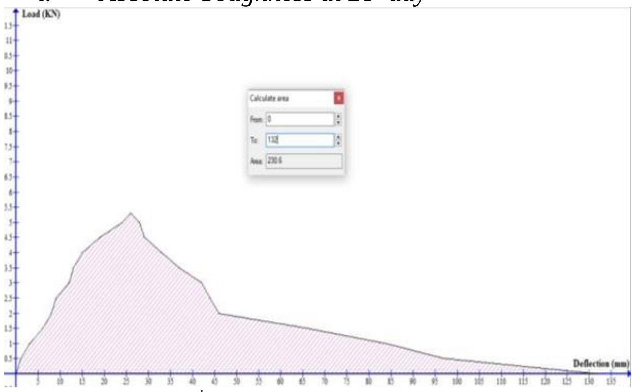

Fig 4.13 *28th day Absolute toughness*

ii. Post crack toughness at 28th day

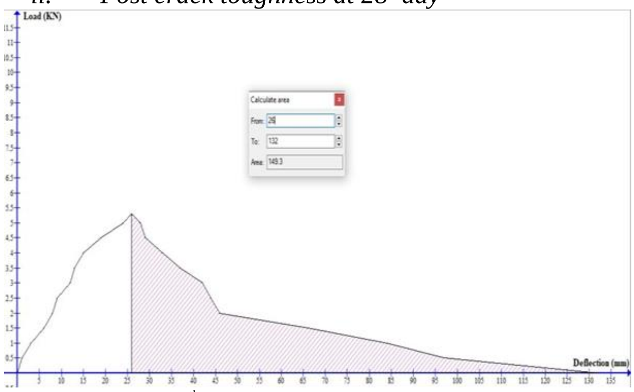

Fig 4.14 *28th day Post crack toughness*

iii. Residual toughness at 28th day

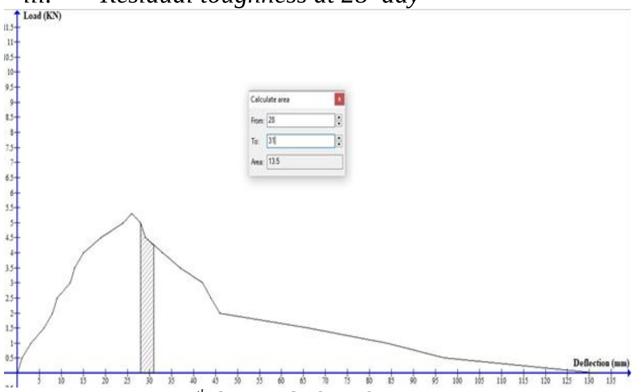

Fig 4.15 *28th day Residual toughness*

iv. Comparison of toughness with ages of concrete

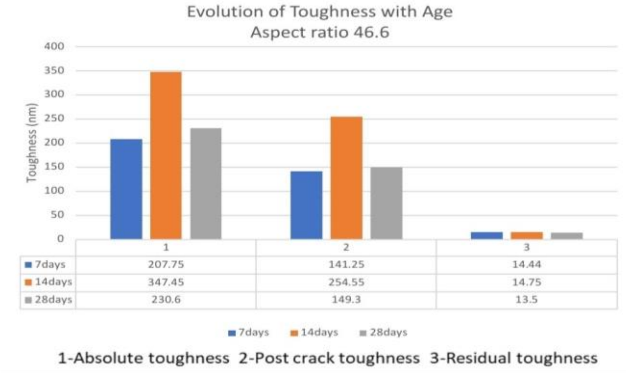

Fig 4.16 *Comparison of toughness with ages graph of aspect ratio 46.6*

From the comparison of absolute, post crack and residual toughness, the following conclusions were made:

- Absolute and post crack toughness was max at 14th day and 10% reduction occurs at 28th day.
- Residual toughness was max at 14th day and 6% reduction at 28th day.

8. Comparison of load deflection curve and toughness properties at various ages of concrete for aspect ratios 30, 38.3, 46.6

a. Load-Deflection at 7 days

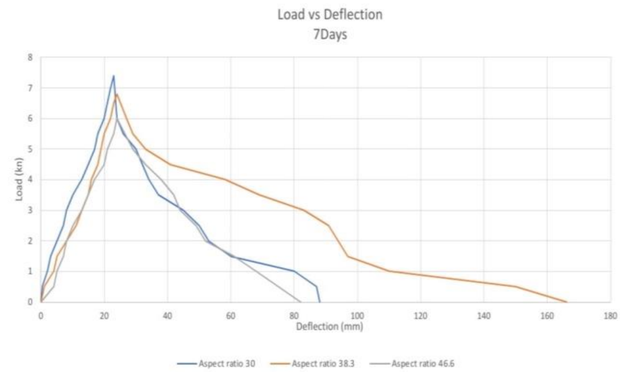

Fig 4.17 *Load-Deflection at 7days*

b. Load-Deflection at 14 days

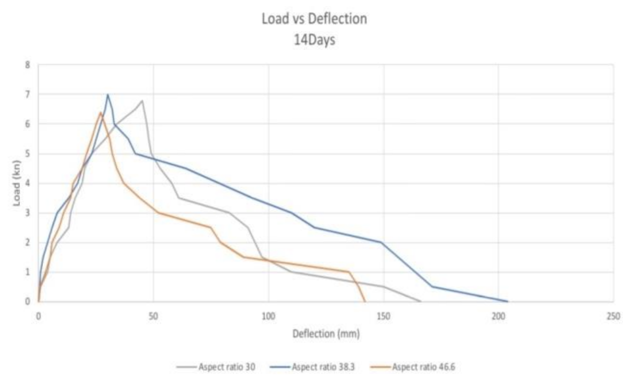

Fig 4.18 *Load-Deflection at 14days*

c. Load-Deflection at 28 days

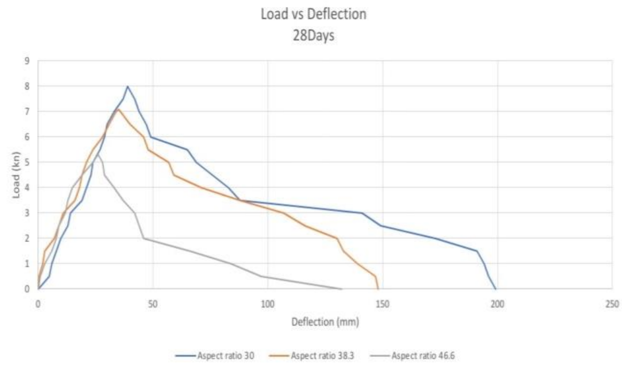

Fig 4.19 *Load-Deflection at 28days*

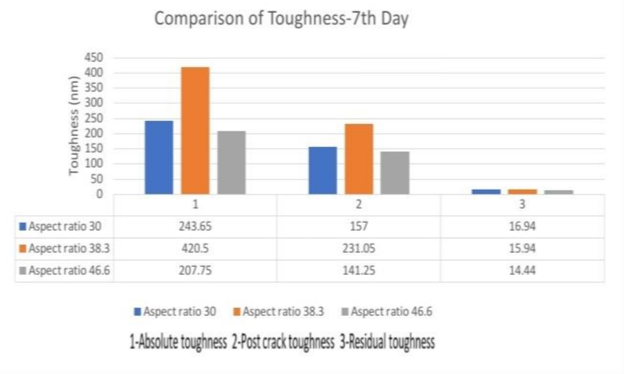

Fig4.20 *Comparison of toughness at 7 days*

From the comparison of absolute, post crack and residual toughness at 7th day for 3 aspect ratios, the following conclusions were made:

- Aspect ratio 38.3 has got max values.

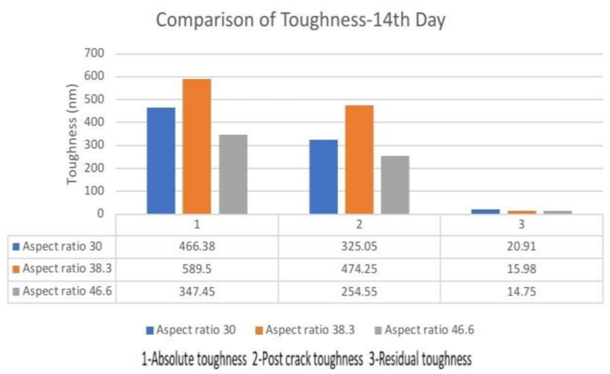

Fig 4.21 *Comparison of toughness at 14 days*

From the comparison of absolute, post crack and residual toughness at14th day for 3 aspect ratios, the following conclusions were made:

- Residual toughness decreases with fibre length.
- Absolute and post crack toughness has got max values for aspect ratio 38.3.

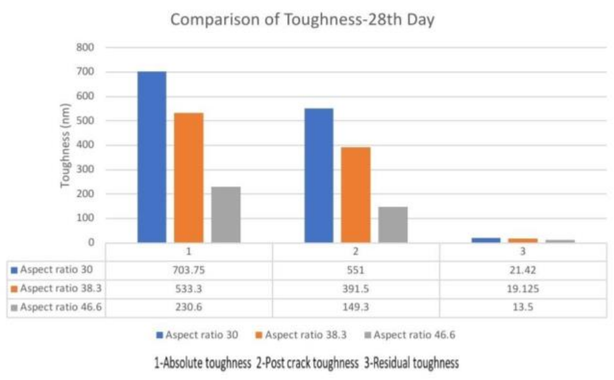

Fig 4.22 *Comparison of toughness at 28 days*

From the comparison of absolute, post crack and residual toughness at 28th day for 3 aspect ratios, the following conclusions were made:

- Aspect ratio 30 got more values for absolute and post crack toughness.

G. Comparison Of BFRC (Aspect ratio 30) And Coventional Concrete

Bamboo fibre reinforced concrete (BFRC) with fibre aspect ratio 30 and Conventional concrete were compared for compressive strength, split tensile strength and flexural strength. Table 5.8 shows the comparison results.

Table 4.8: *Comparison of BFRC and Conventional Concrete*

Age of Speci men (Day)	*Compressive Strength (Mpa)*		*Split Tensile Strength (Mpa)*		*Flexural Strength (Mpa)*	
	BFRC	***Conven tional***	***BFRC***	***Conven tional***	***BFRC***	***Conven tional***
7	12.5	13.5	2.4	2.18	1.15	1.03
14	16	18	2.69	2.43	1.65	1.56
28	18.5	20	2.91	2.67	1.95	1.84

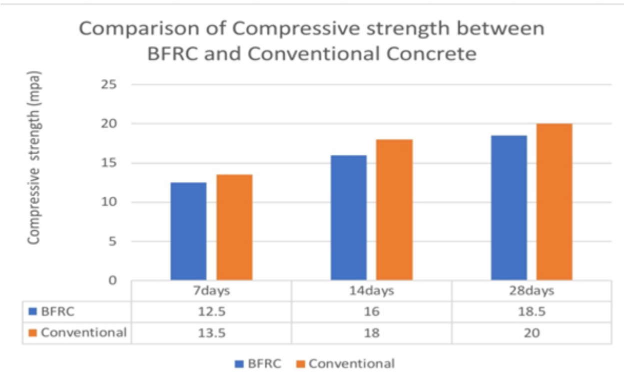

Fig 4.23 *Comparison of compressive strength*

From the comparison of compressive strength between BFRC and Conventional concrete, it was found that:

- Compressive strength is 7.5 % decrease for BFRC when compared to Conventional concrete.

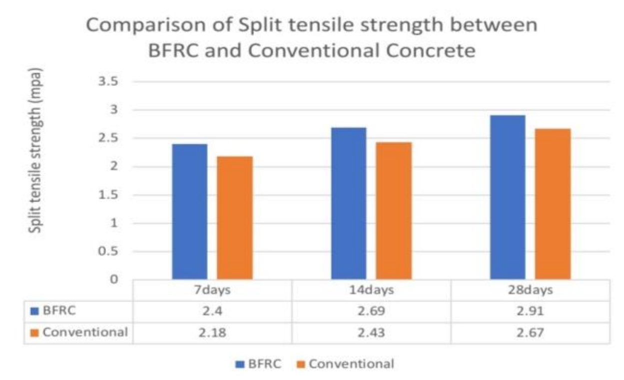

Fig 4.24 *Comparison of split tensile strength*

From the comparison of split tensile strength between BFRC and Conventional concrete, it was found that:

- Split tensile is 9 % more for BFRC when compared with Conventional concrete.

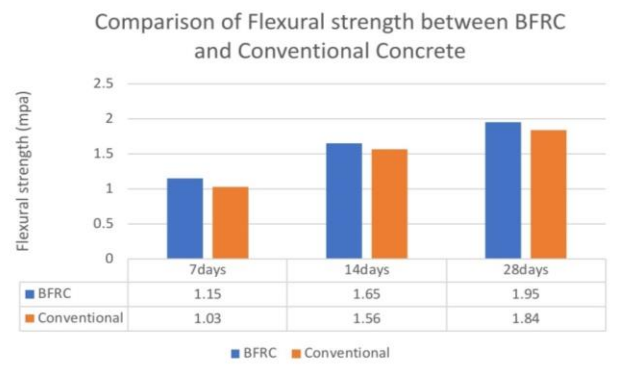

Fig 4.25 *Comparison of flexural strength*

From the comparison of flexural strength between BFRC and Conventional concrete, it was found that:

- Flexural strength is 6 % more for BFRC when compared with Conventional concrete.

V. CONCLUSION

The present study was aimed to investigate the toughness properties of bamboo fibre reinforced concrete by conducting experiments. Experiments were conducted for fresh and hardened properties of Bamboo fibre reinforced concrete includes slump, flexural strength, split tensile strength, compressive strength. The result obtained can be summarized as follows:

- Compressive strength increases with length of fibre from 36 to 46 mm. Further increase in fibre length, compressive strength is found to decrease.
- Split tensile strength decreases with increase in fibre length. For aspect ratio 30 split tensile strength is 2.91 Mpa and for aspect ratio 46.6 it is 2.53 Mpa.
- Absolute and post crack toughness decrease with increase in fibre length.
- Residual toughness increases with length up to 46 mm fibre length and decreases.
- The optimum length of bamboo fibre is 36 mm and diameter 1.2mm.

- The influence of bamboo fibre in flexural strength of concrete is superior than tensile and compressive strength.
- The addition of bamboo fibres makes the concrete very resistive in flexure.
- The fibres act as a crack resistor and reduce crack-width and deflection of concrete.

From the results its concluded that bamboo fibre reinforced concrete provides added strength than Conventional concrete. Additionally, the cost of construction materials including steel is increasing continuously over the years and structures are becoming unaffordable for common man. Therefore, in order to provide shelter to economically deprived persons of the society it is necessary to go either for alternate construction materials with conventional construction technique or to adopt conventional materials with alternate construction technique to reduce the cost of structure. It has been concluded that BFRC can be effectively used in construction of Conventional Concrete structures.

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