Experimental Study on Properties of Basalt Fiber – Reinforced Concrete With Variance To Densities And Lengths of Fiber

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Abstract- *Fibre reinforcement is commonly used to provide toughness and ductility to brittle cementitious matrices. Reinforcement of concrete with a single type of fibre may improve the desired properties to a limited level. This study aims to characterize and quantify the mechanical properties of fibre reinforced concrete made with Basalt fibre. Fiber-reinforced concrete (FRC) has become a viable new material used in various constructions such as building pavements, large industrial floors, and runways. In this work, basalt chopped fibers in filament form were used to develop an FRC material called basalt fiber-reinforced concrete (BFRC) to study the possible improvement in the 28-day compressive strength and modulus of rupture, though the latter one is more important for the construction of pavements, industrial floors, and runways. For this purpose nine mixes of BFRC in vareience to their lengths and densities are prepared namely 15 ,30 and 50 mm long with 2,4,and 8 kg/m3 and one plain control mix were prepared. The results indicated that 50-mm-long chopped basalt filament fiber and a fiber amount of 4 kg/m3 are optimum for achieving high performance in both the compressive strength and modulus of rupture.*

I. INTRODUCTION

Concrete is one of the most versatile building materials. Concrete is composite material which consists of cement, coarse aggregate, fine aggregate and water in required proportions. Concrete is a material which used for the purpose of construction in now a days. Due to its composite nature concrete is weak in tension but strong in compression. Basic Principle involved in the increase in strength of concrete is heat of Hydration. It can be cast to fit any structural shape from a cylindrical water storage tank to a rectangular beam or column in a high-rise building. The advantages of using concrete include high compressive strength, good fire resistance, high water resistance, low maintenance, and long service life. The disadvantages of using concrete include poor tensile strength, low strain of fracture and formwork requirement. The major disadvantage is that concrete develops micro cracks during curing. It is the rapid propagation of these micro cracks under applied stress that is responsible for the low tensile strength of the material. Plain cement concrete is weak in tension because it contains numerous micro cracks. These micro cracks propagate in the concrete matrix when it is subjected to load.

Hence fibres are added to concrete to overcome these disadvantages. The addition of fibres in the matrix has many important effects. Most notable among the improved mechanical characteristics of Fibre Reinforced Concrete (FRC) are its superior fracture strength, toughness, impact resistance, flexural strength resistance to fatigue, improving fatigue performance is one of the primary reasons for the extensive use of Basalt Fibre Reinforced Concrete (BFRC) in pavements, bridge decks, offshore structures and machine foundation, where the composite is subjected to cyclically varying load during its lifetime**.**

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1.2 OBJECTIVES OF THE STUDY

The present proposal involves a comprehensive laboratory study for the newer application of this waste material in the preparation of fiber reinforced concrete. The primary objective of investigation is to study the strength behaviour i.e. compressive strength, and impact resistance of concrete with different lengths and densities of Basalt Fibre.

II. LITERATURE REVIEW

Kurein (1981) studied on the dyeing behavior of banana fibre. During this study 4 different classes of dyes were used on un mercerized, mercerized cotton fibre and banana fibre. Their dye-uptake, wash-fastness and lightfastness were determined. The dyes selected were direct dye, vat dye,reactive dye, and azo dye.

H.T Luo investigated flexural performance of hybrid fiber reinforced concrete beam with longitudinal reinforcement ratio of 1.08% and conformed that ductility of beam is improved due to addition of steel fiber based on load-deflection curves.

A.N.Dancygier and Z.Savir studied the influence of steel fiber on flexural performance of high strength concrete beam with low longitudinal reinforcement ratio, which proved that steel fiber enhance brittleness of beam compared to that of beam with minimum longitudinal reinforcement ratio. Compared to steel fiber reinforced concrete, the hybrid fiber with different type and size can improve effectively strength and toughness of concrete, form hybrid effect during different fiber, play respective beneficial influence from different level. However, few researches on flexural performance of hybrid fiber reinforced RC beam were studied.

Researches on influence of hybrid fiber on beam flexural ductility were blank if beam was made of minimum longitudinal reinforcement ratio and fibers. Researches on FRSCC are a new development trend, which have advantages on both SCC and FRC, fiber content of FRSCC is mainly determined by workability, but fiber content of FRC is determined by mechanical behavior. When steel fiber content maintain constant, the tensile strength, flexural strength and flexural toughness of steel fiber reinforced SCC were improved compared to that of steel fiber reinforced NC.

Based on the investigation on the workability of hybrid fiber reinforced self-compacting concrete (HFRSCC)' a series of hybrid fiber reinforced SCC beams with low longitudinal reinforcement ratio are tested to evaluate the hybrid fiber influence on load-deflection curve, beam flexural ductility. Steel fiber reinforced SCC beams were made in order to compare the load, ductility with hybrid fiber reinforced SCC beams.

omualdi and Batson (1963) after conducting impact test on fibre reinforced concrete specimens, they concluded that first crack strength improved by addition of closely spaced continuous steel fibres in it. The steel fibres prevent the adverting of micro cracks by applying pinching forces at the crack tips and thus delaying the propagation of the cracks. Further, they established that the increase in strength of concrete is inversely proportional to the square root of the wire spacing.

Charles H.Henage (1976) developed an analytical method based on ultimate strength approach, which has taken into account of bond stress, fibres stress and volume fraction of fibres. After his investigations, he concluded that the incorporation of steel fibres significantly increases the ultimate flexural strength, reduces crack widths and first crack occurred at higher loads.

III. METHODOLOGY

Materials Used And Their Properties

3.1 Materials

The Constituent Materials Used In This Study Are Given Below:

1. Cement
2. Normal Weight Coarse Aggregate
3. Fine Aggregate
4. Basalt fibre

3.2 Material Properties

3.2.1 Cement

Ordinary Portland Cement (OPC) is manufactured in the form of different grades, the most common in India being Grade-53, Grade-43, and Grade-33. OPC is manufactured by burning siliceous materials like limestone at 1400 degree Celsius and thereafter grinding it with gypsum. Ordinary Portland cement Grade 53: Having been certified with IS 12269:1987 standards, Grade 53 is known for its rich quality and is highly durable. Hence it is used for constructing bigger structures designed to with stand heavy pressure.

Table 3.1 Physical Properties Of Portland Cement (53 Grades)

S. No.	Properties/ Characteristics	Test Results	Requirements As Per Is 12269-1987
1	Normal Consistency	33%	---
2	Setting time a) Initial Setting Time b) Final Setting Time	39 minutes 453 minutes	Not less than 30 minutes Not more than 600 minutes
3	Specific Gravity	3.09	---
4	Fineness of cement by sieving through sieve No.9 (90 microns) for a period of 15 min.	2.90%	<10%
5	Compressive strength of cement (28 days)	53 MPa	53 MPa

3.2.2 Aggregates

A) Fine Aggregates:

Sand shall be obtained from a reliable supplier and shall comply with IS standards for fine aggregates. It should be clean, hard, strong, and free of organic impurities and deleterious substance. It should inert with respect to other materials used and of suitable type with regard to strength, density, shrinkage and durability of mortar made with it.

Grading of the sand is to be such that a mortar of specified proportions is produced with a uniform distribution of the aggregate, which will have a high density and good workability and which will work into position without segregation and without use of high water content. The fineness of the sand should be such that 100% of it passes standard sieve No.8. The fine aggregate which is the inert material occupying 60 to 75 percent of the volume of mortar must get hard strong nonporous and chemically inert. Fine aggregates conforming to grading zone II with particles greater than 2.36 mm and smaller than 150 mm removed are suitable.

Table3.2: Sieve Analysis (Fine Aggregate)

S. No.	I.S. Sieve No.	Weight retained (gm)	Percentage weight retained	Cumulative percentage retained	Percentage passing
1.	10mm	0	0	0	100
2.	4.75mm	21	2.10	2.10	97.90
3.	2.36mm	65	6.50	8.60	91.40
4.	1.18mm	180	18.00	26.06	73.94
5.	600µ	278	27.80	54.04	45.96
6.	300µ	280	28.00	82.04	17.96
7	150µ	176	17.6	100.00	0
Total :				274.00	

Fineness modulus = 274.0 / 100 = 2.74

Zone = II

B) Coarse Aggregate

Table3.3: Sieve Analysis (Coarse Aggregate)

S No	I.S. Sieve No.	Weight Retained (Gms)	Percentage Weight Retained	Cumulative Percentage Retained	Percentage Passing
1.	40mm	0	0	0	100
2.	20mm	877	35	35	65
3.	10mm	408.5	65	65	35
4.	4.75mm	38	0.76	100.00	0
5.	2.36mm	0	0	100.00	0
6.	1.18mm	0	0	100.00	0
7.	600µ	0	0	100.00	0
8.	300µ	0	0	100.00	0
9.	150µ	0	0	100.00	0
Total :				716.78	

Fineness modulus = 716.78 / 100 = **7.17**

Table 3.4: Physical Properties Of Fine And Coarse Aggregate

S. No.	Properties	Test Results	
		Fine Aggregate	Coarse Aggregate
1.	Specific gravity	2.60	2.73
2.	Bulk Density (Kg/m³)	1590 kg/m³	1520 kg/m³
3.	Fineness Modulus	2.74	7.17

- Basalt composite bars are made by utilizing basalt fibers and a resin epoxy binder. They are non-corrosive, consist of 80% fibers and have a tensile strength three times that of the steel bar normally used in building construction. Wherever corrosion problems exist, basalt fiber composite bars have the potential to replace steel in reinforced concrete. Currently there are many FRP bar manufacturing companies which market their products. Most of these bars are made of E-glass fiber and thermosetting resin. However FRP bars lack sufficient durability under extreme conditions. These bars are costly and are also non-resistant to alkalis. Basalt bars do not possess these disadvantages and can be effectively used in various applications such as highway barriers, offshore structures, and bridge decks. The above mentioned advantages alone could warrant a sufficient argument for substitution of steel bars with basalt bars on a large scale.

IV. EXPERIMENTAL RESULTS

Slump Cone Test:

It is an empirical test that measures the workability of fresh concrete. More specifically, it measures the consistency of the concrete in that specific batch. This test is performed to check the consistency of freshly made concrete. Consistency is a term very closely related to workability. It is a term which describes the state of fresh concrete.

Mix	Slump (mm)	Mix	Slump (mm)	Mix	Slump (mm)
BFRC 15-2	61	BFRC 15-4	56	BFRC 15-8	49
BFRC 30-2	57	BFRC 30-4	49	BFRC 30-8	47
BFRC 50-2	50	BFRC 50-2	47	BFRC 50-8	42

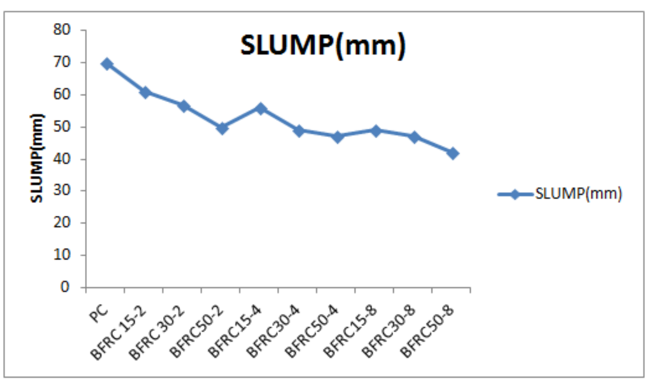


Table4.1 Compressive strength with optimum percentage of fly ash

FIBRE LENGTH+DENSITY(kg/m3)	7 DAY S	14 DAYS	28 DAYS
PLAIN CONCRETE	24.5	37.4	41.3
BFRC15-2	27.4	39.1	44.1
BFRC30-2	27.6	41.2	44.9
BFRC50-2	28.3	42.1	46.3
BFRC15-4	27.5	42.3	45.6
BFRC30-4	27.9	42.5	46.2
BFRC 50-4	29.4	43.9	48.1
BFRC 15-8	28.5	43.4	46.8
BFRC 30-8	29.1	43.9	47.6
BFRC 50-8	28.9	43.7	47.1

Table: 4.2compressive strength for different mixes

	7DAYS (MPa)	14 DAYS (MPa)	28 DAYS (MPa)
PC	**24.5**	**37.4**	**41.3**
BFRC 15-2	27.4	39.1	44.1
BFRC 15-4	27.5	42.3	45.6
BFRC 15-8	27.5	42.3	45.6

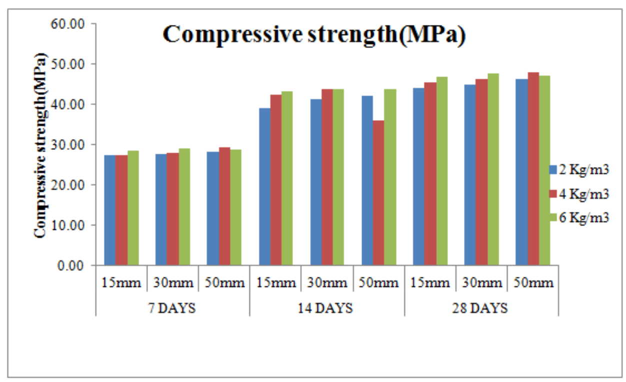
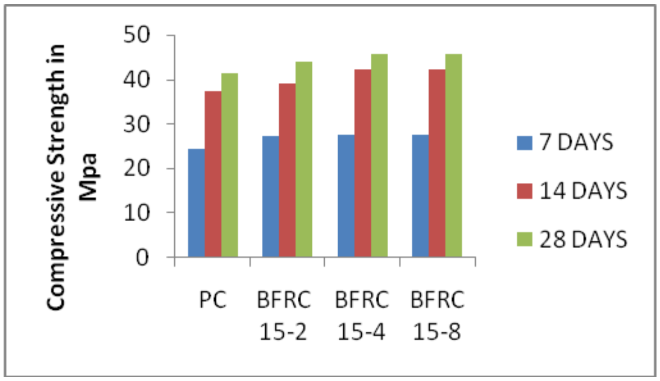


Table: 4.3 Effect of different fiber densities on compressive strength of concrete at different curing periods

	7 DAYS (MPa)	14 DAYS (MPa)	28 DAYS (MPa)
PC	**24.5**	**37.4**	**41.3**
BFRC 30-2	27.6	41.2	44.9
BFRC 30-4	27.9	42.5	46.2
BFRC 30-8	29.1	43.9	47.6

4.3 Graphs

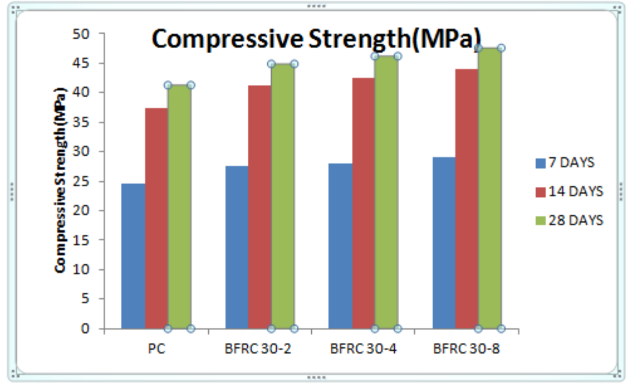
The 28 days compressive strength was found to be 44.9, 46.2 and 47.6 for BFRC 30-2,BFRC 30-4 and BFRC 30-8 respectively . However there is a significant increase in compressive strength upon addition of fibers compared to that of plain concrete.



Plot showing the Variation in compressive strength for 15 mm length fibre with different densities (kg/m^3).

From the graphs it is evident that the fiber amounts of 4kg/m^3 and 8kg/m^3 did not show as much improvement in the compressive strength as compared to that of BFRC made with 2kg/m^3

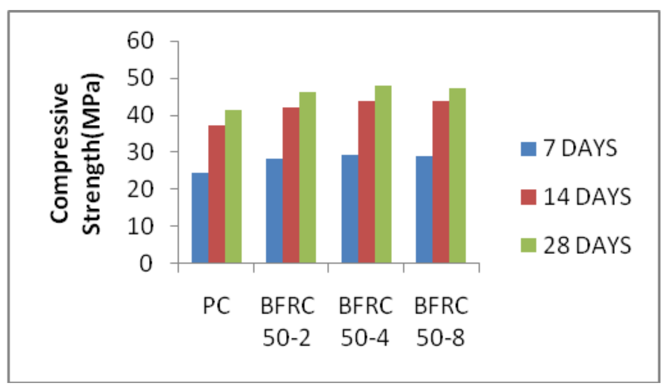
	7 DAYS (MPa)	14 DAYS (MPa)	28 DAYS (MPa)
PC	**24.5**	**37.4**	**41.3**
BFRC 30-2	27.6	41.2	44.9
BFRC 30-4	27.9	42.5	46.2
BFRC 30-8	29.1	43.9	47.6



Plot showing the Variation in compressive strength for 30 mm length fibre with different densities (kg/m^3)

Effect of fiber length (50 mm) on the compressive strength on various densities

	7 DAYS (MPa)	14 DAYS (MPa)	28 DAYS (MPa)
PC	**24.5**	**37.4**	**41.3**
BFRC 50-2	28.3	42.1	46.3
BFRC 50-4	29.4	43.9	48.1
BFRC 50-8	28.9	43.7	47.1



Plot showing the Variation in compressive strength for 50 mm length fibre with different densities (kg/m^3).

There is a decrease in strength of BFRC 50-8 compared to BFRC 50-4. Considerable benefits are observed for BFRC 50-4 in terms of strength aspects.

From the results it is evident that an increase in fiber length from 30 to 50 mm does not provide any additional gain in the Compressive Strength rather it introduces a clumping problem.

From the results it is clear that the compressive strength increases as the fiber length increases for various densities, though there is no specific trend .But however the BFRC 50-4 had optimum results in compressive strength aspects compared to other mixes. So the myth of increasing fiber length increases the compressive strength has been broken by this work. From the result it is evident that BFRC 50-4 gives better result than BFRC 50-8. So addition of fibres does not provide any additional gain in the Compressive Strength rather it introduces a clumping problem.

FLEXURAL STRENGTH

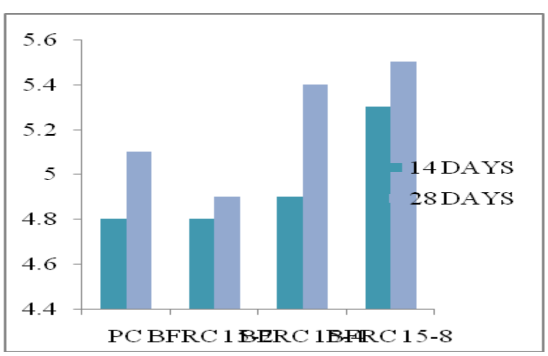
The size of specimens 100 mm x 100 mm x 500 mm was used and the specimens were cured in water. Concrete specimen beams are used to determine flexural strength of concrete and were tested as per as per IS 516 (1959).

Effect of fiber in Flexural strength:

After 7 and 28 days curing, prismatic specimens are placed on flexural testing machine having a maximum of 100 KN and a constant rate of loading of 40 kg/m^2 per minute is applied on the test specimen by placing the specimen in such a way that the two point loading should be placed at a distance of 13.3 cm from both the ends. Ultimate load at which the prismatic specimen fails is noted down from dial gauge reading.

Effect of fiber length (15 mm) on the flexural strength on various densities

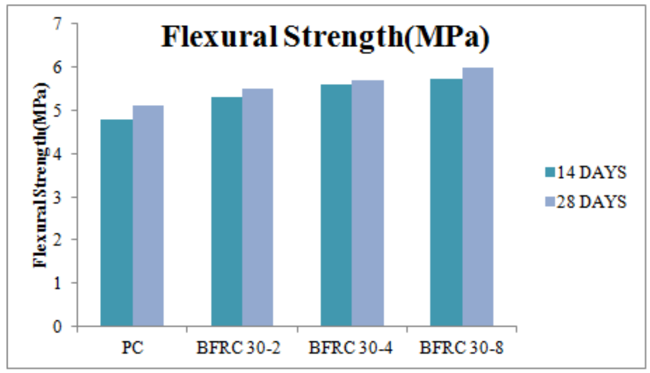
MIX	14 DAYS	28 DAYS
PC	4.8	5.1
BFRC 15-2	4.8	4.9
BFRC 15-4	4.9	5.4
BFRC 15-8	5.3	5.5



Plot showing the Variation in Flexural strength for 15 mm length fibre with different densities (kg/m^3)

Effect of fiber length (30 mm) on the flexural strength

MIX	14 DAYS	28 DAYS
PC	4.8	5.1
BFRC 30-2	5.3	5.5
BFRC 30-4	5.6	5.7
BFRC 30-8	5.73	6

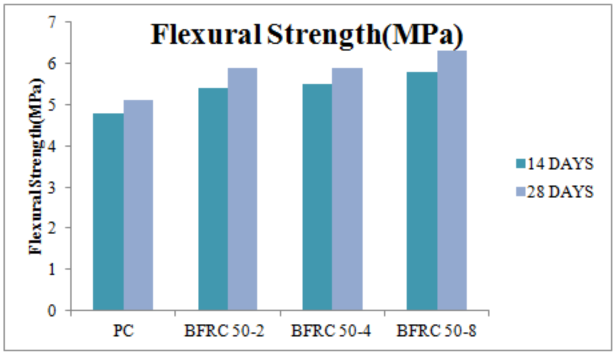


Plot showing the Variation in Flexural strength for 30 mm length fibre with different densities (kg/m^3)

It is evident that the density of fiber has consistent effect on fiber length. The flexural strength values were observed to be 5.3, 5.6 and 5.73 for fibers made with densities 2,4 and 8 for 30mm long fibres BFRC.

Effect of fiber length (50 mm) on the flexural strength on various densities

MIX	14 DAYS	28 DAYS
PC	4.8	5.1
BFRC 50-2	5.4	5.9
BFRC 50-4	5.5	5.9
BFRC 50-8	5.8	6.3



This is a significant gain in the MOR when compared to different densities of this length of fiber. However, the MOR value reduces slightly as the fiber length increases from 30 mm (BF 30-8) to 50 mm (BF 50-8), and this may be due to the clumping of fiber, which was more prominent at higher fiber amounts and especially for longer fiberlengths.

Thus,this study found that the increase in fiber length beyond 30 mm does not improve the flexural strength when the fiber amount is 8 kg/m3. This study found that the optimum length and optimum amount of basalt fiber are 50 mm and 4 kg/m3 if increases in both Compressive Strength

V. CONCLUSIONS

From the present study the following conclusions can be drawn

1. The workability of concrete reduces as the fiber length and fiber amount increase. Low slumps were recorded when a large amount (8 kg/m3) of fiber was added.
2. Clumping or balling of fibers was visible in all mixes when the high fiber amount of 8 kg/m3 was added. This clumping of fibers became a severe problem when the fiber length was increased to 50 mm.
3. Addition of fibers to concrete improves mechanical properties like compressive strength and flexural strength etc. of the mix.
4. There was an optimum percentage of each type of fiber in terms of length and densities, provided maximum improvement in mechanical properties of the concrete resulting in Basalt fibre reinforced concrete (BFRC).
5. The low fiber amount of 2 kg/m3 did show some improvement in both the compressive strength and flexural strengths. However, the improvements are not definite.
6. BFRC made with short fibers (15 mm long) required a large amount(18 kg/m3)of fiber to cause a considerable increase in the MOR. However, the largest increase in the CS was found at the small fiber amount (4 kg/m3) for the 50-mm-long fibers.

REFERENCES

[1] Balaguru P.N and Shah S.P. (1992). „Fibre Reinforced Cement Composites‟ McGraw Hill, In., New York.
[2] Eethar Thanon Dawood and Mahyuddin Ramli (2011). “Contribution of Hybrid Fiber’s on the Properties of High Strength Concrete Having High Workability” proceedings of Twelfth East Asia Pacific Conference on Structural Engineering and Construction. Procedia Engineering 14, 814-820.
[3] IS 10262 - 2009 ‘Indian Standard Recommended Guidelines for concrete Mix Design’, Bureau of Indian Standards, New Delhi - 110 002.
[4] IS 456 - 2000 ‘Indian Standard Code of Practice for Plain and Reinforced Concrete’, 4th revision, Bureau of Indian Standards, New Delhi - 110 002.
[5] IS - 516 - 1959 ‘Indian Standard Methods of Test for Strength of Concrete’, 13th reprint, June 1989, Bureau of Indian Standards, New Delhi - 110 002.
[6] Saandeepani Vajje and Dr.N.R.Krishna murthy (2013). „Study on Addition of Natural Fibers into Concrete‟ International Journal of Scientific & Technology,2(11),26-33.
[7] Samrat, M.; Raul, F.; Yusuf, A (2008). „Banana fibres variability and fracture behavior‟. Journal of Engineered Fibre’s and Fabrics 3(2),39-45.
[8] Nataraja M. C, Dhang N and Gupta A.P. (1998). „Steel Fibre Reinforced Concrete under Compression‟, The Indian Concrete Journal, 353-356.
[9] Yaghoub Mohammedi and Kaushik S.K. (2003). „Investigation of Mechanical Properties of Steel Fibre Reinforced Concrete with Mixed Aspect Ratio of Fibres‟ Journal of Ferrocement,33(1),1-13.
[10] Kumar V, Suman S. D and Mohammad Shamim (1997) „Statistical Prediction of Compressive Strength of Steel Fibre Reinforced Concrete‟ ICI Bulletin, No.60,31-36.
[11] Pervaiz, M., Sain, M.M., Sheet-molded polyolefin natural fiber composites for automotive applications. Macromolecular Materials and Engineering, 288:553-557 (2003).