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AN EXPERIMENTAL STUDY ON THE BEHAVIOUR OF THE BASALT FIBER REINFORCED CONCRETE

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Abstract- The objective of this paper is to investigate & compare the compressive, flexural & split tensile strength of plain M30 grade concrete with basalt fiber reinforced concrete containing 1 kg/m^3, 3 kg/m^3 & 5 kg/m^3 basalt fibers at 7,28,56 and 91 days. The acid resistance tests were carried out on specimens by using 1% diluted sulphuric acid solution. The acid immersed specimens were tested for determination of compressive strength, split tensile strength & flexural strength after curing for 91 days. Similarly, the fire resistance tests carried out by using hot air oven at 100°C, 300°C for 1hour duration.

Key words- Basalt Fiber, Acid resistance, Fire resistance, Compressive strength, Split tensile strength, Flexural strength

1. Introduction

Plain concrete has a very low tensile strength and a low strain at fracture. The plain concrete contains numerous micro cracks under loading conditions and thus it fails in lack of tensile strength. These deficiencies have led to considerable research over this area for developing new ideas to modifying the brittle properties of concrete. It has been found that some type of fibers added in concrete in certain proportions improves the mechanical properties, durability and serviceability of the structure. Thus fiber-reinforced concrete (FRC) is the most widely used solution for improving the strength properties of concrete. Fiber reinforced concrete contains short discrete fibrous material which increases its structural integrity. In concrete, the fibers are usually uniformly distributed and randomly oriented. The main role of FRC is to control the cracking and crack propagation, and to alter the behaviour of the material once the matrix has cracked, by bridging across these cracks and so providing some post-cracking ductility. Different types of commercially available fibers used in concrete and examples of these fibers are steel fibers, glass fibers, polypropylene fibers, carbon fibers, and basalt fibers.
Basalt fibers are manufactured by melting pure raw material in single-stage process. These fibers has an elastic structure, environmentally safe and non-toxic. Basalt fiber has excellent thermal property, it can easily withstand temperature of 650°C for hours continuously, without any physical change. Basalt fibers have very good resistance against alkaline attack but it has poor resistance to acids. It has better corrosion resistance and has tensile strength of 3200 - 3850 MPa.

2. Literature Review

***Jongsung Sim et al* (2005)** has investigated the applicability of the basalt fiber as a strengthening material for structural concrete members through various experimental works for durability, mechanical properties, and flexural strengthening. When the fibers were immersed into an alkali solution, the basalt and glass fibers lost their volumes and strengths with a reaction product on the surface but the carbon fiber did not show significant strength reduction. From the accelerated weathering test, the basalt fiber was found to provide better resistance than the glass fiber. However, the basalt fiber kept about 90% of the normal temperature strength after exposure at 600°C for 2 h whereas the carbon and the glass fibers did not maintain their volumetric integrity. In the tests for flexural strengthening evaluation, the basalt fiber strengthening improved both the yielding and the ultimate strength of the beam specimen up to 27% depending on the number of layers applied. From the results presented herein, two layers of the basalt fiber sheets were thought to be better strengthening scheme. In addition, the strengthening does not need to extend over the entire length of the flexural member. When moderate structural strengthening but high resistance for fire is simultaneously sought such as for building structures, the basalt fiber strengthening will be a good alternative methodology among other fiber reinforced polymer (FRP) strengthening systems.
***Irine* (2014)** done an experimental research on Normal Strength Concrete of grade M30 using Basalt Rock Fibre. Based on the laboratory experimental on basalt fibre reinforced concrete, cube, beam and cylindrical specimens have been designed

with basalt fibre reinforced concrete containing 1kg/m^3, 2kg/m^3 and 4kg/m^3 basalt fibbers'. The experimental test results demonstrated considerable increases in compression, flexural and splitting of specimen at 3, 7 and 28 days with addition of basalt fibres. The Fibre were replaced from 0 to 4 (kg/m^3) at an interval of 1 kg/m^3. The hardened properties of concrete such as compressive strength, split tensile strength and Flexural strength were tested at 3, 7, 28 days. The compressive strength, split tensile strength and flexural strength of concrete increases with increase in the age of curing. The maximum compressive, split, flexural strength of concrete was found at 4 kg/m^3 of Basalt fibre.

***Wu et al* (2014)** has investigated on Durability of basalt fibers and composites in corrosive environments. This study describes an experimental investigation of the degradation of the tensile properties of basalt fibers and epoxy-based composites in various corrosive environments, including alkaline, acid, salt and water solutions, and clarifies the corresponding degradation mechanisms. Carbon and glass fibers and their composites are adopted as references. Accelerated experiments were conducted at temperatures of 25°C and 55°C and the variation in tensile properties was studied by means of tension testing, mass loss weighing, scanning electron microscope imaging and energy spectrum analysis. The experimental results show that basalt fibers possess relatively strong resistance to water and salt corrosion, moderate resistance to acid corrosion and severe degradation in an alkaline solution. The tensile properties of basalt FRP composites are much better than those of basalt fibers. The degradation mechanism of basalt fibers involves damage by etching in salt, water and alkaline solutions and by change in the chemical composites in an acid solution. The fracture properties of basalt FRP composites are controlled by the failure of corroded interfaces between the fibers and the resin, making the interface the critical factor, rather than the fiber itself.

***Iyer et al* (2015)** have investigated on Mechanical Properties of Fiber-Reinforced Concrete made with Basalt Filament Fibers. In this study the basalt fiber specimens were cast using basalt filament fibers of three different lengths and three different amounts. Clumping of fibers at high fiber amounts caused mixing and casting problems. These problems become even more severe when long fibers are used at the high fiber dosage amount. The results indicated that 36-mm-long chopped basalt filament fiber and a fiber amount of 8 kg/m^3 are optimum for achieving high performance in both the compressive strength and modulus of rupture. This paper discusses the test matrix and test results obtained from various BFRC and plain concrete specimens.

3. **Experimental Investigation**

3.1 Materials Used

In this various material used for the study, their properties, test conducted, and results are discussed. This section also explains the mix proportions used for the study.

3.1.1 Cement

Ordinary Portland cement of 43 grade confirming to IS 8112:1989 was used in this study. The table 1 below shows the properties of cement.

3.1.2 Fine Aggregate

The locally available river sand passing through 4.75 mm sieve and retained on 150 µ sieve, conforming to Zone-II of IS 383-1970 has been used as fine aggregate. The Table 2 shows the properties of fine aggregate.

3.1.3 Coarse Aggregate

Conventional coarse aggregate was used from an established quarry satisfying the requirement of IS 383-1970. The locally available crushed granite stone is used as coarse aggregate. The tests conducted on coarse aggregate are tabulated in Table 3.

Table 1. Properties of cement

S. No	Particulars of test	Test Results
1	Standard Consistency	32%
2	Initial setting time (min)	132 min
3	Final setting time (min)	243 min
4	Specific gravity	3.12
5	Fineness (weight of cement retained on IS 90 µ sieve)	2.5%
6	Compressive Strength (N/mm^2) i) 3 Days ii) 7 Days iii) 28 Days	 26.43 34.68 46.72

Table 2. Properties of Fine Aggregate

S. No	Particulars of test	Value
1.	Specific gravity	2.61
2.	Water absorption	1.20%
3.	Bulk Density i. Loose State ii. Compacted state	 1539 kg/m^3 1684 kg/m^3
4.	Fineness modulus	2.60
5.	Zone	II

3.1.4 Super plasticizer

In modern concrete practice, it is essentially impossible to make high performance concrete at adequate workability in the field without super plasticizers. The super plasticizer used in the study was FOSROC Conplast SP 430.

Table 3. Properties of Coarse Aggregate

S.No.	Particulars of test	Value
1.	Specific gravity	2.81
2.	Water absorption	0.55%
3.	Bulk density (i) Loose state (ii) Compacted state	 1512.29 kg/m^3 1744.59 kg/m^3
4.	Fineness modulus	6.80
5.	Flakiness Index	11.30%
6.	Elongation Index	19.44%
7.	Aggregate Crushing value	19.82%
8.	Aggregate Impact value	20.78%

3.1.5 Basalt Fiber

Basalt chopped fibre golden brown colour was used in the concrete mixes. The density of the fiber is 2.63 g/m^3 and is available in the length of 6 mm to 36 mm. The physical properties of these fibers are presented in Table 4.

Figure1. Basalt Fiber

Table 4. Physical properties of Basalt fiber

S.No.	Physical properties	Suggested values by supplier
1.	Colour	Golden Brown
2.	Diameter	6-15 microns
3.	Length (mm)	12
4.	Elastic Modulus (GPa)	75-90
5.	Density (g/cm^3)	2.63
6.	Tensile strength (MPa)	3200-3850
7.	Working temperature (^{o}C)	-260^{o}C - +650^{o}C

3.1.6 Mix Proportion

Mix design is a process of selecting suitable ingredients and determining their relative proportions with the objective of producing concrete of having certain minimum workability, strength and durability as economically as possible. The M30 grade concrete Mix design is made as per IS10262:2009. The table 5 below shows the mix design.

Table 5. Mix Design

Water (litres)	Cement (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)
176	400	668.30	1235.68
0.44	1	1.67	3.09

4. **Test Procedure**

Workability is defined as the ease with which concrete can be placed Slump cone test was done to measure the workability of concrete mix. The compacting factor test is also done because it is more precise than the slump test and is particularly useful for concrete mixes of very low workability.

4.1 Slump Cone Test

Slump cone test is a preliminary test conducted to determine the workability. In this thesis, slump test was conducted on the mix containing cement, fine aggregate, manufactured sand and coarse aggregate. The mix was prepared according to the proportions obtained from mix design. The prepared mix was then placed in slump cone in three layers with simultaneous tamping with a tamping rod for each layer. The slump cone is lifted and the change in slump is observed. The change in slump is measured with a steel rule and is noted down.

4.2 Compaction Factor Test

Compaction factor test is another test conducted to determine the workability of the prepared mix. In this test the mix is poured into the upper hopper of the compaction factor apparatus, and then the lever is pulled, which makes the mix fall down in to the lower hopper and then in to the cylinder under the action of gravity. Now the cylinder is weighed and the weight is noted down. The cylinder is now placed on the vibrator table and then compacted. The cylinder is again weighed and the weight of fully compacted cylinder is noted down. The compaction factor is found out with the help of the formula below.

$$\text{Compaction factor} = \frac{\text{Weight of partially compacted concrete}}{\text{Weihght of fully compacted concrete}}$$

4.3 Vee-Bee Consistometer Test

In this test, the mix is placed in the cone in three layers with simultaneous compaction. After the cone has been removed the circular glass plate attached to the apparatus is placed on the mix. The machine is switched on and the stopwatch is started. The time taken for the cone shaped to mix to transform into a cylindrical shaped mix is noted down. This time recorded is known as Vee-Bee time.

4.4 Compressive Strength Test

In this test, the cubes that have been cast in the cubical mould of dimensions 150mmx150mmx150mm, placed in curing tank for 7, 28, 56, and 91 days and then dried until it is free from moisture are tested in a compression testing machine. The cubes are placed in the machine and then load is applied until failure. The load obtained is recorded and the compressive strength is calculated using the formula below. Figure 2 depicts the placing of concrete cube in compression testing machine.

$$\text{Compressive strength} = \frac{P}{A}\ (N/mm^2).$$

Where,

P = load applied to the specimen.

A = Cross-sectional area of cube on which the load is applied (150mm x 150mm)

Figure 2. Testing of Cube

4.5 Splitting Tensile Strength

In this test, cylinders of dimension 150mm x 300mm have been cast in cylindrical moulds, placed in curing tank for 7, 28, 56 and 91 days and dried until free from moisture. These cylinders are placed in the testing machine and the load is applied until failure. The ultimate load is recorded and then the splitting tensile strength is calculated according to the formula given below. The placing of the cylinder in the testing machine is depicted in Fig 2.

$$F_t = \frac{2P}{\pi \, x \, D \, x \, L} \text{ N/mm}^2$$

Where, P= Maximum load applied to the specimen.

D = Cross sectional dimension of cylinder on which load is applied.

L = Length of specimen in mm.

F_t = Split tensile strength. (N/mm^2)

Figure 3. Testing of Cylinder

4.6 Flexural Strength

In this test, prisms of dimensions 500mm x 100mm x 100mm were cast in the appropriate moulds, placed in curing tank for 7, 28, 56 and 91 days, and then dried until free form moisture. Before the testing of these prisms, two lines with a gap of 5 cm from each of the ends are drawn. Now from this 5 cm lines, two more lines with a gap of 13.33 cm are drawn. This is for the purpose of three point loading. The prism is placed in the testing machine and then load is applied on the roller plate placed on the lines drawn on the prism. The prism is loaded until failure and the ultimate load is recorded. The flexural strength is calculated with the help of the formula given below. Fig 3 depicts the placing of the prism in the universal testing machine.

$$F_b = P \, x \, \frac{L}{B \, x \, D \, x \, D} \text{ N/mm}^2 \text{ (when tensile crack length is greater than 13.33cm)}$$

$$F_b = \frac{3Pa}{B \, x \, D \, x \, D} \text{ N/mm}^2 \text{ (when tensile crack length is between 11.0cm to 13.33cm)}$$

Where,

F_b = Flexural strength of the specimen.

P = maximum load applied to the specimen.

L = Length in mm of the span on which the specimen was supported.

B = width of the specimen.

D = depth of specimen.

Figure 4. Testing of Prism

4.7 Fire Resistance test

In the present project, concrete cube specimens with optimum basalt fiber are tested for the fire resistance at 100^oC and 300^oC in furnace for 1 hour. This test was conducted after 28 days curing. After the curing period the cube specimens were dried at room temperature for some time confirming that the specimens are free from wetness. In between the furnace is to be made ready for our required temperature by pre heating it. Then the specimens which are to be tested are placed in furnace and the time is to be noted. After the required time furnace is switched off and cubes are taken out and are kept to cool at room temperature. Then the specimens are tested at universal testing machine for compression.

Figure 5. Furnace

5. **Discussion of Test Results**

5.1 Workability

These values of Slump cone test, Compaction factor and Vee-Bee time obtained from present investigation are presented in Table 6, 7 & 8 respectively. The Slump cone test and Compaction factor are decreasing, and Vee-Bee time is increasing as the quantity of basalt fiber is increasing.

Table 6. Workability in terms of Slump Cone test

S.No.	Basalt Fibre (kg/m^3)	Slump (mm)	Admixture (%)
1	0.0	28	0.6
2	1.0	37	0.7
3	3.0	32	0.8
4	5.0	29	0.9

Table 7. Workability in terms of Compaction Factor

S.No.	Basalt Fibre (kg/m^3)	Compaction Factor
1	0.0	0.828
2	1.0	0.885
3	3.0	0.854
4	5.0	0.832

Table 8. Workability in terms of Vee-Bee time

S.No.	Basalt Fibre (kg/m^3)	Vee-Bee Time (Sec)
1	0.0	9.4
2	1.0	8.9
3	3.0	9.7
4	5.0	10.9

5.2 Compressive Strength

The results of compressive strength are obtained and are presented in table 9. The variation of compressive strength with respect to fiber content is shown in figure 6.

Table 9. Compressive strength values

Mix ID	BFC 0	BFC 1	BFC 3	BFC 5
kg/m^3 of Basalt Fiber	0	1	3	5
7 days (MPa)	26.74	28.52	35.48	32.67
28 days (MPa)	39.43	43.96	48.72	45.81
56 days (MPa)	42.65	46.13	50.59	48.13
91 days (MPa)	45.86	47.84	51.78	49.41

From the charts can be observed that with the increase in the quantity of fiber up to 3 kg/m^3, the compressive strength has increased by 23.56% over plain concrete. At 1.0 kg/m^3 fiber the compressive strength has increased by 11.49% and at 5.0 kg/m^3 fiber the compressive strength has increased by 16.18% respectively. Hence 3.0 kg/m^3 of fiber can be taken as optimum content. Also, it can be observed that on 5.0 kg/m^3 addition of fiber the compressive strength has decreased when compared to that at 3.0 kg/m^3 fiber. This phenomenon is due to the balling effect that takes place due to the increase in the fiber quantity.

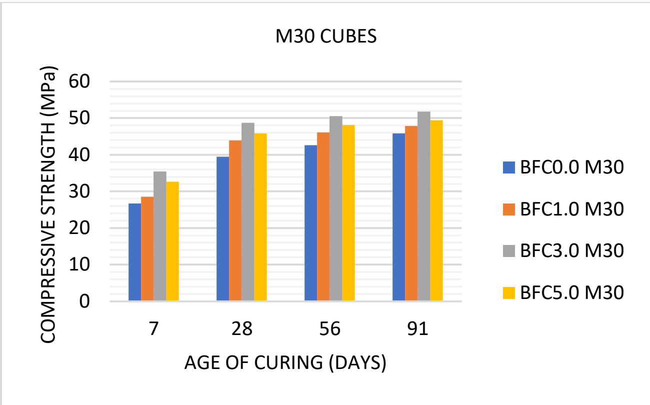

Figure 6. Variation of Compressive Strength for M30 grade of Concrete

5.2.1 Temperature Effect of addition of 3.0 kg/m^3 basalt fiber for M30 mix

From the charts can be observed that with the addition of fiber 3 kg/m^3, the compressive strength has increased by 23.35% over plain concrete. At 100°C the compressive strength has increased by 10.31% and at 300°C the compressive strength has increased by 10.30% respectively.

Table 10. compressive strength (MPa) of M30 Grade Concrete with different proportions of Basalt Fiber for 28 days at room temperature, 100°C, 300°C for 1hour duration.

Mix ID	kg/m^3 of Basalt Fiber	Strength at room temperature (MPa)	Strength at 100°C (MPa)	Strength at 300°C (MPa)
BFC 0.0	0	39.78	42.00	35.17
BFC 3.0	3	49.07	46.33	39.00

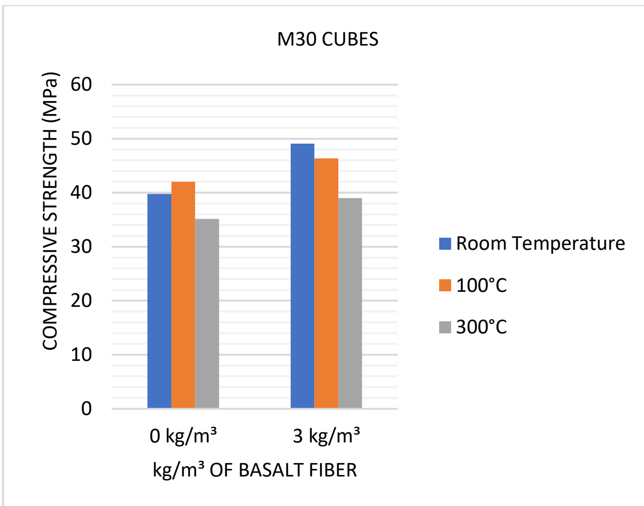

Figure 7. Variation of Compressive Strength for M30 Grade of Concrete at room temperature, 100°C, 300°C.

5.3 Split Tensile Strength

The results of split tensile strength are obtained and are presented in table 11. The variation of split tensile strength with respect to fiber content is shown in figure 8.

Table 11. Split Tensile Strength values

Mix ID	BFC 0	BFC 1	BFC 3	BFC 5
kg/m^3 of Basalt Fiber	0	1	3	5
7 days (MPa)	2.51	2.80	3.08	2.95
28 days (MPa)	3.17	3.38	3.64	3.49
56 days (MPa)	3.36	3.52	3.75	3.58
91 days (MPa)	3.43	3.56	3.82	3.65

From the charts can be observed that with the increase in the quantity of fiber up to 3.0 Kg/m^3, the split tensile strength has increased by 14.85% over plain concrete. At 1.0 kg/m^3 fiber the split tensile strength has increased by 6.62% and at 5.0 kg/m^3 fiber the split tensile strength has increased by 10.09% respectively. Hence 3.0 kg/m^3 of fiber can be taken as optimum content. Also, it can be observed that on 5.0 kg/m^3 addition of fiber the split tensile strength has decreased when compared to that at 3.0 kg/m^3 fiber. This phenomenon is due to the balling effect that takes place due to the increase in the fiber quantity.

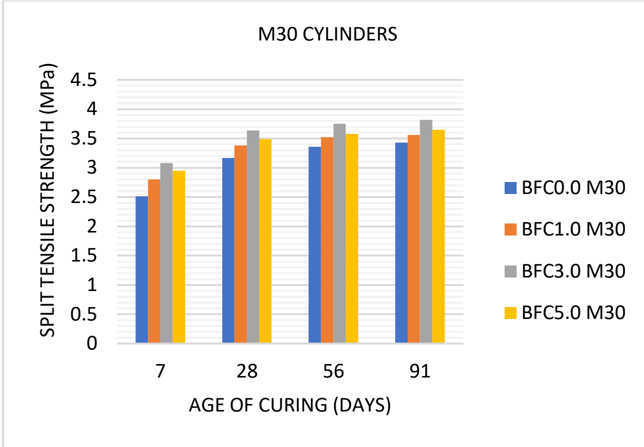

Figure 8. Variation of Split Tensile Strength for M30 grade of Concrete

5.4 Flexural Strength

The results of flexural strength are obtained and are presented in table 12. The variation of flexural strength with respect to fiber content is shown in figure 9.

Table 12. Flexural strength values

Mix ID	BFC 0	BFC 1	BFC 3	BFC 5
kg/m^3 of Basalt Fiber	0	1	3	5
7 days (MPa)	5.27	6.22	6.74	6.48
28 days (MPa)	6.15	6.95	7.63	7.44
56 days (MPa)	6.50	7.15	7.86	7.67
91 days (MPa)	6.78	7.46	8.20	8.00

From the charts can be observed that with the increase in the percentage of fiber up to 3.0 Kg/m^3, the flexural strength has increased by 24.06% over plain concrete. At 1.0 kg/m^3 fiber the flexural strength has increased by 13.01% and at 5.0 kg/m^3 fiber the flexural strength has increased by 20.97% respectively. Hence 3.0 kg/m^3 of fiber can be taken as optimum content.

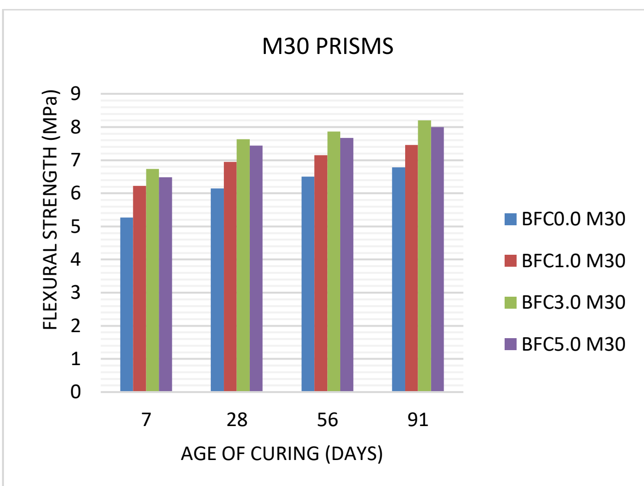

Figure 8. Variation of Flexural Strength for M30 grade of Concrete

5.5 Compressive Strength of Acid Treated Specimens

The comparison of 28 days compressive strength with 91 days acid treated compressive strength with the increase in quantity of basalt fiber for M30 grade concrete were tabulated in the table 13 and is shown in fig.9.

Table 13. Compressive Strength of Acid Treated M30 Grade Cubes with different proportions of Basalt Fiber

Mix ID	BFC 0	BFC 1	BFC 3	BFC 5
kg/m^3 of Basalt Fiber	0	1	3	5
Before Acid Treatment	39.43	43.96	48.72	45.81
After Acid Treatment	37.14	35.08	34.51	33.32

From the graphs we can see that the conventional concrete without basalt fiber gave more resistance to acid treatment than concrete with basalt fiber. For M30 grade concrete the decrease in compressive strength is of order 5.81%, 20.20%, 29.17%, 27.26% for 0 kg/m^3, 1 kg/m^3, 3 kg/m^3, 5 kg/m^3 of basalt fiber respectively.

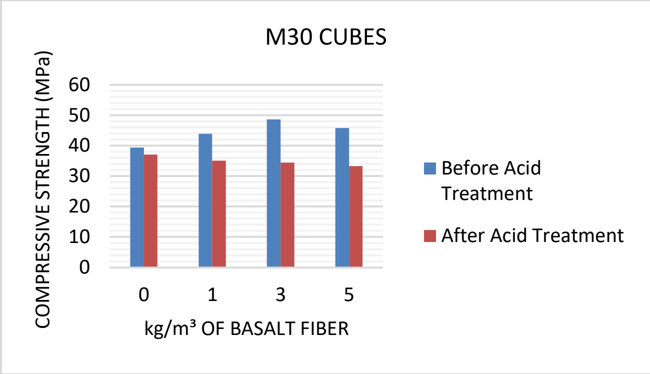

Figure 4.8 Comparison of 28 days compressive strength with 91 days Acid treated compressive strength for M30 Grade concrete.

4.6 Split Tensile Strength of Acid Treated Specimens

The comparison of 28 days split tensile strength with 91 days acid treated split tensile strength with the increase in quantity of basalt fiber for M30 grade concrete were tabulated in the table 14 and is shown in fig.10.

Table 14. Split tensile Strength of Acid Treated M30 Grade Cylinders with different proportions of Basalt Fiber

Mix ID	BFC 0	BFC 1	BFC 3	BFC 5
kg/m^3 of Basalt Fiber	0	1	3	5
Before Acid Treatment	3.17	3.38	3.64	3.49
After Acid Treatment	3.02	2.82	2.65	2.51

From the graphs we can see that the concrete without basalt fiber gave more resistance to acid treatment than concrete with basalt fiber. For M30 grade concrete the decrease in compressive strength is of order 4.73%, 16.57%, 27.19%, 28.08% for 0 kg/m^3, 1 kg/m^3, 3 kg/m^3, 5 kg/m^3 of basalt fiber respectively.

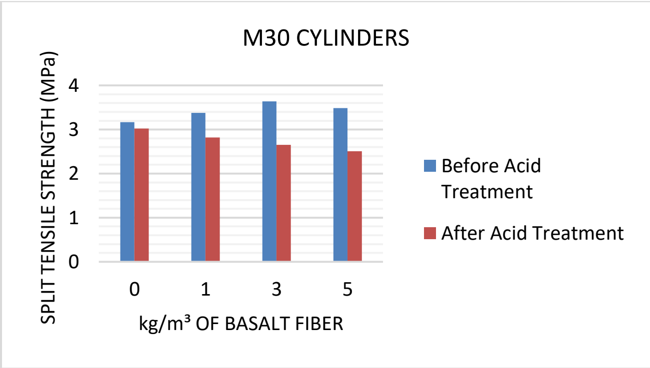

Figure 10. Comparison of 28 days split tensile strength with 91 days Acid treated split tensile strength for M30 Grade concrete.

4.7 Flexural Strength of Acid Treated Specimens

The comparison of 28 days flexural strength with 91 days acid treated flexural strength with the increase in quantity of basalt fiber for M30 grade concrete were tabulated in the table 15 and is shown in fig.11.

Table 15. Flexural Strength of Acid Treated M30 Grade Prisms with different proportions of Basalt Fiber

Mix ID	BFC 0	BFC 1	BFC 3	BFC 5
kg/m^3 of Basalt Fiber	0	1	3	5
Before Acid Treatment	6.15	6.95	7.63	7.44
After Acid Treatment	6.00	5.78	5.54	5.38

From the graphs we can see that the concrete without basalt fiber gave more resistance to acid treatment than concrete with basalt fiber. For M30 grade concrete the decrease in flexural strength is of order 2.44%, 16.83%, 27.39%, 27.69% for 0 kg/m^3, 1 kg/m^3, 3 kg/m^3, 5 kg/m^3 of basalt fiber respectively.

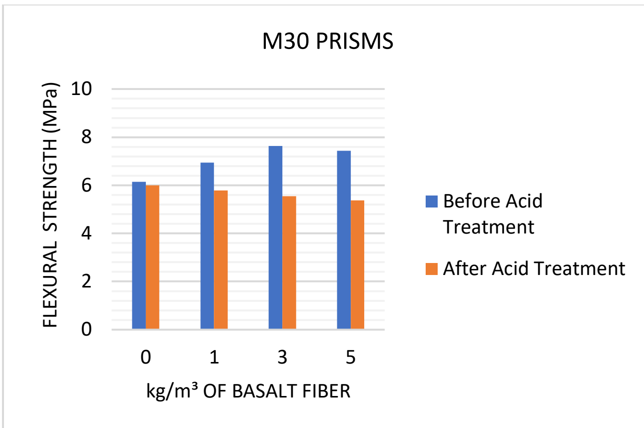

Figure 11. Comparison of 28 days flexural strength with 91 days Acid treated flexural strength for M30 Grade concrete.

5. **Conclusions**

- The workability of concrete measured from slump cone test, as the percentage of basalt fiber increases in mix, the slump value decreases. Hence it can be concluded that with the increase in the fiber content workability decreases.
- The workability of concrete measured from compaction factor test, as the percentage of basalt fiber increases in mix, the compaction factor decreases. Hence it can be concluded that with the increase in the fiber content workability decreases.
- The workability of concrete measured from Vee-Bee test, as the percentage of basalt fiber increases in mix, the Vee-Bee time increases. Hence it can be concluded that with the increase in the fiber content workability decreases.
- From the experimental results, the optimum percentage recommended is 3.0 kg/m^3 basalt fiber for achieving maximum benefits in compressive strength, split tensile strength and flexural strength at any age for the characteristics of basalt fiber reinforced concrete.
- The compressive strength of BFRC M30 mix at 28 days increased with the addition of basalt fiber up to 3.0 kg/m^3 level when compared to that of plain concrete. The maximum percentage increase over plain concrete is 23.56% and the percentage increases ranges from 16.18% to 23.56% over nominal mix for M30 mix.
- The split tensile strength of BFRC M30 mix at 28 days increased with the addition of basalt fiber up to 3.0 kg/m^3 level when compared to that of plain concrete. The maximum percentage increase over plain concrete is 14.85% and the percentage increases ranges from 6.62% to 14.85% over nominal mix for M30 mix.
- The flexural strength of BFRC M30 mix at 28 days increased with the addition of basalt fiber up to 3.0 kg/m^3 level when compared to that of plain concrete. The maximum percentage increase over plain concrete is 24.06% and the percentage increases ranges from 13.01% to 24.06% over nominal mix for M30 mix.
- The maximum percentage increase in the compressive strength of concrete, when the specimens are exposed to 100^{o}C and 300^{o}C for 1 hour. The increase in strength is 10.31% and 10.30% for 28 days.

- The decrease in compressive strength for M30 grade concrete after treating specimens with sulphuric acid for 91 days is of order 5.81%, 20.20%, 29.17%, 27.26% for 0 kg/m^3, 1 kg/m^3, 3 kg/m^3, 5 kg/m^3 of basalt fiber respectively.
- The decrease in split tensile strength for M30 grade concrete after treating specimens with sulphuric acid for 91 days is of order 4.73%, 16.57%, 27.19%, 28.08% for 0 kg/m^3, 1 kg/m^3, 3 kg/m^3, 5 kg/m^3 of basalt fiber respectively.
- The decrease in flexural strength for M30 grade concrete after treating specimens with sulphuric acid for 91 days is of order 2.44%, 16.83%, 27.39%, 27.69% for 0 kg/m^3, 1 kg/m^3, 3 kg/m^3, 5 kg/m^3 of basalt fiber respectively.

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