# A Practical Investigation on the Behaviour of Basalt Fiber Reinforced Concrete

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## Abstract

Concrete made with Portland cement has certain characteristics, it is relatively strong in compression but weak in tension and tends to be brittle. These two weaknesses have limited its use. Another fundamental weakness of concrete is that cracks start to form as soon as concrete is placed and before it has properly hardened. These cracks are major cause of weakness in concrete particularly in large onsite applications leading to subsequent fracture and failure and general lack of durability. The weakness in tension can be overcome by the use of conventional rod reinforcement and to some extent by the inclusion of a sufficient volume of certain fibers. This thesis represent the art of knowledge of basalt fiber, it is relatively new material. Basalt fiber is a high performance non-metallic fiber made from basalt rock melted at high temperature. In the last decade, basalt has emerged as a contender in the fiber reinforcement of composites. Basalt fiber reinforced concrete offers more characteristics such as light weight, good fire resistance and strength. In future it is very beneficial for construction industry. The study on basalt fiber reinforced concretes workability and strength properties of concrete with basalt fibers in proportions of 0, 1, 3 & 5 kg/m$^3$ for M20 and M40 grades at 7,28, 56 and 91 days age of curing can be presented in this thesis.

**Keywords: BFRC, Basal Fiber, Properties of materials, Compressive Strength, split-tensile and flexural strengths**

## I. INTRODUCTION

Plain concrete is weak in tension because it contains numerous micro-cracks. The micro cracks begin to propagate in the matrix when load is applied. Consequently, plain concrete members cannot sustain tensile stresses developed due to the applied forces without the addition of reinforcing elements (re-bar or wire mesh) in the tensile zone. The propagation of micro-cracks and macro-cracks, however, still cannot be arrested by the sole use of continuous reinforcement. The addition of randomly spaced discontinuous fibers help in arresting the propagation of the micro-cracks and macro-cracks. Randomly dispersed fibers in concrete help in reducing the crack width thus, reduces the permeability of concrete. In addition to crack control, fibers also improve the mechanical properties of plain concrete such as fracture resistance, resistance to impact, and resistance to dynamic loads. Basalt fiber is an inorganic material produced from volcanic rock called Basalt. The production of basalt fibers does not create any environmental waste and it is non-toxic in use. Basalt fiber is a unique construction material with high tensile strength, good thermal endurance, and stable in all aggressive environments.

## II. OBJECTIVES OF THE STUDY

The specific objectives of the present investigations are as listed below.

- To conduct feasibility study of producing concrete using basalt Fibers.
- To evaluate the workability characteristics in terms of compaction factor, slump cone and Vee-bee test for M20 and M40 grades of concrete along with basalt fibers (0,1,3 & 5 kg/m$^3$).
- To evaluate the compressive strength at 7, 28, 56 and 91days of Conventional Concrete and BFRC.
- To evaluate the split tensile strength at 7, 28, 56 and 91 days of Conventional Concrete and BFRC.
- To evaluate the flexural strength at 7, 28, 56 and 91 days of Conventional Concrete and BFRC.

## III. EXPERIMENTAL PROGRAM

### A. Materials Used

In this thesis work various materials like Cement, Fine Aggregate ,Coarse Aggregate, water and Basalt fibers were used and their properties are examined by taking the help of IS [INDIAN STANDARD] codes.

*1) Cement*

Ordinary Portland cement of 43 Grade was preferred for this study. The physical properties of cement are categorized in table 1 as per IS 8112-1989.

Table - 1
Properties of Ordinary Portland cement

| *S.No.* | *Particulars of test* | *Test Results* |
|---|---|---|
| *1* | *Standard Consistency* | *33%* |
| *2* | *Initial setting time (min)* | *156* |
| *3* | *Final setting time (min)* | *264* |
| *4* | *Specific gravity* | *3.13* |
| *5* | *Fineness (weight of cement retained on IS 90 µ sieve)* | *8.53 %* |

*2) Fine Aggregate*

The locally available river sand passing through 4.75mm sieve and retained on 600µmsieve, conforming to Zone-II of IS 383-1970 has been used as fine aggregate. The fine aggregate are clean, inert and free from organic matter, silt and clay. The fine aggregate was tested for its physical requirements such as specific gravity, fineness modulus and bulk density in accordance with IS: 2386-1963.

Table - 2
Properties of Fine Aggregate

| *S.No.* | *Particulars of test* | *Value* |
|---|---|---|
| *1* | *Specific gravity* | *2.44* |
| *2* | *Water absorption* | *0.4%* |
| *3* | *Bulk density (kg/m$^3$)* | *1718* |
| *4* | *Fineness modulus* | *2.60* |

*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 is as below, The aggregate was tested for its physical requirements such as specific gravity, fineness modulus and bulk density in accordance with IS: 2386-1963 and IS: 383-1970.

Table - 3
Properties of Coarse Aggregate

| *S.No.* | *Particulars of test* | *Value* |
|---|---|---|
| *1* | *Specific gravity* | *2.76* |
| *2* | *Water absorption* | *0.4* |
| *3* | *Bulk density(kg/m$^3$)* | *1605* |
| *4* | *Fineness modulus* | *6.66* |

*4) Basalt Fibers*

The basalt fibers which i have been choosed were chopped uniformly of 6to 18mm in length. The properties and chemical composition of basalt rock fiber are tabulated in 4 & 5 tables respectively.

Table - 4
Physical Properties of basalt fiber

| *S.No* | *Physical properties* | *Suggested values by supplier* |
|---|---|---|
| *1* | *Colour* | *Golden Brown* |
| *2* | *Diameter* | *13microns* |
| *3* | *Length (mm)* | *6 -18* |
| *4* | *Yield strength (Mpa)* | *>1000* |
| *5* | *Density (g/cm$^3$)* | *2.70* |
| *6* | *Tensile strength(Mpa)* | *3200-3850* |
| *7* | *Working temperature($^o$C)* | *-260$^0$C -+500$^0$C* |

Table - 5
Chemical Composition of basalt fiber

| *S.No* | *Major components* | *% present in basalt rock fiber* |
|---|---|---|
| *1* | *Silicon Dioxide ($SiO_2$)* | *51.6-65%* |
| *2* | *Aluminium Oxide ($Al_2O_3$)* | *17-18.5%* |
| *3* | *Ferric Oxide ($Fe_2O_3$)* | *3-8%* |
| *4* | *Calcium oxide (CaO)* | *5.4-7.8%* |
| *5* | *Magnesium Oxide (MgO)* | *2-3.5%* |

## *B. Concrete Mix Proportion*

The mix design has carried out by following the specifications and limitations of Indian Standard Code (IS 10262-2009).

Table – 6
Mix proportions

| *MIX* | *Cement* | *Fine aggregate* | *Coarse aggregate* | *Water* |
|---|---|---|---|---|
| *M20* | *1* | *2.13* | *3.903* | *0.50* |
| *M40* | *1* | *1.41* | *2.81* | *0.40* |

## IV. RESULTS AND DISCUSSIONS

### *A. Workability:*

The workability of BFRC (basalt fiber reinforced concrete) mixes has been measured by conducting Slump Cone test, Compaction factor test and Vee Bee time test. The experimental results are shown in figures 1, 2 and 3.

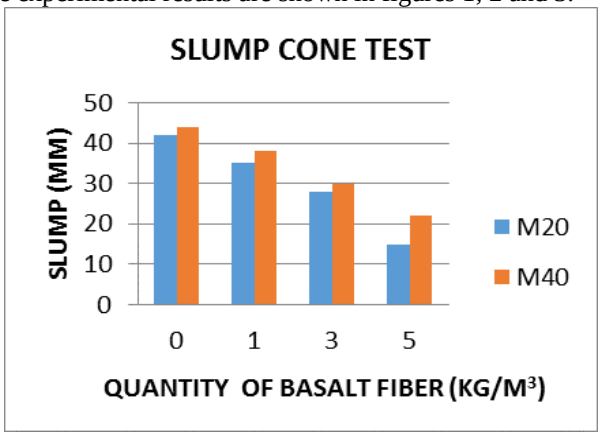


Fig. 1: Variation of Slump for M20 and M40 Grades of Concrete

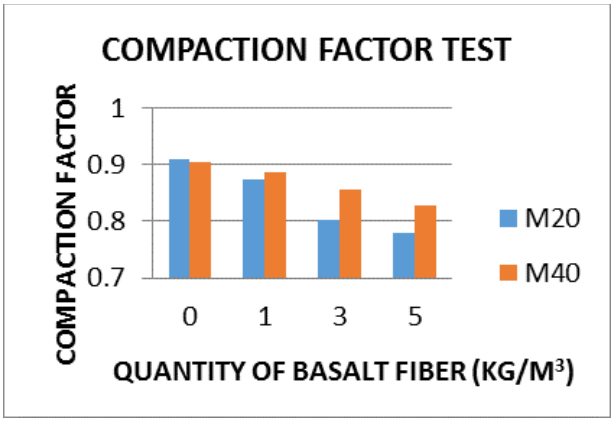


Fig. 2: Variation of Compaction Factor for M20 and M40 Grades of Concrete

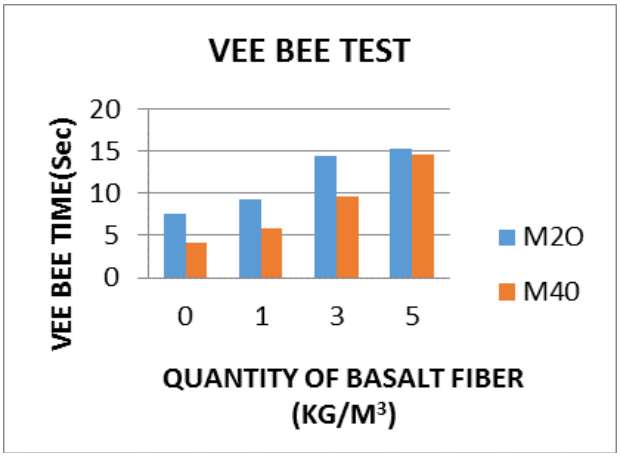


Fig. 3: Variation of Vee-Bee time for M20 and M40 Grades of Concrete

*1) Cube Compressive Strength:*

The compressive strength test is done for cube specimen of sizes 150*150*150 mm for 7, 28,56 and 91 days of curing. The compressive strength results are presented below.

a) Compressive strength of BFRC for M20 Mix

The variation of 28 days compressive strength with increase in quantity of basalt fiber for M20 grade of conventional and BFRC can be presented in figure 4.

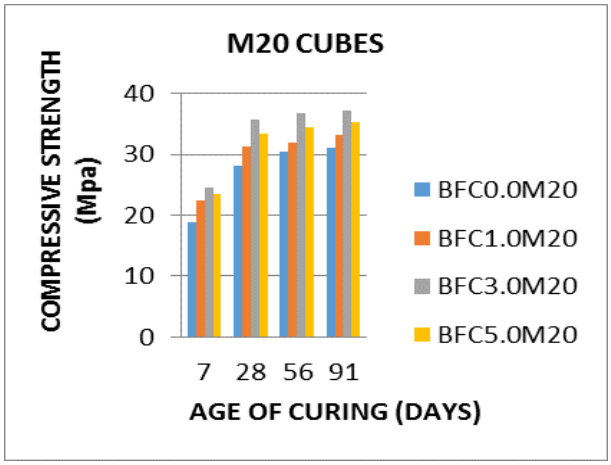


Fig. 4: Variation of Compressive Strength for M20 Grade of Concrete

b) Compressive strength of BFRC for M40 Mix

The variation of 28 days compressive strength with increase in quantity of basalt fiber for M40 grade of conventional and BFRC can be presented in figure 5.

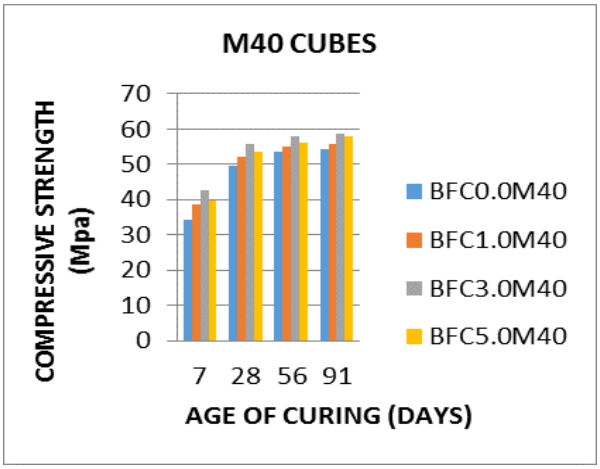


Fig. 5: Variation of Compressive Strength for M40 Grade of Concrete

### *B. Split Tensile Strength:*

The split tensile strength of Conventional concrete and BFRC is observed at 7,28, 56and91 daysFor finding out the tensile strength cylinders of height 300mmand 150mm in diameter are used in this project.

*i) Split Tensile Strength of BFRC for M20 Mix*

The variation of 28 days Split Tensile Strength with increase in quantity of basalt fiber for M20 grade of conventional and BFRC can be presented in figure 6.

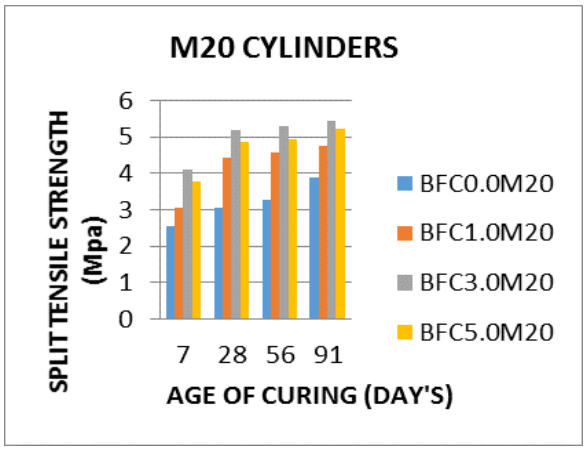


Fig. 6: Variation of Split Tensile Strength for M20 Grade of Concrete

*2) Split Tensile Strength of BFRC for M40 Mix*

The variation of 28 days Split Tensile Strength with increase in quantity of basalt fiber for M40 grade of conventional and BFRC can be presented in figure 7.

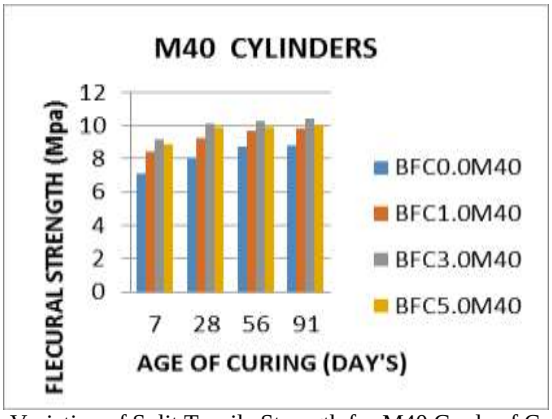


Fig. 7: Variation of Split Tensile Strength for M40 Grade of Concrete

### C. *Flexural Strength:*

The Flexural strength of Conventional concrete and BFRC is observed at 7,28, 56 and91 days For finding out the Flexural strength prims ofsize 150 *100*100 mmare used in this project.

*1) Flexural strength of BFRC for M20 Mix*

The variation of 28 days Flexural strength with increase in quantityof basalt fiber for M20 grade of conventional and BFRC can be presented infigure 8.

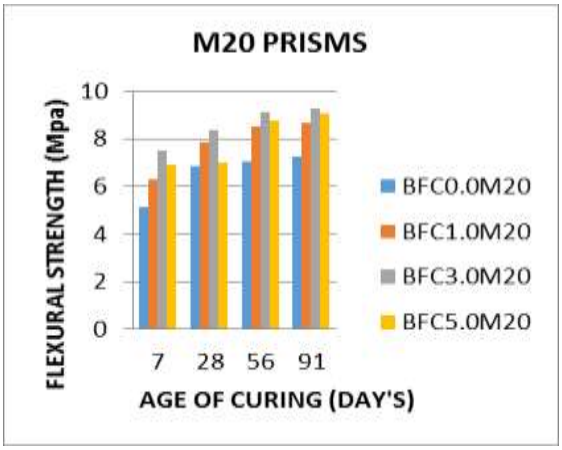


Fig. 8: Variation of flexural Strength for M20 Grade of Concrete

*2) Flexural strength of BFRC for M40 Mix*

The variation of 28 days Flexural strength with increase in quantity of basalt fiber for M40 grade of conventional and BFRC can be presented infigure 9.

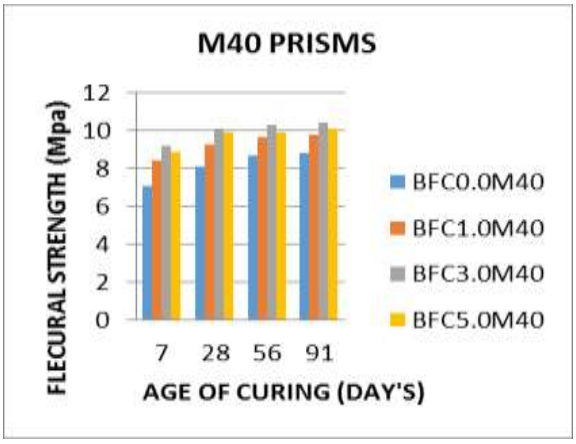


Fig. 9: Variation of flexural Strength for M40 Grade of Concrete

## V. CONCLUSIONS

- In Slump cone test Slump is decreasing when the percentage of Basalt Fiber is increased.
- In Compaction factor test Slump is decreasing when the percentage of Basalt Fiber is increased.
- In Vee Bee test, Vee Bee time is increasing when the percentage of Basalt Fiber is increased.
- For M20 Mix, It was observed that 27.39% of compressive strength has increased for BFRC (Basalt fiber reinforced concrete)with3 kg/$m^3$quantity of basalt fiber over conventional concrete at 28 days age
- For M20 Mix, Split tensile strength of BFRC with 3 kg/$m^3$quantity of basalt fiber has increased by 69.28%when it was compared with conventionalconcrete at 28 days age.
- For M20 Mix, Flexural strength of BFRC with 3 kg/$m^3$quantity of basalt fiber has increased by 21.83%when it was compared with conventionalconcrete at 28 days age.
- For M40 Mix, It was observed that12.43% of compressive strength has increased for BFRC (Basalt fiber reinforced concrete)with3 kg/$m^3$quantity of basalt fiber over conventional concrete at 28 days age
- For M40 Mix, Split tensile strength of BFRC with 3 kg/$m^3$quantity of basalt fiber has increased by 57.38%when it was compared with conventional concrete at 28 days age.
- For M40 Mix, Flexural strength of BFRC with 3 kg/$m^3$quantity of basalt fiber has increased by 25.24%when it was compared with conventional concrete at 28 days age.

## NOTATIONS

- FRC - Fibre Reinforced Concrete
- BFC0.0M20 - M20 Grade of Concrete with 0.0 kg/$m^3$ Basalt fibre
- BFC1.0M20 - M20 Grade of Concrete with 1.0 kg/$m^3$ Basalt fibre
- BFC3.0M20 - M20 Grade of Concrete with 3.0kg/$m^3$ Basalt fibre
- BFC5.0M20 - M20 Grade of Concrete with 5.0 kg/$m^3$ Basalt fibre
- BFC0.0M40 - M40 Grade of Concrete with 0.0 kg/$m^3$ Basalt fibre
- BFC1.0M40 - M40 Grade of Concrete with 1.0 kg/$m^3$ Basalt fibre
- BFC3.0M40 - M40 Grade of Concrete with 3.0 kg/$m^3$ Basalt fibre
- BFC5.0M40 - M40 Grade of Concrete with 5.0 kg/$m^3$ Basalt fibre
- BFRC - Basalt Fiber Reinforced Concrete

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