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*Research Article*

# Effect of Basalt Fiber on Strength of Cement Concrete

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***Abstract***

*Cement concrete is weak in tension limited ductility and little resistance to cracking, as the cement holding the aggregate can crack, causing concrete to break. An effective way to improve the tensile strength of concrete and reduce the number of defects is by adding different fractions of small, closely spaced and randomly oriented fibers, dispersed uniformly in the matrix. The present work focuses on investigation of characteristic of M40 grade concrete with various proportions of basalt fiber. M40 grade of concrete is prepared with water cement ratio 0.38 to study the effect of basalt fiber on compressive strength, flexural strength and split tensile strength. The concrete specimens were casted using basalt fiber of 18 mm length and varying fiber dosage from 0% to 5 % by weight of cement at interval of 1%. All specimens were cured in water tank for 28 days. It provided the significant improvement in flexural and split tensile strength with the inclusion of basalt fibers in plain concrete. However maximum gain in different characteristic of concrete is found to be dependent upon the amount of fiber content.*

***Keywords:*** *Basalt fiber, FRC, compressive strength, split tensile strength, flexural strength.*

## 1. Introduction

Concrete is known as the construction material most used around the world. It is strong in compression as the aggregates can effectively carry the compression load. However, concrete is weak in tension limited ductility and little resistance to cracking, as the cement holding the aggregate can crack, causing concrete to break. Internal micro crack are inherently present in the concrete and its poor tensile strength s due to the propagation of such micro cracks, eventually leading to brittle fracture of concrete(ACI, 1982) .

An effective way to improve the tensile strength of concrete and reduce the number of defects is by adding different fractions of small, closely spaced and randomly oriented fibres, dispersed uniformly in the matrix. Fibres can enhance the concrete strength, which enables the construction to withstand external forces.

Basalt is a volcanic igneous rock which performs well in terms of strength, temperature range, and durability. Basalt fibres are obtained from basalt rocks through melting process. It is known that the basalt fibres have better tensile strength than the E-glass fibres, greater failure strain than the carbon fibres as well as good resistance to chemical attack, impact load and fire with less poisonous fumes (Ahmet, 2015). Previous study showed that inclusion of basalt fiber in concrete get significantly improved the flexural strength, tensile strength, reduce brittleness. Tehmina *et.al* (2013) studied mechanical properties of high-performance concrete reinforced with basalt fibers. Research showed that the addition of basalt fibers up to 2% fiber volume together with mineral admixtures improved the compressive strength. The improvement in the strains corresponding to maximum compressive strength and splitting tensile strength results was observed at all fiber volumes.

There is limited study available on basalt fiber reinforced concrete. This study will help to understand the effect of addition of basalt fiber on hardened properties of concrete.

## 2. Materials and mix proportion

IS 10262:2009 is used for mix design of M40 grade of concrete. The mix proportion of concrete for grade M40 was 1: 2.52: 0.68: 1.02:.0.38 (Cement: Fine aggregate: Coarse aggregate 20 mm: CA 10 mm: Water). The quantity of ingredient material and mix proportion as per design is shown in Table 1

For experimental work 53 grade Portland cement has been used confirming to IS 12269:2013. Drinking water has been used for preparing concrete mix design. The water cement ratio of the concrete is kept constant at 0.38 for all mixes. To maintain workability sulphonated naphthalene formaldehyde plasticizer was used at varying dosage. Locally available crushed basalt coarse aggregate of 10 and 20 mm in size with 2.6 specific gravity and angular in shape used for mix proportion. Natural river sand with specific gravity 2.8

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and fineness modulus 2.9 confirming zone II used for concreting.

**Table 1** Mix proportion for concrete

| Sr. No. | Material | | Proportion by Weight | Weight in kG/m$^3$ |
|---|---|---|---|---|
| 1 | Cement | | 1 | 396 |
| 2 | Fine aggregate | | 2.52 | 1001.19 |
| 3 | Coarse aggregate | 20 mm | 0.68 | 302.11 |
| | | 10 mm | 1.02 | 453.16 |
| 4 | Water | | 0.38 | 146.2 |
| 5 | Plasticizer | | 0.02 | 7.92 |

**Table 2** Properties of basalt fiber

| Sr. No. | Properties | Results |
|---|---|---|
| 1 | Length of fiber | 18 mm |
| 2 | Thickness | 16 micrometer |
| 3 | Aspect ratio | 1125 |
| 4 | Modulus of Elasticity | 89 GPa |
| 5 | Tensile strength | 2000-2840 MPa |
| 6 | Elongation at break | 3.15% |
| 7 | Specific gravity | 2.8 |

**Fig.1** Basalt Fiber

## 3. Test setup and procedure

In present study compression test and non destructive testing on cube, flexure test on beam and split tensile test on cylinder are carried out on number of specimen

### *3.1 Compressive Test*

The test was carried out as per IS 516:1959. Tests were conducted in compression testing machine with a capacity of 2000 kN. Test set up is shown in Figure 2 The compressive strength of specimen was calculated by formula

$$f_{cu} = \frac{Pc}{A} \quad (1)$$

### *3.2 Split Tensile Test*

In this investigation, the test was carried out on the cylinder by splitting along its middle plane parallel to the edge by applying the compressive load to apposite edges. The test was carried out as per IS 5816:1999. Test set up is shown in Figure 3. Split tensile strength of cylinder is calculated by equation

$$f_t = \frac{2Ps}{\pi DL} \quad (2)$$

**Fig.2** Test setup for compression test

**Fig. 3** Test setup for splitting tensile test

### *3.3 Flexural Test*

To find out flexural strength of concrete, prism specimens of size 150 mm x 150 mm X 700 mm are used. The test was carried out as per IS 516:1959. The arrangement for loading of flexure test specimen is shown in Figure 4

The flexural strength of the specimen shall be expressed as the modulus of rupture ($f_{cr}$) and calculated by using following expression

$$f_{cr} = \frac{Pl}{bd^2} \quad (3)$$

**Fig. 4** Test setup for flexural test

## 4 Results and discussion

### *4.1 Compressive strength*

Compression strength of nominal concrete and basalt fiber reinforced concrete has been calculated by equation 1. Results have mentioned in Fig 5. It is observed that percentage increase in compressive strength is 7.31% for 3 % basalt fiber content. Compressive strength increases up to 3% basalt fiber content, and then it gets decrease beyond 3 % basalt fiber content.

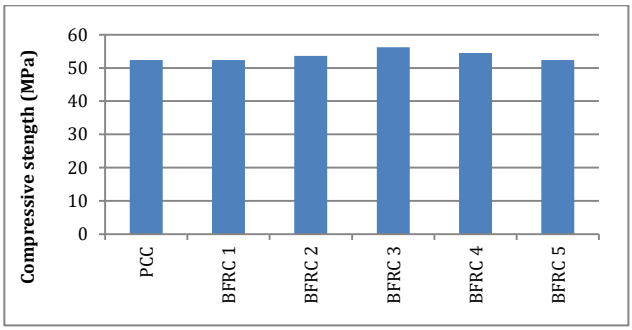


**Fig. 5** Effect of basalt fiber on compressive strength concrete

*4.2 Split tensile strength*

Results of split tensile strength obtained from equation 2 and results are presented in Fig. 6. split strength increases continuously with increase in percentage of basalt fiber up to 4% basalt fiber content, beyond that it decreases. Split tensile strength is maximum for 4 % basalt fiber content is 33.6%.

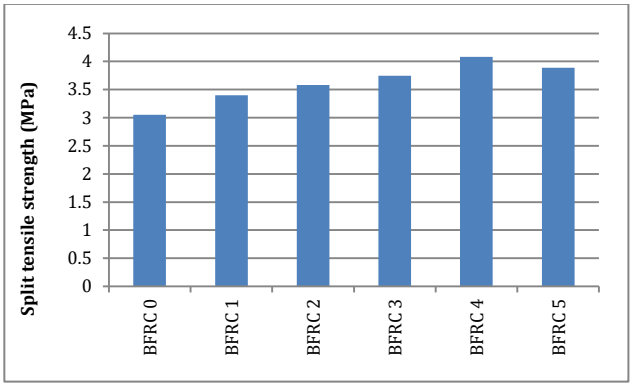


**Fig. 6** Effect of basalt fiber on splitting tensile strength of concrete

*4.3 Flexural strength*

The flexural strength ($f_{cr}$) of normal concrete and basalt fiber reinforced concrete is obtained from using equation 3.

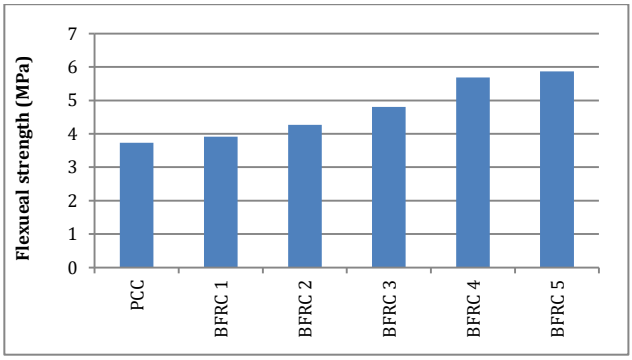


**Fig. 7** Effect of basalt fiber on flexural strength of concrete

The results of flexural load are shown in Fig. 7. It is observed that 28 days flexural strength increases continuously up to 5 % basalt fiber. As compared to normal concrete 57.14 % increases in flexural strength for 5% basalt fiber

## Conclusions

1) The maximum increase percentage in compression strength is 7.31% for 3 % basalt fiber content. There is no significant increase in compressive strength of concrete due to inclusion of basalt fibers.
2) The addition of basalt fiber resulted increase in flexural strength. Flexural strength increase with percentage of basalt fiber increases. Flexural strength is increased by 57.14 % for 5 % basalt fiber
3) Split tensile strength is increased by 33.6% for 4 % basalt fiber content.
4) There is significant improvement in flexural and split tensile strength with the inclusion of basalt fibers in plain concrete. However maximum gain in the different strength of BFRC is found to be dependent upon the amount of fiber content.

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