

Optimized Proportion of Basalt Fiber in Concrete

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Abstract - The use of fibers produced by molten basalt rock has gained in the last years an increasing interest, as a result of the good physio-chemical properties that can be achieved. Fiber concrete is a most widely used for improving compressive and flexural strength of concrete. Various types of fibers such as steel, polypropylene, carbon, glass and polyester are generally used in concrete. In this study, the effect of inclusion of basalt fibers on the compressive strength, flexural and splitting tensile strength of fiber concrete was studied. The influence of addition of 0.1, 0.2, 0.3, 0.4, and 0.5%. Basalt Fiber volume fraction in five different mixes of total volume of concrete is investigated and compared it with conventional concrete. Basalt fiber volume together with concrete improved the compressive strength and flexural strength. In the corresponding to maximum compressive and Flexural strength results was observed at fiber volume which gives maximum compressive strength, whereas there is a negligible influence of the fiber addition on the splitting tensile strength. The overall test result shows that Basalt Fiber could be utilized in concrete which improves the mechanical properties of concrete.

Key Words: 1) Basalt fiber, 2) Basalt fiber reinforced concrete, 3) Compressive strength, 4) Splitting tensile strength 5) Flexural strength

1. INTRODUCTION

Basalt fiber has recently gained popularity in concrete applications due to its environmentally friendly manufacturing process and excellent mechanical properties. Basalt fibers are relatively cheaper and new fibers for concrete recently investigated by a few researchers. [6] In fact, basalt fibers exhibit good strength and stiffness properties also at high temperatures, long-term durability, high acid and solvent resistance, low water absorption, remarkable heat and sound insulation properties, good process ability, as well as their fabrication process is generally significantly cheaper than carbon and glass fibers.

Basalt rock fibers have no toxic reaction with air or water, are non-combustible and explosion proof. Basalt fiber has good hardness and thermal properties. The Basalt fiber and material on their basis have the most preferable parameter a ratio of quality and the price in comparison with glass fiber, steel fiber, carbon fiber and other type fiber. In this study, influence of addition of 0.1, 0.2, 0.3, 0.4, and 0.5% Basalt Fiber volume fraction in five different mixes of total volume of concrete is investigated and

compared it with conventional concrete. Concrete mixtures were prepared for different proportions of Basalt Fiber ranging from 0.1 to 0.5% with an increment of 0.1% of each and tested for compressive strength of 3,7 and 28 days of curing and proportion which gives maximum compressive strength checked for Tensile, and Flexural strength after 28 days of curing.

1.1 OBJECTIVES OF INVESTIGATION

Experiment was conducted on concrete prepared by conventional concrete by using basalt fiber to changing the volume of basalt fiber in concrete by ranging from 0.1 to 0.5% with an increment of 0.1%. The main objectives of this investigation as follows: -

- 1) To check mechanical properties of concrete by use of chopped basalt fiber.
- 2) To get optimized proportion of the chopped basalt fiber in concrete.
- 3) Comparing the performance of the conventional concrete with the basalt fiber reinforced concrete.

1.2 MATERIALS

The material details are as follows:

A. Cement

For this research, locally available cement which is of the ordinary Portland cement type (53 grade) was used throughout the work. Specific gravity of cement was 3.10

B. Fine Aggregates

Locally available crushed sand used was 4.75 mm size confirming to zone III with specific gravity 2.65. The testing of sand was conducted as per IS: 383-1970. Water absorption and fineness modulus of fine aggregate was 2.08 % and 3.29 respectively.

C. Course Aggregates

Coarse aggregate used was 20 mm and less size with specific gravity 2.88. Testing of coarse aggregate was conducted as per IS: 383-1970. Water absorption of coarse aggregate was 1.26 %.

D. Water

The water used was potable, color less and odour less that is free from organic impurities of any type.

E. Basalt Fiber

In this experiments basalt fiber having Length 12 mm and diameter is 13 micron size was used. Chemical properties of Basalt Fiber are tabulated as follows

Table No 1

Physical Properties of Basalt Fiber		
Sr.No	Properties	Value
1.	Tensile Strength (MPa)	3100-4840
2.	Modulus of Elasticity (GPa)	85-95
3.	Iron Oxide (gm/cm ³)	2.8
4.	Elongation at break (%)	3.15

Table No 2

Chemical Properties of Basalt Fiber		
Sr.No	Composition	Basalt Fiber %
1.	Silicon Dioxide (SiO ₂)	52.8
2.	Aluminum Oxide (Al ₂ O ₃)	17.5
3.	Iron Oxide (Fe ₂ O ₃)	10.3
4.	Magnesium Oxide (MgO)	4.63
5.	Calcium Oxide (CaO)	8.60
6.	Sodium Oxide (Na ₂ O)	3.42
7.	Titanium (TiO ₂)	1.20

2. EXPERIMENTAL WORK AND TEST

A. Mix Design

Mix design carried out for M30 grade of concrete by IS 10262:2009, having mix proportion of 1:1.41:2.50 with water cement ratio of 0.4. The Basalt fiber can be used total volume of concrete by 0.1 % to 0.5 % at an increment of 0.1% each. Chemical admixtures are not used in the work.

B. Compressive, Flexure and Split Tensile strength

Concrete prepared with different percentage of total volume of concrete by 0.1 % to 0.5 % at an increment of 0.1% each was cured under normal condition as per recommendations of IS and were tested at 3 days, 7 days and 28 days for determining the compressive, flexural and split tensile strength compared with the test results of conventional concrete.

3. TEST RESULTS

A. Compressive Strength

Three cubes of size 150 mm x150 mm x150 mm were casted to work out the 3rd, 7th and 28th day's compressive strength of all the proportions. The table III gives the results of test conducted on hardened concrete with 0 - 0.5 % Basalt Fiber for 3 days, 7days and 28 days.

Table No 3

Experimental test results for Compressive Strength			
% of Basalt Fiber	3 Days	7 Days	28 Days
0	16.67	24.29	43.28
0.1	16.74	25.33	43.55
0.2	17.47	25.85	43.70
0.3	18.51	26.67	44.00
0.4	18.81	26.96	45.33
0.5	18.07	26.50	42.73

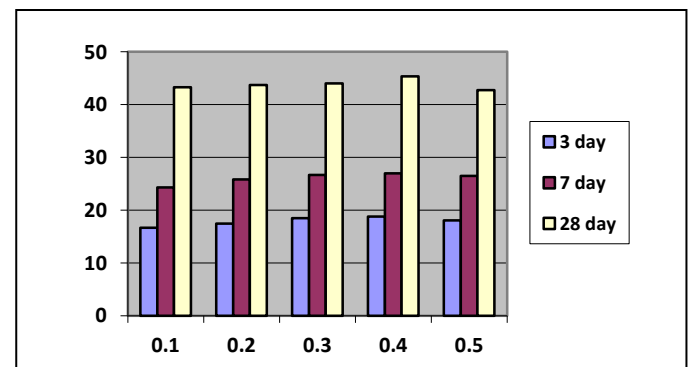


Fig.1. Comparative Compressive Strength of Concrete with Basalt Fiber

It is clear from table 3 compressive strength obtained for concrete with 0.4 % basalt fiber by total volume of concrete showed a higher value by 11.37 % compared to conventional concrete for 3 days, 9.90 % compared to conventional con. For7 days and 4.52 % compared to conventional concrete for 28 days.

B. Flexural Strength

Three beam section of size 100 mm x 100 mm x 500 mm without mix and having 0.4 % were casted and cured for 28 days. The flexural strength is determined by the Formula:

$$fcr = PfL / bd^2 \text{ or } 3Pf a / bd^2$$

Where,

fcr = Flexural strength, MPa

Pf = Central load through two point loading system, N

L = Span of beam, mm

b = Width of beam, mm

d = Depth of beam, mm

a = distance between line of fracture to the nearest support, mm.

The table IV gives the results of test conducted on hardened concrete with 0 - 0.5 % Basalt Fiber for 28 days.

Table No 4

Experimental test results for Flexural Strength	
% of Basalt Fiber	28 days
0 %	9.30
0.4 %	11.90

It is clear from Table No 4 Flexural strength obtained for concrete with 0.4 % Basalt fiber by total volume of concrete showed a higher value by 21.84 % compared to conventional concrete for 28 days.

C. Split Tensile Strength

Three cylindrical sections of diameter 150 mm and length 300 mm without mix and having 0.4 % were casted and cured for 28 days. The split tensile strength of cylinder is calculated by the following formula:

$$f_{cys} = 2P_{sp} / \pi D L$$

Where,

f_{cys} = split Tensile strength, MPa

P_{sp} = Load at failure, N

L = Length of cylinder, mm

D = Dia. Of cylinder, mm

The table VI gives the results of test conducted on hardened concrete with 0 - 0.5 % Basalt Fiber for 28 days.

Table No 5

Experimental test results for Split Tensile Strength	
% of Basalt Fiber	28 days
0 %	3.20
0.4 %	3.65

It is clear from Table No 5 Flexural strength obtained for concrete with 0.4 % Basalt fiber by total volume of concrete showed a higher value by 12.32 % compared to conventional concrete for 28 days.

4. CONCLUSIONS

Based on experimental observations, following conclusions can be established:

- 1) Basalt Fiber concrete increases the compressive strength, flexural and tensile strength as compared with the conventional concrete.

- 2) From strength point of view, Conventional concrete by using basalt fiber shows positive results.
- 3) It was found from the failure pattern of the specimens, that the formation of cracks is more in the case of concrete without fibers than the basalt fiber concrete.

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