Compressive and Split Tensile Strength of Chopped Basalt Fiber Concrete

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Abstract - *In this paper, there is investigation of the compressive and split tensile strength of chopped basalt fiber reinforced concrete of M20 grade concrete. A coir fiber, glass, steel, polypropylene, polyester fibers are used in concrete to gain strength to the concrete. In this study, the compressive and splitting tensile strength was studied after introducing chopped basalt fibers. In this research, 12 mm long and 13 µm in diameter basalt fibers were used as well as the cubes and cylinders have casted with basalt fiber reinforced concrete for 0.5 %, 1.0% and 1.5% of basalt fibers by the weight of cement along with ordinary concrete. The compressive and split tensile strengths are carried out on cubes and cylinders by using Compressive Testing Machine (CTM) and Universal Testing Machine (UTM). And lastly all the results were compared and analyzed with ordinary concrete, and it shows that, basalt fiber reinforced concrete will improves the compressive and split tensile strength of the concrete.*

Key Words: Chopped Basalt Fiber, Basalt Fiber Concrete, Compressive Strength, Split Tensile Strength etc.

1. INTRODUCTION

Basalt fiber is natural material and originates from volcanic rock, which is melted at temperature of 1450 ° C and rapidly drawn into a continuous fiber. It then can be chopped into required lengths. The basic characteristics of Basalt materials are high-temperature resistance, high corrosion resistance, resistance to acids and alkalis, high strength and thermal stability. Basalt materials can be used as a reinforcing composite material for the construction industry, specifically as a less expensive alternative to carbon fiber. In addition to high specific strength, high specific modulus, Basalt Fiber also has excellent temperature resistance, anti-radiation, thermal and sound insulation, anti-compression strength and high shear strength, high availability, and good cost performance.

Basalt fiber is easy to disperse when mixed with cement concrete. Fresh concrete with basalt fibers has important characteristics like good workability, good stability, excellent thermal resistance, anti-seepage, crack resistance and impact resistance. It is found in nature as an inorganic non-metal material, and is a new basic material and high-tech fiber that can satisfy the demand for the development of basic infrastructures.

2. LITERATURE REVIEW

Krassowska and Lapko [1] concluded that the test results of models of BFRC beams showed a distinct increase in flexural and shear capacity as compared to the beams without fibers.

Jiang et al. [2] concluded that as compared with the plain concrete, concrete reinforced with Basalt fibers have high flexural strength and tensile strength. But the compressive strength of concrete reinforced by Basalt fibers increases slightly at the early age and even decreases at the late age.

Abdulhadi [3] studied the effect of Basalt and Polypropylene Fibers with different volumes and concluded that the compressive strength for C30 grade of concrete from two different type of fiber at different volume fraction shows different degree of reduction. The addition of 0.3%, 0.6%, 0.9% and 1.2% resulted in a decrease of compressive strength relative to plain concrete by 9%, 19%, 1%, and 18% respectively. Similarly, addition of 0.3%, 0.6%, 0.9%, and 1.2% volume of polypropylene resulted in a decrease of strength relative to plain concrete by 8%, 7%, 17% and 24% respectively. It was observed that the incorporation of fibers in the concrete matrix greatly increases splitting tensile strength. The addition of 0.3% and 0.6% volume of basalt fiber increase the splitting tensile strength of concrete by 2.6% and 22.9% respectively; while for 9% and 1.2% volume, the splitting tensile strength of concrete decreased by 11.3% and 19.8% respectively; therefore, the optimum dosage for the splitting tensile strength of basalt fiber is in the vicinity of 0.6%. Also, addition of 0.3%, 0.6%, and 0.9%, volume of polypropylene fiber increase the splitting tensile strength of concrete by 15.1%, 7.8%, and 5.6% respectively; therefore, the optimum dosage for the splitting tensile strength of polypropylene fiber is in the vicinity of 0.3%.

Smriti et al. [4] investigated that for incorporating basalt fiber into composite mix, there is decrease in workability and increase in density as volume fraction of fiber increases. Experimental results showed increase in compressive strength for basalt fiber reinforced composite. Among four different volume fraction of basalt fiber 0.3%,0.5%, 1% and 2%,optimal volume fraction has been found as 0.5% which showed 12% increase in compressive strength. Although mode of failure is nearly same for specimen with and without fiber, but modulus of Elasticity for basalt fiber reinforced composite is higher than composite mix alone. Yet many more experimental investigation needs to be done for showing the effect of basalt fiber on compressive strength enhancement and to get complete ascending and descending branch of stress-strain curve for basalt fiber reinforced composites.

George et al. [5] Studied that, the basalt fiber inclusion enhanced the split tensile and flexural strength of concrete. Through the SEM (Scanning Electron Microscope) analysis, it is confirmed that the rod like structure of basalt fiber observed at the interface of cementitious and aggregate matrix could probably be the reason for the increased split tensile and flexural strength of concrete, as it bridges or connects the weak and strong matrix upon loading. However, the quantitative nature of this benefit is difficult to determine, as it is required to conduct further studies to prove.

Irine [6] concluded that the workability of concrete decreases with the addition of Basalt Fibers. But this difficulty can be overcome by using plasticizers or super-plasticizers. The percentage increase of compressive strength of basalt fiber concrete mix compared with 28 days compressive strength of Plain Concrete is observed as 14%. The percentage increase of split tensile strength of basalt fiber concrete mix compared with 28 days compressive strength of Plain Concrete is observed as 62%. The flexural strength of basalt fiber concrete is also found have a maximum increase of 54% at 4kg/m3 of fiber content. It was observed that, the percentage increase in the strength of basalt reinforced concrete increases with the age of concrete. Also it was found from the failure pattern of the specimens, that the formation of cracks is more in case of concrete without fibers than the basalt fiber reinforced concrete. It shows that the presence of fibers in the concrete acts as the crack arrestors. The ductility characteristics have improved with the addition of basalt fibers. The failure of fiber concrete is gradual as compared to that of brittle failure of plain concrete.

3. EXPERIMENTATION

The main objectives has obtained by casting 36 no. of concrete cubes (150mm x150mm x 150mm) for compressive strength, 36 nos. cylinder (150mm x300mm) for split tensile test. All the specimens were casted as per IS specifications. After casting the M-20 grade concrete, specimen were demoulded and specimens were kept for a period of 7,14 and 28 days in the curing tank. The mix ratio of M20 grade of concrete is given in Table 1.

Table -1: Quantity of Materials Per Cubic Meter of Concrete

Material	Proportion by Weight	Weight in Kg/m³
Cement	1	424.50
Fine Aggregate	1.42	677.50
Coarse Aggregate	2.36	1115.45
W/C ratio	0.40	178

3.1 Materials

The materials used for preparing a concrete mix were describe below-

3.1.1 Cement

In the present work 53 grade J.K. super cement is used for casting of cubes and cylinders. The cement has uniform greenish grey colour and is free from lumps.

3.1.2 Sand

The sand used for the experimental work indicates zone I grading. It is sieved through 4.75mm sieve to remove greater particles.

3.1.3 Coarse aggregate

Local available coarse aggregate having size of 20 mm was used in this work.

3.1.4 Water

In the present investigation, tap water is used for both mixing and curing purposes.

3.1.5 Basalt fiber

Basalt fiber is a material made from extremely fine fibers of basalt. The fibers used in the study are of 13 μm in diameter and 12 mm in length shown in fig.1.

Fig -1: Basalt Fibers

Fibers used for this work are 0.5 %, 1.0% and 1.5% by the weight of cement. Some of the properties of basalt fiber are give in Table 2.

Table -2: Physical properties of Basalt fiber

Sr. No.	Property	Value
1.	Diameter	13μm
2.	Length of fiber	12mm
3.	Appearance	Golden Brown
5.	Tensile strength	4840 MPa
6.	Modulus of elasticity	89000 MPa
7.	Specific gravity	2700 Kg/m^3

4. TEST PROCEDURE

4.1 Compression test

Compression strength of concrete with and without basalt was conducted for 7, 14 and 28 days. The load was applied and increased continuously till the formation of first crack. The maximum load applied to the cube specimens were recorded. Mean of three values was taken as the compressive strength of the specimen.

The experimental set up for this is shown in Figure 2. The compressive strength of cube can be calculated by using following formula-

$$Fc = \frac{P}{A}$$

Where,

Fc = Compressive strength of cube in MPa.

P = Load at failure in N.

A = Loaded area of cube in mm^2

Fig -2: Set up for compression test

4.2. Splitting Tensile Test

This test is conducted as recommended in IS 5816:1999.The dimensions of cylinder is 300 mm in length and 150 mm in diameter. The specimen were kept in water for curing for the period of 7, 14 and 28 days and then tested. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder. The maximum load applied to each specimen was recorded and average of three values was taken as the split tensile strength. Figure 3 shows the testing of split tensile test.

The split tensile strength of cylinder is calculated by the following formula –

$$F_t = \frac{2P}{\pi LD}$$

Where,

F_t = Tensile strength in MPa.

P = Load at failure in N.

L = Length of cylinder in mm.

D = Diameter of cylinder in mm.

Fig -3: set up for split tensile test.

5. RESULTS

5.1. Compressive Strength

The results of compressive strength are obtained and are presented Table 3. The variation of compressive strength with respect to fiber content is shown in Chart-1.

Table -3: Compression Strength Values

Sr. No.	Mix designation	Fiber Content (%)	Compressive strength (MPa)		
			7 Days	14 Days	28 Days
1.	M0	0.0	26.91	29.36	32.55
2.	M1	0.5	30.70	33.11	36.87
3.	M2	1.0	28.72	32.40	36.18
4.	M3	1.5	28.74	31.75	34.85

The above Results of compressive strength shows the optimum content of fiber, which give maximum strength at 28 days is 0.5%. The percentage of increase in strength at these percentages of fibers over normal concrete at 7, 14 and 28 days is 14.08%, 12.77% and 13.27% respectively at 0.5%. After optimum level, there is decrease in compressive strength which indicates air entrapment in the concrete due to addition of high fiber content.

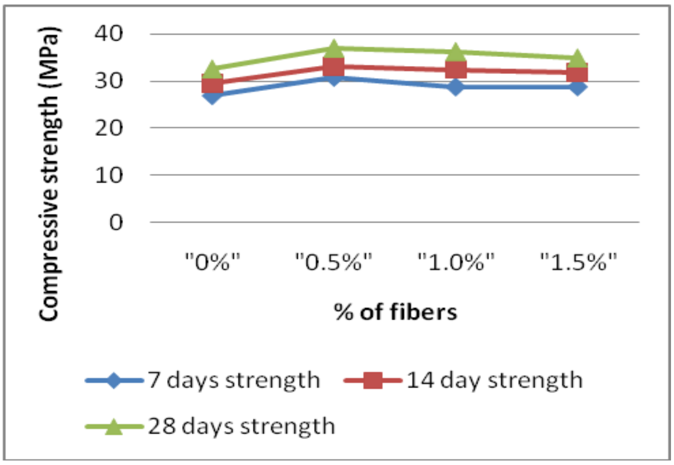

Chart -1: Compressive strength test results

The 7, 14 and 28 days variation of compression strength with respect to fiber content is represented in Chart-1.

5.2. Split tensile Strength

The results of Split tensile strength are obtained and are presented Table 4. The variation of Split tensile strength with respect to fiber volume fraction is shown in Chart -2.

Table -4: Split tensile Strength Values

Sr. No.	Mix designation	Fiber content (%)	Split Tensile Strength (N/mm^2)		
			7 Days	14 Days	28 Days
01.	M0	0.0	2.78	2.85	2.92
02.	M1	0.5	2.91	3.02	3.25
03.	M2	1.0	3.02	3.19	3.36
04.	M3	1.5	3.19	3.35	3.51

From Table 4, It indicates the optimum volume fraction of fibers which give maximum strength at 28 days is 1.5 %. The maximum increase in split tensile strength is 14.75% for 7 days, 17.54% for 14 days and 20.20% for BFRC at 28 days.

The split tensile strength increases up to 1.5% fiber content. This variation in split tensile strength may due to degree of compaction, mix proportion, size of aggregate, loading rate during test procedure, etc.