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STUDY OF SILICA FUME AND BASALT FIBER REINFORCED CONCRETE

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ABSTRACT

Now - a - days , In the construction industry world , use of alternative sources as construction material is recent trend which can be substitute the virgin material in order to reduce environmental influence such as pollution , energy consumption , global warming , waste disposal , etc . Thus recycled concrete aggregate (RCA) from construction and demolition waste plays an important role to preserve natural resource is growing interest in the construction industry as it reduces the demand of virgin aggregate . The use of concrete deficiencies to certain extend like brittleness , poor tensile strength and poor resistant to impact strength , fatigue , low ductility and low durability is found in concrete structure .To overcome this , admixtures and fibers like basalt , carbon and glass fibers are introduced in concrete .This research presents a comprehensive review on the use of silica fume (SF) and basalt fiber (BF) reinforced concrete and the comparison with conventional used concrete regarding their properties . This research also presents the review on combined use of silica fume and basalt fiber together in reinforced concret .

Keywords - Silica Fume, Basalt Fiber, Compression Strength, Split Tensile Strength, Flexural Strength.

1. INTRODUCTION:

In this modern age, civil engineering constructions have their own structural and durability requirements, every structure has its own intended purpose and hence to meet this purpose, modification in traditional cement concrete has become mandatory. It has been found that different type of fibers added in specific percentage to concrete improves the mechanical properties, durability and serviceability of the structure. It is now established that one of the important properties of Fiber Reinforced Concrete (FRC) is its superior resistance to cracking and crack propagation. The weak matrix in concrete, when reinforced with fibers, uniformly distributed across its entire mass, gets strengthened enormously, thereby rendering the matrix to behave as a composite material with properties significantly different from conventional concrete. Fibers are usually used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water.

1.1 **Basalt Fiber**

Basalt is fine-grained, extrusive, igneous rock composed of plagioclase, feldspar, pyroxene and magnetite, with or without olivine and containing not more than 53 wt% SiO_2 and less than 5 wt% total alkalis. Many types of basalt contain phenocrysts of olivine, clinopyroxene (augite) and plagioclase feldspar. Basalt is divided into two main types, alkali basalt and tholeiites. They have a similar concentration of SiO_2, but alkali basalts have higher content of NA_2O and K_2O than tholeiites. The production of basalt fibers is similar to the production of glass fibers. Basalt is quarried, crushed and washed and then melted at 1500° C. The molten rock is then extruded through small nozzles to produce continuous filaments of basalt fiber.

1.2 Sillica Fumes

Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. It primarily consists of amorphous (non-crystalline) silicon dioxide (SiO_2). The individual particles are extremely small, approximately 1/100th the size of an average cement particle, silica fume is a very reactive pozzolana when used in concrete. Condensed silica fume is a very fine, amorphous, and reactive mineral admixture. It reacts readily with the calcium hydroxide, which is produced during Portland cement hydration. Silica addition refines pore structure and produces concrete of improved mechanical strength.

2 LITERATURE RIVIEW

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.

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.

3. METHODOLOGY

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.

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 given 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
4.	Tensile Strength	4840 MPa
5.	Modulus of Elasticity	89000Mpa
6.	Specific Gravity	2700 kg/m3

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 loads 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 mm2

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.

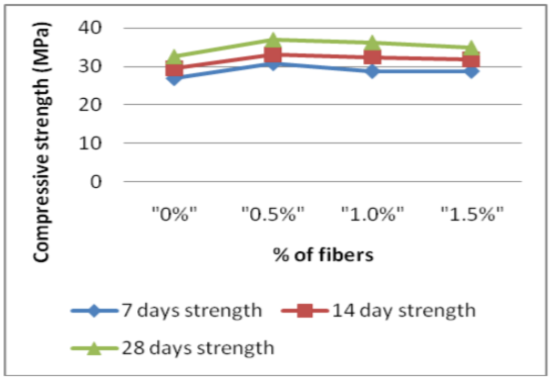

Chart -1 Compressive strength test results

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 (%)	Compressive strength (MPa)		
			7 Days	14 Days	28 Days
1.	M0	0.0	2.78	2.85	2.92
2.	M1	0.5	2.91	3.02	3.25
3.	M2	1.0	3.02	3.19	3.36
4.	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.

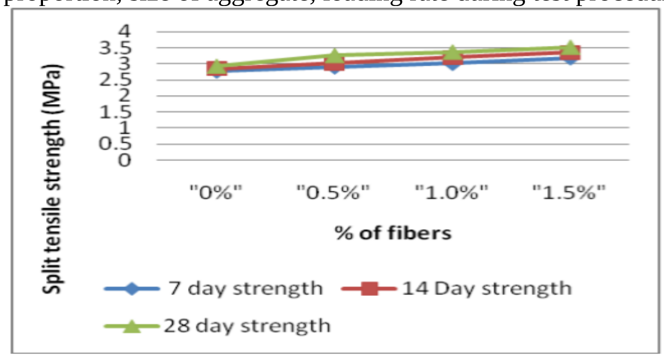

Chart -2 Split tensile strength test results

6. CONCLUSIONS

The concrete with basalt fiber content of 0%, 0.5%, 1.0%, and 1.5%, the split tensile strength increases from 0% to 1.5%.The optimum value of compressive strength is obtained for 0.5% and then it is decreases for 1.0% and 1.5% of fiber content. The Results from experimental studies shows that the optimum percentage of basalt fibers for maximum compressive strength of 36.87 MPa is 0.5 %, which gives 13.27% increase in compressive strength than normal concrete. For maximum Split tensile strength, optimum fiber content is 1.5% gives maximum strength of 3.51 MPa which is 20.20% higher than normal concrete. From the study it was proposed that, the usage of Basalt fibers in low cost composites for civil infrastructure applications gives good mechanical properties like strength and lower cost predicted for basalt fibers. Basalt fiber has used as a cost effectively replace to fiberglass, steel fiber, polypropylene, polyethylene, polyester, aramid and carbon fiber products in many applications.

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