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EVALUATION OF MECHANICAL PROPERTIES OF CONCRETE BY USING BASALT FIBER WITH SILICA FUME

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Abstract— ***Worldwide, a great deal of research is currently being conducted concerning the use of fiber reinforced plastic wraps, laminates and sheets in the repair and strengthening of reinforced concrete members. in this paper to investigate the effect of replacing cement with silica fume and adding basalt fiber and study its mechanical properties and durability. to characterized mechanical properties and durability.110 specimens with different fiber proportion 0.7%,0.8%,0.9% ,1.2% with the replacing cement with 10% silica fume. the mechanical and durability properties of concrete, apart from different curing regimes only normal water curing has been chosen. Performance of the various mixes is tested by the compressive strength, split tensile strength and flexure strength. A cube specimen of size 150mmX150mm X150mm, cylindrical specimen of size 100 mm dia X 200 high mm and beam specimen of size 150mm × 150 mm × 700mm were cast and demoulded after 24 hours then they allowed for normal water curing also performed SEM analysis. The results show improvement in compressive strength, split tensile strength and flexural strength in cement replaced mixes with adding basalt fiber. The maximum compressive strength, split tensile strength and flexural strength value that can be achieved in this study with the silica fume content of 10% cement replacement and adding 0.9% basalt fiber.***

Keywords— basalt fiber, silica fume, compressive strength, split tensile strength, flexural strength

I. INTRODUCTION

The global use of concrete is second only to water. As the demand for concrete as construction material increases, so also the demand for Portland Cement.The cement manufacture is highly energy intensive and each tonne emits about a tonne of CO2, which is a greenhouse gas causing global warming [1].With respect to the previous studies, adding the silica fume to the fiber reinforced concrete (FRC) with particular shapes, lengths, and diameters of steel fibers improves the impact resistance and the mechanical properties [2].Fiber reinforced concrete is the composite material containing fibers in the cement matrix in an orderly manner or randomly distributed manner. Its properties would obviously, depend upon the efficient transfer of stress between matrix and the fibers, which is largely dependent on the type of fiber, fiber geometry, fiber content, orientation and distribution of the fibers, mixing and compaction techniques of concrete, and size and shape of the aggregate. Fiber reinforced concretes (FRC) exhibit property improvement caused by the fibers [3].A fiber is a material made into a long filament with a density generally in the order of 300g/cm2 of 50cm [4].CONCRETE is widely used in the construction industry, as it can take up compressive stress significantly. Different studies have been carried out by using varying amounts of different types of fibres.The fibres used for making fibre reinforced concrete are steel fibres, synthetic fibres, glass fibres and natural fibres [5]. The production of basalt and glass fibers are similar. Crushed basalt rock is the onlyraw material required for manufacturing the fiber. It is a continuous fiber produced through igneous basalt rockmelt drawing at about 2,700° F (1,500° C)[6]. Two main weaknesses of concrete, namely its brittle behavior and its weakness under tension, which lead to low ductility, have posed problems for the structural application of normal concrete. Generally, the addition of fibers to the concrete mixture can significantly improve the concrete mechanical properties [8].

II. MATERIALS USED AND THEIR PROPERTIES

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A. **Cement:** Ordinary Portland cement of grade 53 make from a single lot is used for the study. The physical properties of cement as obtained from various tests are listed in Table 1. All the tests are carried out in accordance with procedure laid down in IS 1489 (Part 1):1991, valid for ordinary Portland cements.

Sr. No.	Characteristics	Test Value	Value specified by IS :1489-1991 (Part 1)
1.	Standard Consistency in (%)	31	---
2.	Soundness (mm)	0.86	Max 10 mm
3.	Fineness of cement as retained on 90 micron sieve (%)	8 %	----
4.	Setting time (min.) 1.Initial 2.Final	 90 180	 Min 30(min.) Max 600(min.)
5.	Specific gravity	3.12	

Table 1 physical properties of cement

B. **Silica fume:** The silica fume was used in this experiment conforms to IS 15388:2003. The specific gravity 2.63.The silica fume is extremely fine particle size of 0.5µm-1µm.

C. **Sand (Fine Aggregates):** Locally available sand is used as fine aggregates in the preparation of the concrete mix. Grade 1 (particles size ranges from 600µm- 1.18 mm) and grade 2 (particle size ranges from 300µm-600µ) which conforms to IS 383:1970. The physical properties and sieve analysis results of sand are shown in Table 2.

Table 2 Physical Properties of Fine Aggregates

Sr. No.	Characterisics	Value
1.	Specific gravity (oven dry basis)	2.644
2.	Fineness modulus	3.35
3.	Water absorption	0.54 %
4.	Grading Zone (Based on percentage passing 60 µm sieve)	Zone III

D. **Coarse aggregate:** crushed stone aggregates(locally available) of 20 mm and 10 mm are used through out the experimental study.the physical properties of coarse aggregate is given table 3.

Table 3 Physical Properties of Coarse Aggregates

Sr. No.	Characteristics	Value	
		CA – I	CA - II
1.	Type	Crushed	Crushed
2.	Maximum nominal size (mm)	20 mm	10 mm
3.	Specific gravity	2.93	2.847
4.	Total water absorption	1 %	1.12 %
5.	Fineness modulus	7.67	5.97

E. **Water :** The water, which is used for making concrete and for curing, is clean and free from harmful impurities such as oil, alkali, acid, etc, in general, The water, which is fit for drinking is used for making concrete.

F. **Basalt fiber :** Basalt fiber is a material made from extremely fine fibers of basalt, which is composed of the minerals plagioclase, pyroxene, and olivine. The fibers used in the study are of 13 µm in diameter and 12mm in length.

G. **Super plasticizer :** Master Rheobuild 822 is used as a admixture in concrete mix design

Table 4 Properties of Super plasticizer

Sr no	properties	Master Rheobuild 822
1	Appearance	Dark brown
2	PH value	≥6
3	Specific gravity	1.08
4	Chloride content	<0.2%

III EXPERIMENTAL PROGRAMME

A. Mix proportion

Table 5 Standard Mix Design

Sr. No.	MATERIAL	QUANTITY (per cu.m)
1.	Portland Cement	402.95 kg/m3
2.	Fine aggregate	714 kg/m3
3.	Coarse aggregate (20 mm)	811 kg/m3
4.	Coarse aggregate (10 mm)	414 kg/m3
5.	Superplasticizer	4 L/m3
6.	Total Water	177.3 L/m3
7.	W/B Ratio	0.44

Table 6 Percentage of silica fume replace and basalt fiber adding

Sr. No.	Mix	Silica fume	Basalt fiber
1	Standard Mix (M)	0%	0%
2	Mix 1 (M1)	0%	0.8%
3	Mix 2 (M2)	0%	0.9%
4	Mix 3 (M3)	10%	0%
5	Mix 4 (M4)	10%	0.7%
6	Mix 5 (M5)	10%	0.8%
7	Mix 6 (M6)	10%	0.9%
8	Mix 7 (M7)	10%	1.2%

Where, M, M1, M2, M3,M4,M5,M6 are Composition of Standard Mix, Mix 1, Mix 2, Mix 3 ,Mix 4,Mix 5,Mix 6 and Mix 7 respectively.

B. Specimen preparation and curing

Casting and testing of specimen was carried out as per IS codes IS:516-1959 for compression strength, split tensile and flexural strength. Materials are weigh batched, mixed in a mixer, cast into steel moulds and specimens were stored in room temperature for 24 hours, then removed from the moulds, and cured in normal water until tested.

C. Testing

Cubes of size 150 mm × 150 mm × 150 mm were tested to compute compressive strength, cylinders of size 100 mm dia × 200 mm high were tested to compute split tensile strength and beam of size 150mm × 150 mm × 700mm were tested to compute flexural strength of concrete. Specimens were tested under the Compression testing machine of 3000 KN capacity. Average of 3cubes compressive strength, 3 cylinders split tensile strength and 3 beams flexural strength are tabulated.

D. Durability test

The concrete cube specimens of various concrete mixtures of size 150 mm were cast and after 28 days of water curing, the specimens were removed from the curing tank. and allowed to dry for one day. The weights of concrete cube specimen were taken. The acid attack test on concrete cube was conducted by immersing the cubes in the acid water for 28 days after 28 days of curing. Sulfuric acid (H_2SO_4) with pH of about 0.1 at 5% weight of water was added to water in which the specimens were stored. The pH was maintained throughout the period of 28 days.

E. Scanning Electron Microscope

Microstructural characterisation of Cement, silica fume and basalt fiber are carried out by using scanning electron microscopy.

III. RESULTS AND DISCUSSIONS

A. Mechanical properties

The test results of compressive strength, split tensile strength, flexural strength and theoretical for corresponding mixes are tabulated.

1) Compressive Strength

Cube specimens of size 150mmX150mm X150mm were cast for compressive strength as per Indian standard specifications BIS: 516-1959. Compressive strength test results are shown in table 7 and fig no 1 and 2. The compressive strength result shows that there is an increase in compressive strength at 28 days by replacing silica fume and adding basalt fiber by weight of cement (M6) compared to the Standard mix(M). The highest compressive strength of 53.58 is obtained at 28 days for M6 mix containing 10% of silica fume and adding 0.9% basalt fiber.

Table 7 compressive strength test

Mix type	Compressive strength(N/mm^2)	
	7 days	28 days
M	30.56	40.21
M1	31.2	43.7
M2	31.50	44.1
M3	32.07	45.42
M4	32.68	49.19
M5	33.64	51.21
M6	33.10	53.58
M7	29.5	49.57

Figure 1 compressive strength

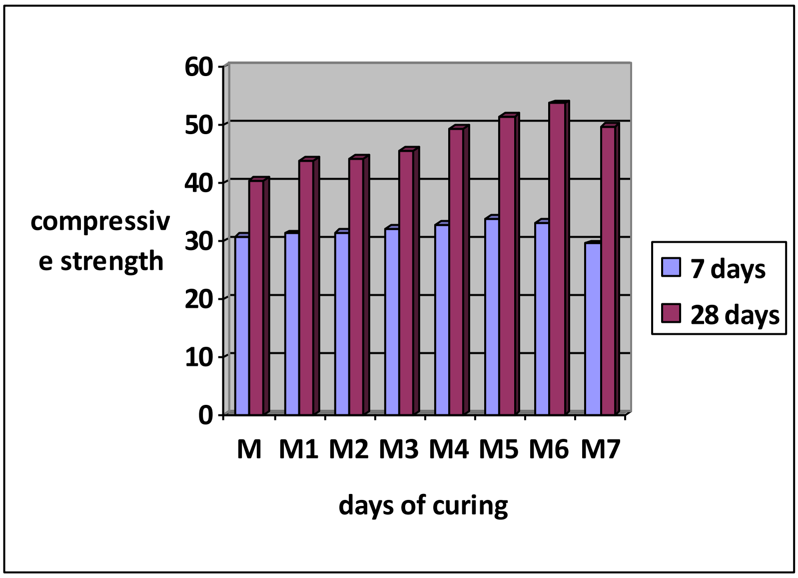

Figure 2 compressive strength test

2) Split tensile strength

Split tensile strength results are shown in table 8 and fig no 3 and 4. The split tensile strength of M6 is more than that of conventional concrete. It was recorded that maximum split tensile strength is 2.57 N/mm² for Standard mix(M).

Table 8 split tensile strength

Mix type	Split tensile strength(N/mm²)	
	7 days	28 days
M	1.82	2.17
M1	1.83	2.30
M2	1.85	2.32
M3	1.91	2.34
M4	2.01	2.39
M5	2.12	2.48
M6	2.15	2.57
M7	2.03	2.41

Figure 3 split tensile strength strength

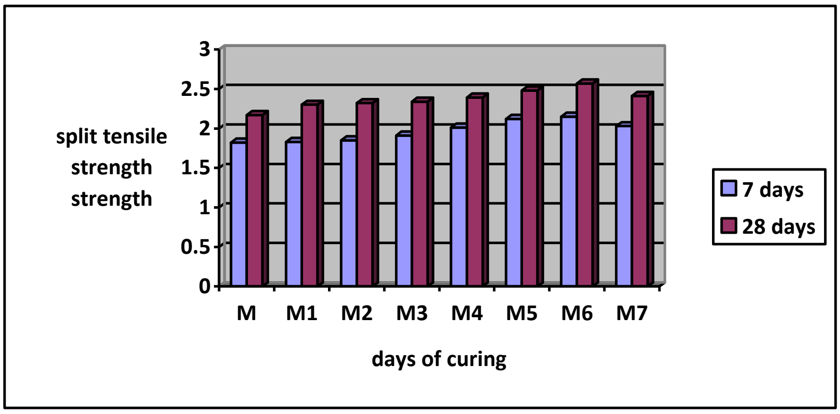

Figure 4 split tensile strength test

3) Flexural Strength

Flexural strength results are shown in table 9 and fig no 4 and . Effect of basalt fiber and silica fume on flexural strength is very small or negligible as compared to compressive strength. The split tensile strength of M6 is more than that of conventional concrete. It was recorded that maximum flexural strength is 5.89 N/mm² for Standard mix(M).

Table 9 flexural strengt

Mix type	flexural strength(N/mm²)	
	7 days	28 days
M	3.93	4.7
M1	3.94	5.0
M2	4.01	5.10
M3	4.2	5.28
M4	4.35	5.50
M5	4.38	5.62
M6	4.60	5.89
M7	4.45	5.74

Figure 5 flexural strength

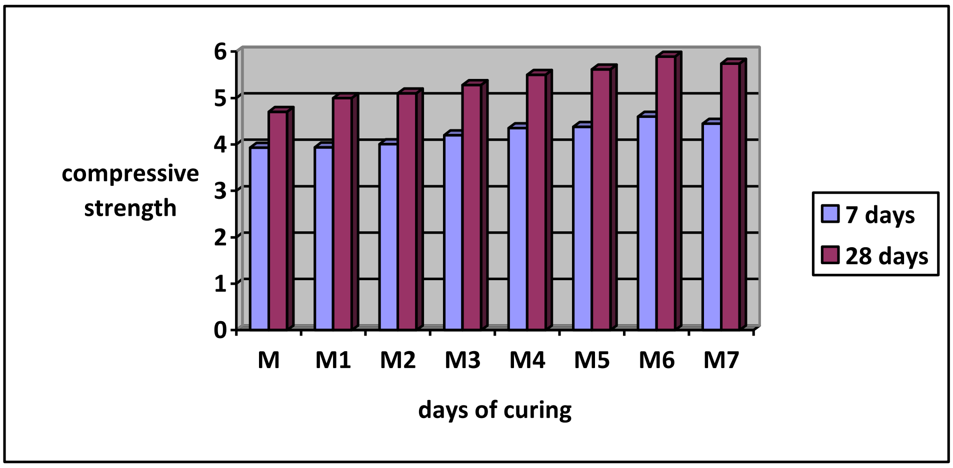

Figure 6 flexural strength

B. **durability test**

the % loss of weight M is higher compare to mix6 .the % weight loss of standard mix(M) is 10.66 %.and also %loss of compressive strength M is higher compare to mix 6.the % loss of compressive strength of standard mix(M) is 45.15 %.

table 10 durability test

Sr no	description	Weight after 28 days of curing(kg)	Weight after 28 days of acid attack(kg)	% loss of weight	Compressive strength after 28 days of curing (N/mm^2)	Compressive strength after 28 days of acid attack (N/mm^2)	%loss of compressive strength
1	**Standard mix(M)**	8.53	7.62	10.66	40.21	22.04	45.18
2	**Mix 6(M6)**	8.42	7.80	7.36	53.58	35.53	33.7

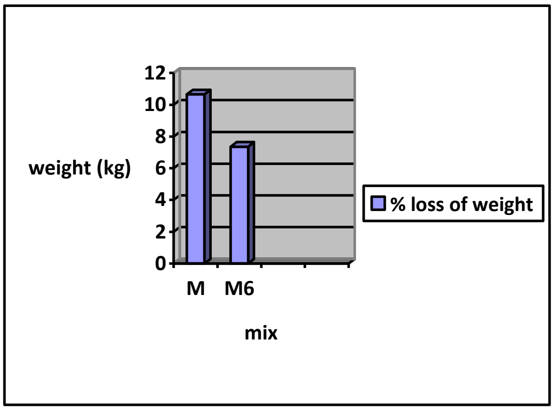

Figure 7 %loss of weight

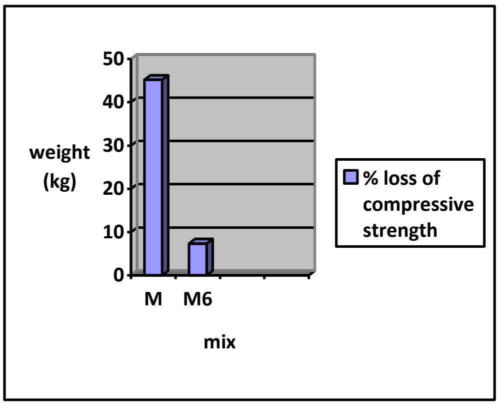

figure 8 %loss of compressive strength

Figure 9 durability test

C. **scanning electron microscope**

SEM images of basalt fiber, silica fume and cement shown in fig 10,11 and 12.

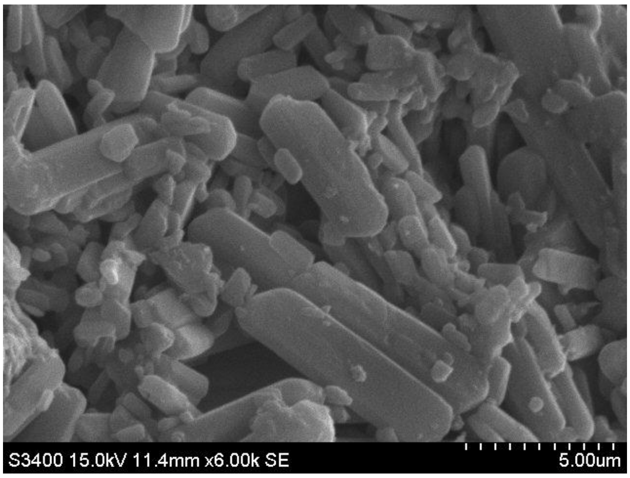

Figure 10 SEM image of basalt fiber

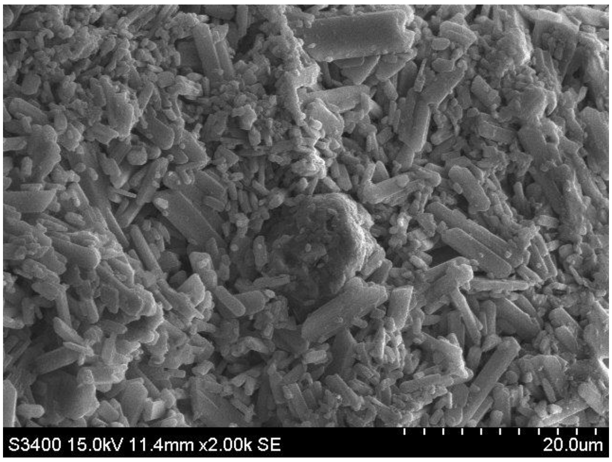

Figure 11 SEM image of basalt fiber with silica fume

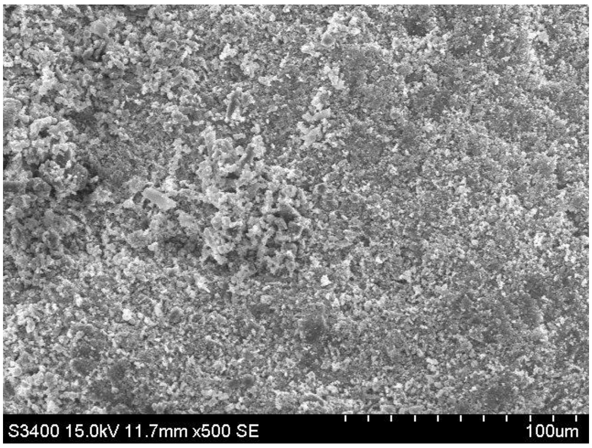

Figure 12 SEM image of cement

IV. Conclusions

In this paper, the effect of replacing cement with silica fume and adding basalt fiber on mechanical properties were experimentally studied. in this regard ,one hundred and ten specimens were tested experimentally under compressive test, split tensile and flexural test .and also performed acid attack test and SEM analysis. Then, based on relatively large experimental database was carried out. Following conclusions can be highlighted:

1. The combined effect of silica fume and basalt fiber improves the mechanical properties.
2. Mix(M6) with 10% cement replacement with silica fume and adding 0.9% basalt fiber gave highest 28 days compressive strength of 53.58 N/mm² as compared to Standard mix (M) having 28 days strength of 40.21 N/mm².
3. The various mix considered mix(M6) with 10% replacement of cement with silica fume and adding 0.9% basalt fiber gave better results.
4. mix(M6) with 10% cement replacement with silica fume and adding 0.9% basalt fiber gave highest 28 days split tensile strength of 2.57 N/mm² as compared to Standard mix (M) having 28 days strength of 2.17 N/mm².
5. Mix(M6) with 10% cement replacement with silica fume and adding 0.9% basalt fiber gave highest 28 days flexural strength of 5.89 N/mm² as compared to Standard mix (M) having 28 days strength of 4.7 N/mm².
6. Increase the content of basalt fiber after 1% reduce the compressive strength, split tensile strength and flexural strength.
7. The durability studied on specimens with acidic exposure conditions were studied. it was noticed that due to the acidic exposure, the deterioration in the control specimen was high than the M6 specimens.
8. Through the SEM analysis, it is conform that the road like basalt fiber observed at the interface of cementitious and aggregate bonding could probably be the reason increased compressive strength ,split tensile strength and flexural strength.

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