AN EXPERIMENTAL INVESTIGATION ON STRENGTH AND DURABILITY CHARACTERISTICS OF BASALT FIBER REINFORCED CONCRETE PRODUCED BY PARTIALLY REPLACING CEMENT WITH FLY ASH AND SILICA FUME

Deepali Bhagaje[1], Swapnil Cholekar[2]

[1]M.Tech (Structural Engg.) Student, Department of Civil Engineering, KLEMSSCET, Karnataka, India.
[2] Asst. Prof, Department of Civil Engineering, KLEMSSCET, Karnataka, India.

Abstract - *The most broadly utilized construction material on the planet is concrete which has enormous applications and design techniques. The present project deals with using OPC, M30 Grade concrete reinforced with basalt fibers at constant rate of 1.5% and replacing cement by mineral admixtures at 30%. The admixture consists of silica fume and fly ash at varying proportions of 0% SF - 0% FA, 25% SF - 75% FA, 50% SF - 50% FA, 75% SF - 25% FA, 100% SF - 0% FA, 0% SF - 100% FA. Plasticizer is used at 1%. Cubes and beams were casted of size 150mmx150mmx150mm and 100mmx100mmx500mm respectively. Workability test was carried out initially. Compressive test, flexural test at 90 days is carried out for the specimens subjected to sulphate attack and the specimens not subjected to sulphate attack. From the outcomes obtained we can say, compressive strength and flexural strength decreased, but it is above the design strength and contributing to eco-friendly environment. 90 days strength with sulphate attack was more than that of without sulphate attack. Soroptivity increases with increase in silica fume content. Therefore we conclude that fly ash and silica fume tends to decrease the strength but basalt fibres helps in gaining the strength and hence the strength obtained is satisfactory.*

Key Words: **Basalt Fibers, Fly ash, Silica fume, Compressive Strength, Flexural strength, Soroptivity, Sulphate Attack, eco friendly**

1. INTRODUCTION

The most broadly used material in construction industry is concrete which is a combination of water, cement, fine aggregate and coarse aggregate. Concrete is used because it has high compressive strength, durability and low cost. As consumption of cement is increasing day by day, the production of Portland cement leads to carbon dioxide emissions, which leads to global warming. So the alternative cement replacement materials such as flay ash, silica fume, ggbs, etc. are used in concrete which has pozzolanic properties, whose disposal is a problem and also contributes to the environment. Concrete can withstand compression stresses significantly and is weak in withstanding tensile stresses, so to overcome this, fibers are introduced in concrete. Fibers not only help in withstanding tensile stresses but also enhance strength and durability. Rishabh Joshi studied the Effect on Compressive Strength of Concrete by Partial Replacement of cement by fly ash and concluded that optimum replacement of cement by fly ash is 30%.[1] . Shivakumara B, Dr. Prabhakara H R, Dr. Prakash K B studied Effect Of Sulphate Attack On Strength Characteristic Of Fiber Reinforced High Volume Fly Ash Concrete and concluded that compressive strength and Compressive Strength and flexural strength increased after sulphate attack[2]. Jayeshkumar Pitroda, Dr F S Umrigar studied Evaluation of Sorptivity and Water Absorption of Concrete with Partial Replacement of Cement by Thermal Industry Waste (Fly Ash) and concluded that water absorption and soroptivity increased with increase in fly ash content[3].

1.1BASALT FIBER REINFORCED CONCRETE

Basalt is a molten rock shaped by the quick cooling of lava at the surface of a planet. It is widely recognized rock in the Earth's hull. Basalt rock attributes fluctuate from the source of lava, cooling rate, and authentic presentation to the components. Excellent strands are produced using basalt stores with uniform chemical makeup. Crushed basalt rock is the main crude material required for assembling the fiber. It is a consistent fiber created through volcanic basalt rock softens drawing at around 2,700° F (1,500° C). Concrete to which basalt fibers are added as reinforcement is called Basalt Fiber Reinforced Concrete.

2.OBJECTIVE OF THE STUDY

Following are the objectives of this experiment:

- The important objective of the work is to know the behaviour of concrete which is produced using OPC and Reinforced with Basalt fibers fixed 1.5%, and mineral admixtures Fly ash (FA) and Silica Fume (SF) (0% SF-0% FA, 25% SF-75% FA, 50% SF-50% FA, 75% SF-25% FA, 100% SF-0%FA, 0% SF-100% FA) for a fixed 30% replacement by weight of cement, with and without subjected to Sulphate attack.
- To find the variation in compressive and flexural strength of BFRC with M-30 grade.

- To compare the compressive strength and flexural strength of specimen with addition of Basalt fibers and admixtures for different percentage for a fixed 30% dosage of cementitious material
- To conduct the durability test of Sulphate attack with Magnesium sulphate (MgSO4) at 10% concentration and check the variation in strength of the specimens.
- To study the workability properties of concrete.
- To inspect the soroptivity of basalt fibre reinforced concrete

3.MATERIALS AND METHODS

3.1Cement

OPC 43 grade with specific gravity 3.15 was used conforming to IS: 8112: 2013.

3.2Fine aggregates

River Sand used is locally procured and was conforming to zone II with Specific gravity as 2.62. Moisture content and water absorption is 0.1% and 1.0% respectively.

3.3Coarse aggregates

Locally available crushed angular coarse aggregate having the maximum size of 20 mm is used. The specific gravity of coarse aggregate is 2.71. Moisture content and water absorption is 0.5% and 2.0% respectively.

3.4Fly ash

Fly ash is procured from Raichur Thermal Plant and specific gravity is 2.1

3.5Silica fume

Silica fume is procured from Corniche Suppliers, Navi Mumbai and specific gravity is 2.2.

3.6Super plasticizer

Conplast SP 430 which helps in reducing water content up to 25%. Specific gravity is 1.2.

3.7Basalt Fiber

Basalt fibers used in this experiment is procured from Nickunj Eximp Entp P Ltd, Mumbai.

3.8Mix Design

The results are obtained using IS 10262 – 2009 code, mix design is carried out for M30 grade of concrete. The mix proportion obtained for M 30 grade concrete is 1:2.32:3.76 for water cement ratio of 0.45.

4.EXPERIMENTAL TEST PROCEDURE

The design mix for M30 concrete is designed with the guidelines of IS: 10262-2009 and using the preliminary test results. OPC cement is used in this experiment. The mix proportion is 1:2.32:3.76 with water-binder ratio of 0.45 and super plasticizer dosage of 1% (by weight of cement). Fibers are added at constant percentage of 1.5%. Fly ash and silica fume are added at varying percentages of 0% SF - 0% FA, 25% SF - 75% FA, 50% SF - 50% FA, 75% SF - 25% FA, 100% SF - 0% FA, 0% SF - 100%, of total replacement of 30% of total cement content, by weight of cement. The specimens are cast for compressive strength and flexural strength test. The specimens are cured in water for 28 and then the specimens are subjected to sulphate attack for 60 days. They are immersed in magnesium sulphate solution of 10% concentration for 60 days. After 60 days of sulphate attack, the specimens are removed from the sulphate media and weighed accurately. Then they are tested for their respective strengths.

5.EXPERIMENTAL TEST RESULTS AND DISCUSSION

5.1Workability Results

It is observed that slump value decreases due to replacement of cement by fly ash and silica fume.

Table-1 Slump Values for different ratios of cementious material

Specimen ID (30% of Cementious Material)	SLUMP (mm)
0%SF-0%FA	56
25%SF-75%FA	48
50%SF-50%FA	45
75%SF-25%FA	42
100%SF-0%FA	30
0%SF-100%FA	34

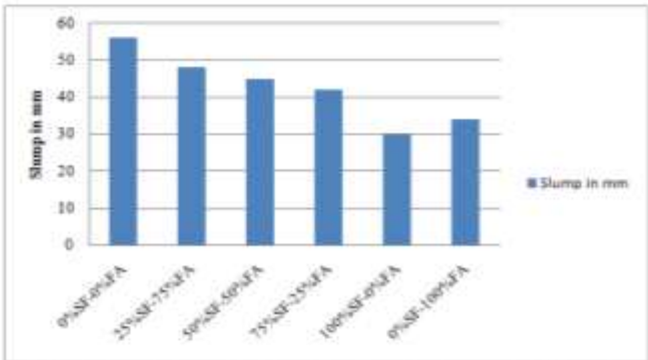

Chart-1: Variation in Slump

5.2Compressive Strength Test Results

Table-2 Compressive Strength of 28 Days	
Specimen ID (30% of Cementious Material)	28Days Compressive Strength
0%SF-0%FA	39.70
25%SF-75%FA	36.74
50%SF-50%FA	35.85
75%SF-25%FA	34.52
100%SF-0%FA	33.19
0%SF-100%FA	37.78

At 90days, for the specimens subjected to sulphate attack, it is observed that the compressive strength decreases due to fly ash and silica fume, and the strength obtained is less than that of conventional concrete, but it is more than design strength and less than target strength. Also the strength achieved is more than the strength of specimens subjected to normal curing for 90 days. This is because, when fly ash and silica fume comes in contact with sulphate solution, it gives rise to pozzolanic reaction and fills the minute pores in the concrete matrix, making the concrete denser and hence strength increases. It is also observed that fly ash contributes more than silica fume in gaining the strength, therefore fly ash is more reactive than silica fume.

Table-3 Overall Results of Compressive Strength with and without Sulphate Attack				
Specimen ID (30% of Cementious Material)	90 days mean Compressive Strength (MPa) Without sulphate attack	% variation with respect to reference mix	90 days mean Compressive Strength (MPa) with sulphate attack	% variation with respect to reference mix
0% SF - 0% FA	40.89	-	41.63	-
25%SF-75%FA	36.89	-9.78	37.48	-9.96
50%SF-50%FA	36.00	-11.95	36.44	-12.46
75%SF-25%FA	34.67	-15.21	34.81	-16.38
100%SF-0%FA	32.30	-21.00	34.37	-17.43
0%SF-100%FA	38.81	-5.08	39.85	-4.27

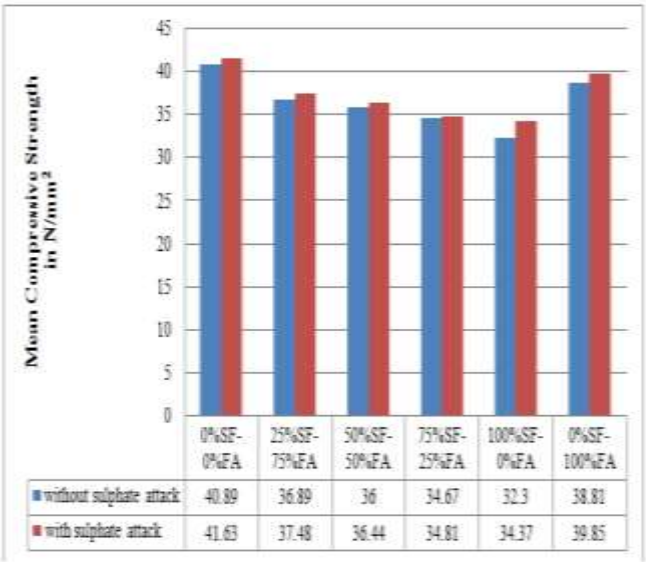

Chart-2: Variation in Compressive Strength

5.3Flexural Strength Test Results

At 90days, for the specimens subjected to sulphate attack, it is observed that the flexural strength decreases due to fly ash and silica fume, and the strength obtained is less than that of conventional concrete, but it is more than design strength and less than target strength. Also the strength achieved is more than the strength of specimens subjected to normal curing for 90 days. This is because, when fly ash and silica fume comes in contact with sulphate solution, it gives rise to pozzolanic reaction and fills the minute pores in the concrete matrix, making the concrete denser and hence strength increases. It is also observed that fly ash contributes more than silica fume in gaining the strength, therefore fly ash is more reactive than silica fume.

Table-4 Overall Results of Flexural Strength with and without Sulphate Attack				
Specimen ID (30% of Cementious Material)	90 days mean Flexural Strength (MPa) without sulphate attack	% variation with respect to reference mix	90 days mean Flexural Strength (MPa) with sulphate attack	% variation with respect to reference mix
0%SF-0%FA	4.47	-	4.53	-
25%SF-75%FA	4.33	-3.13	4.40	-2.86
50%SF-50%FA	4.27	-4.47	4.33	-4.41
75%SF-25%FA	4.13	-7.60	4.20	-7.28
100%SF-0%FA	3.93	-12.08	4.07	-10.15
0%SF-100%FA	4.40	-1.56	4.47	-1.32

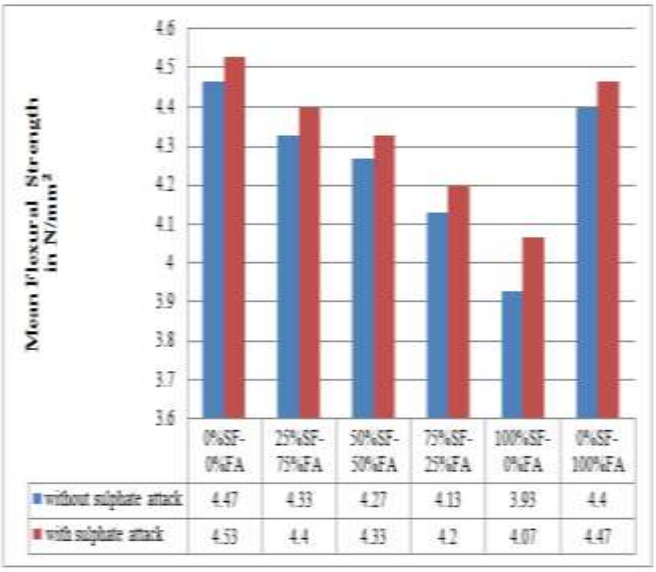

Chart-3: Variation in Flexural Strength

5.4Soroptivity Test Results

It is observed that soroptivity increases with increase in silica fume content. Soroptivity is highest at 100% silica fume content because silica fume absorbs more water than fly ash.

Table-5 Soroptivity Test Results of BFRC

Specimen ID (30% of Cementious Material)	Dry wt. in gms W1	Wet wt. in gms W2	Soroptivity value in 10^{-5} mm/min$^{0.5}$
0%SF-0%FA	8875	8880	2.02
25%SF-75%FA	8622	8630	3.24
50%SF-50%FA	8855	8865	4.05
75%SF-25%FA	8859	8872	5.27
100%SF-0%FA	8348	8365	6.89
0%SF-100%FA	8330	8339	3.65

6.CONCLUSIONS

From the observations and discussions, following are the conclusions arrived from the experiments conducted on the strength and durability characteristics of basalt fiber reinforced concrete. We conclude that

a) The addition of basalt fibers enhance the strength and replacing the cement by fly ash and silica fume decreases the strength

b) The strength obtained after replacing the cement by fly ash and silica fume was less than the conventional concrete but above the design strength and hence contributed to eco-friendly environment.

c) Fly ash contributes more to gain the strength than silica fume

d) Concrete specimens when subjected to sulphate attack have exhibited increase in strength when compare to specimens without subjected to sulphate attack.

e) Therefore, it is recommended that 50%FA-50%SF of 30% replacement of cement in concrete for effective strength.

f) Soroptivity increases with increase in silica fume content.

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AUTHORS

Deepali Bhagaje,
PG Student, Structural Engineering, Department of Civil Engineering, KLEMSSCET, Karnataka, India

Swapnil B. Cholekar
Assistant Professor, Department of Civil Engineering, KLEMSSCET, Karnataka, India