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

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**Abstract -** Cement concrete is the most extensively used construction material in the world. The reason f0r its extensive use is that it provides good workability and can be turn it to any shape. Normal concrete gives a very low tensile strength, restricted ductility and small amount of resistance to cracking. Internal small cracks lead to brittle failure of concrete. In this new generation civil engineering constructions have their own structural and durability requirements. Every structure has its own design criteria and shape so meet that requirement change in cement concrete is mandatory. It was seen that different type of fibers added to concrete in specific amount or percentage that make rise in mechanical properties, durability and serviceability of the structure. In this experiment effect of fibers and supplementary materials on the strength of concrete for M30 grade have been studied by keeping the constant percentage of fibers and replacing 30% of the cement content by GGBS and Flyash in concrete. Basalt Fibers used in this experiment. In this experiment 1.5% of total dosage of fiber content was fixed with Supplementary materials Flyash GGBS in varying percentages i.e. 0%FA-GGBS, 100%FA-GGBS, 25%FA-75%GGBS, 50%FA-50%GGBS and 75%FA-25%GGBS of total dosage ( i.e.30%) by weight of cement. Cubes and Beams are casted to check the compressive & flexural strength of concrete. In this experiment it is also aimed to study the effect BFRC when subjected to sulphate attack. Here study cited on effect of sulphate on Basalt fiber reinforced concrete. Also checking the strength parameters compare the test results with sulphate and without sulphate attack. Results are taken after 90 days curing and 90 days of sulphate attack. The optimum supplementary material content while studying the strength parameters of all specimens is found 100%FA-0%GGBS.

***Key Words***: **Basalt Fibers, Fly ash, GGBS, 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, ggbs, 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 Fiber is prepared from fine fibers of basalt. Basalt is a kind of igneous rock which is formed by cooling of lava. These basalt rock melt at high temperature from that melated rock basalt fibers are prepared. And it is made up of the minarals like pyroxene, olivine, and plagioclase. It increses tensile strength by 15-20%. It has better heat insulation property. It has good chemical resistance. This fiber is environment friendly. This fiber is recyclable. The temperature range of applications of basalt fiber concrete varies between -269 °C to 650 °C.

## 2. OBJECTIVE OF THE STUDY

Following are the objectives of this experiment:

- The main objective of this experimental subject field is to find out the behavior of concrete produced using OPC, Reinforced with Basalt fibers (BF) at a constant percentage of fiber content (i.e 1.5% basalt fibers) and replacing 30% of cement with suplementory cementitious materials Flyash and GGBS in varying percentages (i.e 0%FA-GGBS, 100%FA-GGBS, 25%FA-75%GGBS, 50%FA-50%GGBS and 75%FA-25%GGBS).
- To find and tally the compressive, flexural strength of basalt fiber reinforced concrete with plain M30 grade concrete.
- To perform the durability test of Sulphate attack using Magnesium sulphate ($MgSO_4$) at 10% concentration and to check the strength of specimens.
- To Attain M30 grade strength of concrete.
- To investigate the strength results with and without subjected to sulphate attack.
- 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.

### 3.3 Coarse 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.

### 3.4 Fly ash

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

### 3.5 GGBS

Ggbs is procured from JSW and specific gravity is 2.85.

### 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 ggbs are added at varying percentages of 0% GGBS - 0% FA, 25% GGBS - 75% FA, 50% GGBS - 50% FA, 75% GGBS - 25% FA, 100% GGBS - 0% FA, 0% GGBS - 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 90 days. They are immersed in magnesium sulphate solution of 10% concentration for 90 days. After 90 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 ggbs.

**Table-1** Slump Values for different ratios of cementious material

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

### 5.2Compressive Strength Test Results

| **Table-2** Compressive Strength of 90 Days | |
|---|---|
| Specimen ID (30% of Cementious Material) | Average Compressive Strength without Sulphate attack |
| 0%GGBS-0%FA | 42.67 |
| 25%GGBS-75%FA | 41.33 |
| 50%GGBS-50%FA | 41.78 |
| 75%GGBS-25%FA | 40.44 |
| 100%GGBS-0%FA | 39.56 |
| 0%GGBS-100%FA | 42.22 |

At 90days, for the specimens subjected to sulphate attack, it is observed that the compressive strength decreases due to fly ash and ggbs, 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 ggbs 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 ggbs in gaining the strength, therefore fly ash is more reactive than ggbs.

| **Table-3** Overall Results of Compressive Strength with and without Sulphate Attack | | | | |
|---|---|---|---|---|
| Different % of FA and SF (30% total admixture content) | 90 days mean Compressive Strength without sulphate attack (MPa) | % variation with respect to reference mix | 90 days mean Compressive Strength with sulphate attack (MPa) | % variation with respect to reference mix |
| 25%GGBS-75%FA | 41.33 | -0.03 | 42.67 | -0.04 |
| 50%GGBS-50%FA | 41.78 | -0.02 | 42.81 | -0.04 |
| 75%GGBS-25%FA | 40.44 | -0.05 | 41.78 | -0.06 |
| 100%GGBS-0%FA | 39.56 | -0.07 | 40.74 | -0.08 |
| 0%GGBS-100%FA | 42.22 | -0.01 | 43.41 | -0.02 |

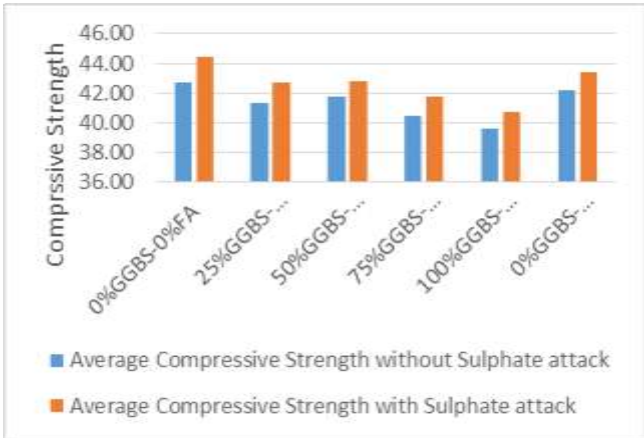


**Chart-1:** Variation in Compressive Strength

### 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 ggbs, 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 ggbs 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 ggbs in gaining the strength, therefore fly ash is more reactive than ggbs.

| **Table-4** Overall Results of Flexural Strength with and without Sulphate Attack | | | | |
|---|---|---|---|---|
| Different % of FA and SF (30% total admixture content) | 28 days mean Flexural Strength (MPa) | % variation with respect to reference mix | 60 days mean Flexural Strength (MPa) | % variation with respect to reference mix |
| 0% GGBS - 0%FA (Ref mix) | 5.58 | - | 5.83 | - |
| 25%GGBS-75%FA | 5.17 | -0.07 | 5.42 | -0.07 |
| 50% GGBS -50%FA | 5.25 | -0.06 | 5.50 | -0.06 |
| 75% GGBS -25%FA | 5.08 | -0.09 | 5.33 | -0.09 |
| 100% GGBS - 0%FA | 4.58 | -0.18 | 4.83 | -0.17 |
| 0% GGBS - 100%FA | 5.50 | -0.10 | 5.75 | -0.10 |

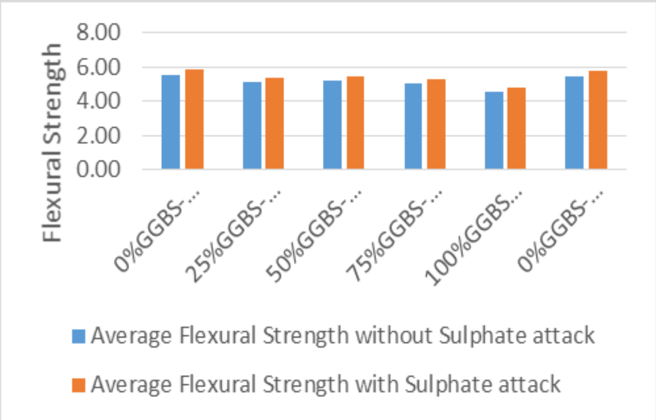


**Chart-2:** Variation in Flexural Strength

### 5.4Soroptivity Test Results

It is observed that soroptivity increases with increase in Flyash content. Soroptivity is highest at 100% Flyash content because Flyash absorbs more water than GGBS.

**Table-5** Soroptivity Test Results of BFRC

| Different % of FA and SF (30% total admixture content) | i (mm) | t (min) | Sorptivity S=i/√t (mm/√min) | Average sorptivity |
|---|---|---|---|---|
| 0% GGBS - 0%FA | 62 | 240 | 4.00 | 3.87 |
| | 60 | 240 | 3.87 | |
| | 58 | 240 | 3.74 | |
| 25% GGBS-75%FA, | 51 | 240 | 3.29 | 3.55 |
| | 56 | 240 | 3.61 | |
| | 53 | 240 | 3.42 | |
| 50% GGBS-50%FA, | 58 | 240 | 3.74 | 3.80 |
| | 61 | 240 | 3.94 | |
| | 58 | 240 | 3.74 | |
| 75% GGBS-25%FA, | 69 | 240 | 4.45 | 4.26 |
| | 63 | 240 | 4.06 | |
| | 66 | 240 | 4.26 | |
| 100% GGBS-0%FA, | 49 | 240 | 3.16 | 2.92 |
| | 42 | 240 | 2.71 | |
| | 45 | 240 | 2.90 | |
| 0% GGBS-100%FA | 63 | 240 | 4.06 | 4.22 |
| | 68 | 240 | 4.39 | |
| | 65 | 240 | 4.20 | |

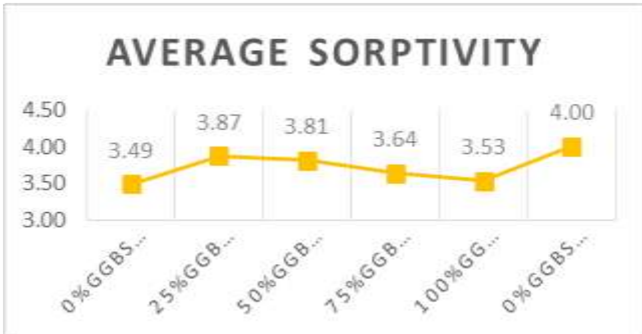


**Chart-3:** Variation in Soroptivity

### 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) Addition of fibres increases the strength of concrete and replacing cement by Flyash and GGBS slightly decreases the strength of concrete.

b) The strength obtained after replacing cement by Flyash and GGBS decreases the strength of concrete but that is more than that of characteristic strength hence it results in eco-friendly environment.

c) Flyash contribute more to gain strength than GGBS.

d) When concrete specimens are subjected to sulphate attack the strength increased compare to concrete specimens without subjected to sulphate attack specimens.

e) It is recommended that 100%FA-0%GGBS of 30% replacement can be added to the concrete for maximum strength.

f) At 50%FA-50%GGBS shows increase in compressive strength and flexural strength upto average 4% when binary blends are considered.

g) Hence 50%FA-50%GGBS is considered to be optimum for M30 mix.

h) Soroptivity increases with increase in Flyash content.

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