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# Experimental Study on Basalt Fiber Blended with Flyash in Geopolymer Concrete

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**ABSTRACT:** This project investigates the effect of basalt fibres on the durability and strength of binary mix geopolymer concrete. Geopolymer concrete will be prepared with fly ash as raw material, fly ash will comply with composite design IS 1489-Part-1 2005 as geopolymer concrete is one of the building materials emerging worldwide in recent research. Geopolymer concrete is more brittle. In order to improve the engineering performance of conventional concrete Geopolymer concrete, metal and non-metal basalt fibres will be incorporated into the material of the composite concrete. Consider basalt fibres with different volume percentages such as 0.25%, 0.3% and 0.35%. Various combinations of basalt fibres are tested to test durability parameters such as compressive strength, split tensile strength and durability. Similarly, long-term properties such as permeability, water absorption, sea erosion and sulfuric acid attack will be evaluated. According to data analysis, 0.3% basalt fibres have better strength and performance than binary hybrid geopolymer concrete. Basalt fibres improve many properties of geopolymer concrete. Basalt fibres control different levels of cracking, soft and smooth fibres effectively prevent micro-level cracking, while strong and thick fibres effectively control macro-level cracking.

**KEYWORDS:** Geopolymer concrete, Basalt Fiber, Flyash, Sodium hydroxide Solution, Tensile Strength, Durability

## I. INTRODUCTION

Concrete is the second most popular materials in this planet after water. It is versatile material and is widely used in civil engineering practice because of its mouldability, low production cost and high response under compression. Though it have more merit there is some demerit too. Nowadays there is much more problem of global warming which is caused by CO<sub>2</sub> gas. The cement industry plays major role for the emission of CO<sub>2</sub> into the atmosphere. It is said that for producing one ton of Ordinary Portland cement (OPC) about one ton of CO<sub>2</sub> is released into atmosphere. So, to protect the environment, alternative to OPC has been developed as Geopolymer Concrete (GPC) by Joseph Davidovits in 1978. Geopolymer materials are formed by reaction of an aluminosilicate powder with an alkaline silicate solution at ambient conditions. GPC is emerging as a new environmentally friendly construction material for sustainable development, using fly ash and alkali in place of OPC as the binding agent. GPC uses waste material such as fly ash, blast furnace slag to produce concrete. Plain GPC is weak in tension so different types of fibre are added to enhance the strength to the concrete. The different types of fibre are steel fibre, basalt fibre, glass fibres etc. Basalt fibre is a fibre that is obtained from basalt rock and has higher working temperature and has a good resistance to impact load, fire resistance and chemical attack. When amount of basalt fibre is added to GPC, the flexural strength increases upto 68% for the content of 2%.

In this study, geopolymer material like flyash is used which is by product of thermal plant and steel plant respectively. Firstly, optimum percentage of fly ash is identified and then in that percentage fiber is added at an increase of 0.1% upto 0.5%. Compressive strength for cube, split tensile strength for cylinder and flexural strength for prism is carried out to identify the optimum percentage of fibre. Other properties like stress-strain curve and modulus of elasticity is also studied.



## II. MATERIALS

### 1. Fly Ash

Fly ash is by-product of thermal power plant. In this study, class f type fly ash is used that is obtained from Raichur Thermal Power Plant, Tamilnadu. The chemical composition of fly ash is shown in table-1.

**TABLE -1:** Chemical Composition of Fly Ash

Compound	SiO <sub>2</sub>	CaO	MgO	Fe <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	LOI
Fly Ash (%)	68.09	1.24	1.70	2.07	19.23	1.78

### 2.2 Alkaline Activator Solution

Sodium hydroxide (NaOH) in the form of pellete is used to make a solution of 10 molarity concentration by using tap water. This solution is then mixed with sodium silicate solution to form an alkaline activator solution. The solution is prepared 24 hours before the casting.

### 2.3 Fine Aggregate

River sand of size below than 2.36mm is used.

**Table -2:** Properties of Fine Aggregate

Properties	Specific Gravity	Bulk Density	Fineness Modulus
Fine Aggregate	2.6	1736.41 kg/m <sup>3</sup>	2.5

### 4. Coarse Aggregate

Crushed stone of 12.5mm down size coarse aggregate is used.

**Table -3:** Properties of Coarse Aggregate

Properties	Specific Gravity	Bulk Density	Fineness Modulus
Coarse Aggregate	3.24	1632.07 kg/m <sup>3</sup>	6.92

### 2.5 Basalt Fibre

Basalt fibre is obtained from igneous rock called basalt. It is golden brown in color. It has several advantages in construction field. It has good resistance to acid and chemical attack, UV-light, fungal attack, impact load and fire resistance.

**Table -4:** Properties of Basalt fibre

Density	2600 kg/m <sup>3</sup>
Tensile Strength	500-600 MPa
Elastic Modulus	90-120 GPa
Elongation at break	3.1%
Length	12mm
Diameter	(7-15) $\mu$ m
Color	Golden Brown

## 2.6 Water

Water is added in GPC only for workability.

## 2.7 Super- Plasticizer

Conplast-sp 430 is used to improve the flow of GPC and to increase the strength.

## III. MIX DESIGN

**Table -5:** Mix Proportion

Materials	Mix for 1m <sup>3</sup> GPC
Fly Ash + GGBS (kg/m <sup>3</sup> )	394.3
Fine Aggregate (kg/m <sup>3</sup> )	554.4
Coarse Aggregate(kg/m <sup>3</sup> )	1293.6
NaOH (kg/m <sup>3</sup> )	45.06
Na <sub>2</sub> SiO <sub>3</sub> (kg/m <sup>3</sup> )	112.65
Water (kg/m <sup>3</sup> )	59.142
Super plasticizer (kg/m <sup>3</sup> )	11.828

## IV. CASTING OF SPECIMEN

### 1. Cube for Compressive Strength

The cubes of size 100mmx100mmx100mm were cast to find out the compressive strength of plain geopolymer concrete and fibre reinforced GPC. Six cubes were cast for each ratio of fly ash and GGBS and for fibre also. The fresh concrete mix was filled in mould in three equal layers and each layer is compacted using tamper rod. Ambient curing was done upto 7 and 14 days and testing is done in compressive testing machine of 100 ton.

### 2. Cylinder for split tensile strength test

The cylinders of 100mmx200mm are cast to find out the tensile strength of GPC and also cylinders of size 150mmx300mm were also cast to see stress-strain relationship. Three number of cylinder for each ratio of fibre is prepared. The fresh concrete mix was filled in mould compacted using tamper rod. Ambient curing was done upto 7 and 14 days and testing is done in compressive testing machine of 100 ton.



3. Cube for durability test  
Sulphuric Acid attack test on 150mm cubes. Three number of cylinder for each ratio of fibre is prepared. Testing is done after 7 and 14 days.

## V. TESTING PROCEDURE

### 1. Compressive Strength

The Compressive Strength is the primary test to identify the strength of cube specimen. The test is done after 7 and 14 days.

### 2. Split Tensile Strength

The split tensile strength is indirect test to measure tensile strength of concrete. The test is done after 7 and 14 days of curing.

### 3. Durability test

The test is done after 7 and 14 days of curing.

## VI. RESULTS AND DISCUSSION

### 6.1 Compressive strength:

The compressive strength increases as the amount of flyash is added. In this ratio, fibre is added from .25 to 0.35% to get the optimum fibre content to give high strength in concrete. From the test, it is found that 0.3% of fibre gives high strength.

Type of test	Ratios	7 days	14 days
Compression test	0.25	21.3 Mpa	27.2 Mpa
	0.30	22.5 Mpa	29.1 Mpa
	0.35	22.1 Mpa	6. Mpa

### 6.2 Split tensile strength:

The Split tensile strength test is done in cylinder at 7 and 14 days of ambient curing and tested on compressive strength machine.

Type of test	Ratios	7 days	14 days
Split tensile test	0.25	2.21 Mpa	2.31 Mpa
	0.30	2.36 Mpa	2.41 Mpa
	0.35	2.29 Mpa	38. pa

### 6.3 Durability test:

Sulphuric acid test is done at 7 and 14 days after curing.

Type of test	Ratios	7 days	14 days
Durability test	0.25	1.52%	1.37%
	0.30	1.47%	1.34%
	0.35	1.41%	1.29%



## VII. CONCLUSION

Basalt fiber has become an effective support in geopolymer materials. They develop new, hardened, micro and macro structural properties of concrete. They maintain high resistance to chemicals. Basalt fiber reinforced geopolymer concrete is superior to ordinary concrete. The combination of basalt fibers helps improve bone function and makes it harder for cracks to propagate. It was found that the dissolution time of the concrete increased with the basalt fiber percentage and also decreased the dry shrinkage of the geopolymer mortar. Basalt fibers increase resistance to sulfate and chloride attacks. They increase the durability of the mortar against thawing cycles.

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