A STUDY ON FLEXURAL BEHAVIOUR OF BASALT FIBER REINFORCED GEOPOLYMER CONCRETE

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Abstract - *Concrete is most used construction material in the world. Construction industry uses most of the natural resources as it includes production of cement. It is the major contributing factor to the CO_2 emissions, causing global warming. An alternate to the OPC has been found out known as Geopolymer concrete. It uses industrial waste material such as fly ash, GGBS, rice husk ash instead of cement thereby decreasing impacts due to cement production. In this study both fly ash and GGBS are utilized in making Geopolymer concrete. Alkaline solution is used is comprises of sodium silicate(103 kg/m^3) and Sodium hydroxide(41 kg/m^3) in the ratio of 2.5.sodium hydroxide of 10 molarity is used. Plain concrete is weaker in tension. Fibers are added to enhance the strength to the concrete to meet given serviceability requirements. Basalt fiber is considered a promising new material. It has good strength characteristics, resistance to chemical attack, sound insulation properties. It has wide range of applications like soil strengthening, bridges and highways, industrial floors. In present study various proportions of basalt fibers added to the geopolymer concrete and compressive and split tensile strength of the different mixes were compared with the geopolymer concrete without basalt fibers. Fibers are added to the geopolymer concrete in the range of 0.5% to 2.5% at 0.5% increments. Flexural strength of different mixes were compared with reference mix(0% fiber).from the results it is concluded that addition of basalt fibers at an optimum content to the geopolymer concrete can increase flexural strength.*

Key Words: Basalt Fibre, Geopolymer Concrete, flexural strength, fly ash,ggbs

1. INTRODUCTION

Concrete is the most used construction material around the world. It uses cement, fine aggregate and coarse aggregate as its constituents. Because of its extensive use the consumption of cement is increasing now days. Portland cement production is major contributing factor to the Carbon di-oxide emissions, this causes global warming. So an alternate to the ordinary Portland cement has been developed and known as Geopolymer concrete. It uses industrial waste material such as fly ash, blast furnace slag to produce concrete. Usually plain concrete is weak in tension, because of concrete hold aggregates can crack, and cause concrete to break. Different type of fibers is added to the concrete to enhance the strength to the concrete. Fibers act as crack arrestors in concrete. The different types of fibers used in concrete are steel fibers, basalt fibers, glass fibers polypropylene fibers.

1.1 Basalt Fiber

Basalt is a volcanic rock and can be chopped into small particles then formed into continues or chopped fibers. Basalt fiber has a higher working temperature and has a good resistance to impact load, fire resistance and chemical attack. The applications of these basalt composites are plastic polymer reinforcement, soil strengthening, construction of bridges and highways, heat and sound insulation for residential and industrial buildings, bullet proof vests and retrofitting and rehabilitation of structures.

1.2 Geopolymer concrete

Geopolymer is being studied extensively and shows promise as a greener alternative to Portland cement concrete. Research is shifting from the chemistry domain to engineering applications and Commercial production of geopolymer. It has been found that geopolymer concrete has good engineering properties. It has been reported that geopolymer material does not suffer from alkali-aggregate reaction even in the presence of high alkalinity, and possesses excellent fire resistant. Geopolymer is used as the binder, instead of cement paste, to produce concrete. The geopolymer paste binds the loose coarse aggregates, fine aggregates and other un-reacted materials together to form the geopolymer concrete. The manufacture of geopolymer concrete is carried out using the usual concrete technology methods. As in the Portland cement concrete, the aggregates occupy the largest volume, i.e. about 75-80% by mass, in geopolymer concrete. The silicon and the aluminum in the fly ash are activated by a combination of sodium hydroxide and sodium silicate solutions to form the geopolymer paste that binds the aggregates and other un-reacted materials.

2. MATERIALS

The following materials are used in this experimental work.

2.1 Fly Ash

Fly ash is one of the waste products from the power plants. It is obtained in the process of burning of bituminous. It is rich in silica and alumina, this property of fly ash tends to use it in the preparation of geopolymer concrete. It is also a crucial ingredient in the creation of geopolymer concrete due to its role in the geopolymerization process. Fly ash is a powdery pozzolana. A pozzolana is a material that exhibits cementatious properties when combined with calcium hydroxide. Fly ash separated from the combustion gases by dust collection system with the help of electrostatic precipitators.fly ash particles are finer, spherical diameter of the fly ash particles varies from 1μm to 150 μm.

Table -1: Chemical Composition of Fly Ash

Sl.no	Element Code	Percentage
1	SiO_2	61.2
2	Al_2O_3	28.22
3	CaO	2.94
4	MgO	0.93
5	MnO_2	0.01
6	TiO_2	0.69
7	K_2O	0.01
8	Na_2O	1.34
9	Fe_2O_3	3.91

2.2 GGBS

Ground-granulated blast-furnace slag is obtained in the process of quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam to produce a glassy, granular product that is then dried and ground into a fine powder. Ground granulated blast furnace slag (GGBS) is a byproduct from the iron industries. Blast furnaces are feeder with controlled mixture of coke, iron ore and limestone, and operated at a high temperature of about 1,500°C. When iron-ore, coke and limestone melt in the blast furnace, molten iron and molten slag were produced. The molten slag is lighter hence floats on the top while molten iron is deposited at bottom. The molten slag contains mostly silicates and alumina from the original iron ore, combined with some oxides from the limestone. The way toward crushing the slag includes cooling of liquid slag through high-weight water planes. This quickly extinguishes the slag and structures granular particles by and large not greater than 5 mm. The fast cooling keeps the arrangement of bigger gems, and the subsequent granular material involves around 95% non-crystalline calcium-alumino silicates. In this study the GGBS is taken from JSW steel industries.

Table -2: Chemical Composition of GGBS

Sl.no	Parameter	Percentage
1	Cao	37.34
2	Al_2O_3	14.42
3	Fe_2O_3	1.11
4	SiO_2	37.73
5	MgO	8.71
6	MnO	0.02
7	Sulphide	0.39
8	LoI	1.41
9	Insoluble resudue	1.59
10	Glass content	0.92

2.3 Basalt Fibers.

Basalt is a volcanic rock and can be chopped into small particles then formed into continues or chopped fibers. Basalt fiber has a higher working temperature and has a good resistance to chemical attack, impact load, and fire with less poisonous fumes. Some of the potential applications of these basalt composites are: plastic polymer reinforcement, soil strengthening, bridges and highways, industrial floors, heat and sound insulation for residential and industrial buildings, bullet proof vests and retrofitting and rehabilitation of structures.

Table -3: Properties of Basalt Fiber.

Properties	Value
Density	2630 kg/m³
Tensile Strength	3200 -3850 M Pa
Elastic Modulus	75-90 G Pa
Elongation at break	3.1 %
Softening Point	1050 ⁰C
Working Temperature	-260 – 650 ⁰C
Thermal Conductivity	0.0030 – 0.0036 W/m-K

2.4 Alkaline Solution

Sodium Hydroxide (NaOH) is available in the local market in pellet form 10 Molar solutions to be used. Since the molecular weight of Sodium Hydroxide is 40, and in order to prepare 10 molar solution 10 x 40= 400 grams of Sodium Hydroxide is to be dissolved in 1000 ml of water. Sodium Silicate (Na_2SiO_3) and sodium hydroxide solution with a ratio of SiO_2 to Na_2O is 2(approximately) is used. That is 34.80% SiO2, 16.51 % Na_2O and 48.69 % of water.

2.5 Super Plasticizer

MYK Remicrete PC 5 is the super plasticizer used which is high performance water reducing and super plasticizing admixture based on PCE base polymers and is supplied as a clear to light brownish liquid instantly dispersible in water.

2.6 Fine Aggregates

River sand is used as fine aggregates in this mix. Fine aggregates are tested for specific gravity, sieve analysis & moisture content. The properties of fine aggregates are given in table 4.

Table -4 Properties of Fine Aggregates

Specific Gravity	2.63
Moisture content	0.65
Fineness Modulus	7.56
Grading(IS 383-1970)	Zone 4

2.7 Coarse Aggregates

Coarse aggregates of 20 mm down size are used in this experimental work. Properties of coarse aggregates are given below.

Table -5 Properties of Coarse Aggregates

Specific Gravity	2.70
Moisture content	0.5
Fineness Modulus	2.56
Grading(IS 383-1970)	Zone 2

3. METHODOLOGY

Concrete Beam specimens for flexural strength are prepared as per IS standards. Beams of cross section 150X150 mm and length 700 mm were casted. Flexural strength of Geopolymer concrete with different basalt fibers were calculated at 7 and 28 days.

3.1 Design of Geopolymer Concrete

Based on previous studies geopolymer concrete the geopolymer concrete was designed. Sodium hydroxide of 10 molarity is used. Alkaline solution used in the ratio of 2.5 was used. Common methods of manufacturing of Geopolymer concrete used.

Table -6 Mix Design

Constituents weight	0% Fiber Mix
Fly ash (kg/m³)	245
GGBS (kg/m³)	163
Basalt fibers (kg/m³)	0
Fine aggregate (kg/m³)	554
Coarse aggregate (kg/m³)	1294
Sodium silicate (kg/m³)	103
Sodium hydroxide (kg/m³)	41
Super plasticizer (kg/m³)	6

Basalt Fibers are added at 0.5%, 1%, 1.5%, 2%, and 2.5% by the weight of cemantacious material (fly ash + GGBS) for the different Mixes. Results were noted and compared with reference mix.

3.2 Flexural Strength Test

It gives an idea about characteristics of a concrete. It is the resistance of the concrete against failure under compressive load. Flexural strength of the Geopolymer concrete depends on many factors like water/geopolymer solids ratio, concentration of NaOH (in terms of molarity), curing.

Flexural strength of the Beams at 7 and 28 days (according to IS516-1959).Beams were tested under two point load to found the split strength of GPC with various percentage of geopolymer concrete. Split tensile strength of the GPC is given in Table 6

Fig -1: Flexural Strength Test

Place the specimen centrally on the Universal testing machine and point load is applied continuously on the surface perpendicular to the direction of tamping. The load is increased until the specimen fail, the maximum load is recorded for each specimen during the test as shown in fig.1

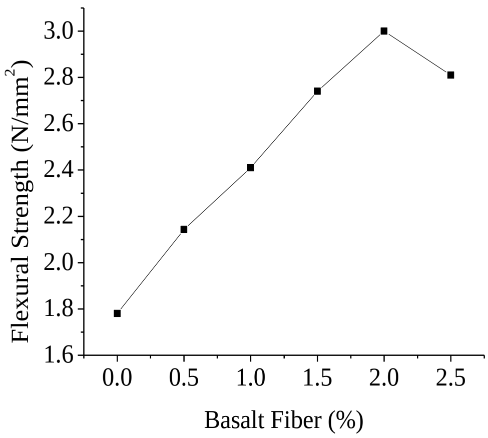

Fig -2: Variation of Flexural Strength at 7 days

Above figure shows the Flexural strength of geopolymer concrete reinforced by basalt fibers. It shows that for increase in the basalt fiber content increases flexural strength of GPC.there has been maximum increase of 67.88% flexural strength for an optimum fiber content of 2%.also for higher basalt content the specimens were sustained for greater deflection from this we can say that ductility property of the material can be increased.

Table -7 Flexural Strength results.

Basalt Fiber	Flexural Strength (N/mm²)	
%	At 7 days	At 28 days
0	1.78	2.74
0.5	2.14	3.29
1	2.41	3.71
1.5	2.74	4.22
2	3	4.6
2.5	2.81	4.32

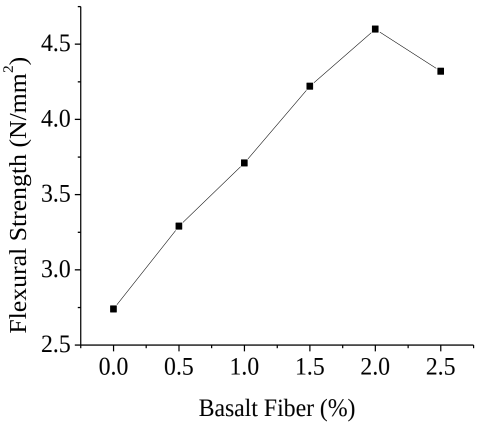

Fig -3: Variation of Flexural Strength at 28 days.

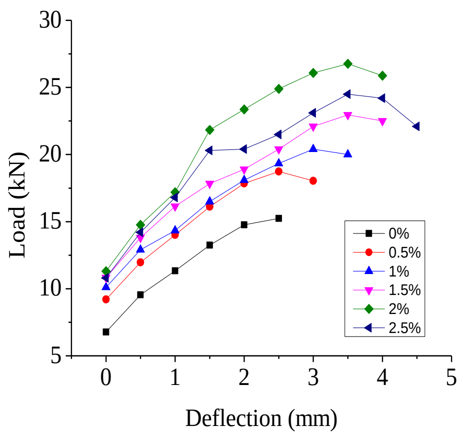

Fig -4: Load-Deflection curve for varying proportions of basalt fibers.

3. CONCLUSIONS

From the above test results the following conclusions may be drawn. When basalt fibers added to Geopolymer concrete Increase in the basalt fiber increases the Flexural strength of the concrete up to 67.88% for the basalt fiber content of 2%. After that compressive strength decreases. So addition of basalt fiber up to 2% is recommended in Geopolymer Concrete.

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