[Bhasgi, 5(7): July 2018] ISSN 2348 – 8034
DOI: 10.5281/zenodo.1310839 Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

MECHANICAL PROPERTIES OF GEOPOLYMER CONCRETE COMPOSITES REINFORCED WITH NATURAL FIBERS

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ABSTRACT

Geopolymer concrete of composites have recently become a showing sign of future ecological alternative to the conventional use cementitious materials. The geopolymer concrete are cost-effectively, friendly to environmentally and production make very small amount of energy to produced. They have good thermal properties being highly resistant to flame and heat. flash based concrete has compressive strength and durability but it have comparative to low flexural and tensile strength. This paper explain the studies of the fly ash based geopolymer concrete with reinforced with cotton, sisal, raffia and coir are used as natural fibre. The study is to analysis the impact of addition of different natural fibers on the geopolymer concrete. The actual part of the research was based on the compressive strength tests on geopolymer concrete with different molarity, compression test and flexural strength test of geopolymer concrete with fibre such as natural fibre are sisal, cotton coir and raffia fibre. The results show that the adding of sisal, cotton, coir and raffia such as natural fibers can increase the mechanical properties of geopolymer concreter composites.

Keywords: *Flyash-based geopolymers, geopolymer composites, natural fibers, cotton fiber, sisal fiber, raffia fiber, coconut fiber, ambient curing, oven curing.*

I. INTRODUCTION

The fiber-reinforced concrete composite materials, including those produced based on alkali-activated materials, play an important role in many branches of the industry area e.g., in advanced technological solutions used in the aerospace and automotive industry, naval architecture and ground transportation. The natural fibre have a lot of advantages which can in comparison to the conventional materials. by using natural fibre in concrete which improve the properties of fracture is an method for improving such mechanical properties. The fibres in concrete which reduces the cracking effect on concrete and minimize the width of crack that occurring in concrete.by using of fibre in fly ash-based concrete it absorbs all brittle behavior and enhance the ductility to concrete. The fly ash-based concrete can use for using fiber-reinforcement which increases the compression and flexural strength of composites. The natural fibers can also increase those properties of fly ash-based concrete that relate to their energy absorption and resistance to deformation. Here, the presenting of short natural may especially add in concrete to the change of the physical and mechanical properties of the geopolymer. This is a standout amongst the best methods for geopolymer cement to strengthening the impact and toughening geopolymer concrete through reinforced, particularly in light of simple fiber scattering and fiber perspective proportion. The most widely recognized fiber fortifications added to geopolymer composites are these days inorganic filaments, for example, carbon or glass fibre.

II. EXPERIMENTAL INVESTAGATION

Characterisation

The bulk density (D_b) is carried out by using the following equation:

$$D_b = \frac{M}{V}$$

Where, D_b = bulk density, M = specimen mass, and V = specimen of volume.
The calculation of porosity(D_a) was carried out by using the following equation:

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$$D_a = \left(\frac{m_1}{m_2 - m_3}\right) D$$

Where, m1, m2 and m3 = mass of the sample weighted, and D is the density of water.
Flexural tests were conducted to determine the flexural strength, flexural modulus and fracture toughness of concrete.

$$\sigma_F = \frac{3}{2}\frac{PmS}{WD^2}$$

where Pm = Maximum load, S = Span, D = thickness of specimen and W = width of specimens.

Geopolymer concrete
The flyash based concrete are made of fly ash, fine aggregate, coarse aggregate, and alkaline solution, its play a empiral role in the surrounding area to control of greenhouse gas effects. In the making of geopolymer concrete, the mix is a 100% by-product (fly ash), i.e. The ordinary Portland cement is hundred percent replaced by the flyash based concrete paste.

The morality is made of 8, 12 and 16 of mole of sodium hydroxide and combined with sodium silicate solution to form alkaline activator. The sodium hydroxide is available in flakes, so to make in solution we use water of one lit. whose modulus was 2.5 and density 1.45 g/cm^3. The Tap water is used as batching water instead of the distilled water. The solution of sodium hydroxide and sodium silicate were prepared and pour in one liter of tap water to form a alkaline solution. The solution left until it temperature became normal to room temperature and then concentration solution is mixed in fly ash and course and fine aggregate.

Material : Types of fibers and Aspect ratio

Table 1: Types of fibres

Sr No	Young's modulus Gpa)	Tensile Strength (Mpa)	Total elongation %	Length of fiber (cm)	Dia. of fiber (mm)
Coconut	4.8	400	3 – 8 %	3	0.5
Cotton	9 - 38	363-700	2 – 7 %	3	0.5
Raffia	30	500	2 – 4 %	3	0.5
Sisal	2.2 - 6	95 - 230	15 – 51.4 %	3	0.5

Flyash
Low calcium fly ash of class F is conforming from IS 3812-2003 specifications collected from Paras in District of Akola (Maharashtra) taken from Thermal power station.

Table 2: Composition of Fly Ash (mass %)

SiO2	**Al_2O_3**	**Fe_2O_3**	**TiO_2**	**CaO**	**MgO**
56.01%	29.8%	3.58%	1.75%	2.36%	0.30%

K_2O	**Na_2O**	**SO_3**	**P_2O_5**	**LOI***
0.73%	0.61%	NIL	0.44%	0.44%

ISSN 2348 – 8034
Impact Factor- 4.022

Mix proportions of different molarity.

Table 3: Geopolymer concrete mixes for different grades

Grade	Quantity of water (kg/m3) (W/GPB)	GPB (kg/m3)	Fine aggregate (kg/m3)	Coarse aggregate (kg/m3)
M20	118.20	378	727.40	1350.88
	0.313	**1**	**1.92**	**3.57**
M25	118.20	445.50	707.53	1313.97
	0.265	**1**	**1.59**	**2.95**
M30	108.35	513	690.54	1282.43
	0.211	**1**	**1.82**	**3.37**
M35	108.35	594	667.19	1239.07
	0.182	**1**	**1.12**	**2.08**
M40	98.50	661.50	649.37	1205.97
	0.149	**1**	**0.98**	**1.82**

III. PREPARATION OF SAMPLE

The specimen was prepared by using geopolymer concrete and natural fibres adding of 1% by weight of natural fiber as per aspect ratio. The solution 16M of sodium hydroxide solution were prepared and combined with the sodium silicate solution. The natural fibre such as Cotton fibre, sisal fibre, raffia fibre and coir fibre are used as a filler material in geopolymer concrete.the flyash and aggregate are taken in mechanical mixer and then alkaline solution with water is mixed so to get well homogeneous past.

IV. CURING OF GEOPOLYMER CONCRETE

The curing of cube after casting the sample is kept in mould for 3 days at room temperature and then after it demold. As the geopolymer concrete does not hard immediately as the tradition concrete get hard. Geopolymer concrete take a minimum of 3 days for the completely setting without leaving a thumb impression on the hard surface.the sample after 3 day get sufficient hard is taken for curing under ambient condition at room temperature and other cube is cured by heat at 60 C in oven for 48 hr.

V. RESULTS AND DISCUSSION

Compressive strength of geopolymer concrete

The fly ash-based concrete with different molarity are cured by two methods, the first one is curing by room temperature and second by heat curing at 60^{o}C. The result of 7 day and 28 days of compression test result as shown below.

Table 4: Compressive strength of geopolymer concrete

Spec.	Curing	Compressive Strength MPa	
		7-days	28-days
8M	ambient curing	5.64	17.81
	Oven curing	15.11	19.54
12M	ambient curing	7.46	22.34
	Oven curing	18.62	29.81

16M	ambient curing	9.01	25.72
	Oven curing	21.33	30.51

Under heat curing conditions, increasing of NaOH solution from 8 molarity to 12 molarity resulted show that the improvement of compressive strength by about 33% for 7 days & 43% for 28 days. When the NaOH solution is increased from 12 molarity to 16 molarity, then the compressive strength also increases by about 2% for both 7 days and 28 days. under ambient curing the increasing condition the NaOH solution from 8 molarity to 12 molarity resulted in increase of compressive strength by about 22% for 7 days and 47% for 28 days. When the concentration of NaOH solution is increased from 12M to 16M, the compressive strength also increases by 13% for 7 days and 18% for 28 days.

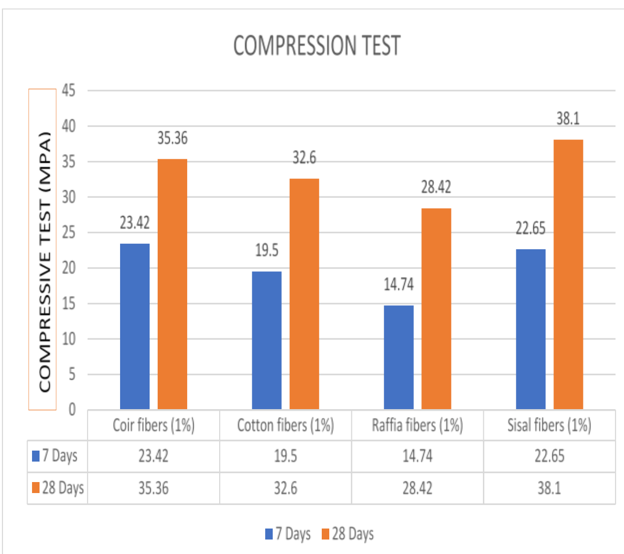
Results of the compressive strength tests

The compressive strength test was made for 28-days with natural fibre samples.

Table 5: Compressive test on geopolymer concrete with natural fibre

Sample	Compressive strength test MPa	
Days	7 Days	28 Days
Coir fibers (1%)	23.42	35.36
Cotton fibers (1%)	19.50	32.60
Raffia fibers (1%)	14.74	28.42
Sisal fibers (1%)	22.65	38.10

As compare to coir fibre to raffia fibre, the coir fibre which gain 37.06 % for 7 days and 19.62 % for 28 days more strength than the raffia fibre. The sisal fibre which gain 3.28 % for 7 days and 7.19% for 28 days more strength than coir fibre. The cotton fibre which gain 24.41% for 7 days and 12.82% for 28 days more than raffia strength. The comparation of four naturals composite fibre as show in graphically format.



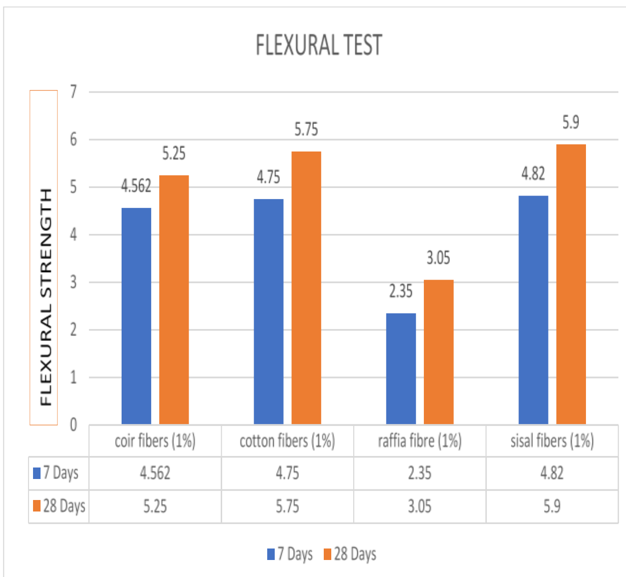
Results of flexural strength tests

The flexural strength test was made for 7 and 28-days with natural fibre samples.

Table 6: Result of Flexure Strength

Sample	Flexural Strength MPa	
Beam700x150x150mm	**7 days**	**28 days**
coir fibers (1%)	4.562	5.25
cotton fibers (1%)	4.75	5.75
raffia fibre (1%)	2.35	3.05
sisal fibers (1%)	4.82	5.90

The results show the adding of sisal fibre give 48.30% more resistant to flexural as compared to raffia fibre. The adding of 1% of fibre give result in decreased 45% as compared with other fibre due to the cohesiveness between the geopolymer matrix and fibre.



VI. CONCLUSION

The samples of geopolymer concrete with different types of natural fiber are used in 1% by mass of the composite.

1. As the concentration of NaOH solution increases simultaneously compressive strength also increase. This is applicable for all the curing temperatures, age of concrete and sources of fly ash.
2. The compressive strength test and flexural strength test with the addition of sisal fibre and coir fibers has given maximum strength of 75% in 7 days.
3. The raffia fibre and cotton fibre has reduce by 24 % in compressive strength test and flexural strength test reduce by 48 % .

4. The cotton fibre content increasing up to 1% wt. its increases the flexural strength, but it decreases the compression strength.
5. Further increase in cotton fibre content above 1%of wt. caused decrease in workability which led to the formation of voids.

Moreover, the addition of the natural fibers, such as coir, cotton and sisal fibre, can improve their compression and flexural properties. It produced good composites of relatively good properties from the industrial.

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