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MECHANICAL PROPERTIES OF GEOPOLYMER CONCRETE WITH CONCENTRATED SISAL AND COIR FIBERS

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Abstract: Geopolymer concrete is gathering on which research attention owing to its quintessential properties fire resistance, drying shrinkage, acid resistance are, mechanical and stinted heat of hydration. In comparison to conventional cement and other materials. In general it is being utilized as an alternative Portland cement concrete. Geopolymer is highly alkalized by sodium silicate and sodium hydroxide, and replaced by 40% of fly-ash and 60% ground granulated blast furnace slag. Present work transpires on investigating the mechanical properties of aforementioned concrete specimens with two concentrated fibers i.e. sisal and coir with varying percentages of 0%,0.5%,1%,1.5%. Mechanical properties such as compressive strength, spilt tensile strength and flexural strength are accentuated in this work. The results suggest that annexation of natural fibers leverages the mechanical properties of geopolymer composites. The findings of this work have serious implications that have proportional applications in construction buildings.

Keywords: Geopolymer concrete, GGBS, Natural fibers, Sisal fibers, coir fibers.

1. INTRODUCTION

Geopolymer concrete is an innovative binder material produced by totally replacing Portland cement, thus helps to reduce in the global warming (Davidovits, 2005). Geopolymer concrete is an alkali-activated binder produced by a polymeric reaction of alkaline liquids with the silicon and the aluminum oxides in source materials of geological origin like metakaolinite (calcined kaolinite) or by-product materials such as fly ash ,rice husk ash and ground granulated blast furnace slag. By the activation of alumina-silicate materials such as fly ash, blast furnace slag and metakaolin using alkaline solutions to produce binders free of Portland cement is being advance towards in increasing the beneficial use of industrial waste products and reducing the impact of cement production. Kolli Ramujee et.al investigated that the mechanical properties of geopolymer concrete are activated with different molarities of sodium hydroxide is 8M-16M and alkaline to liquid binder ratio in between 0.40-0.60. The specimens are made out from lower grade to higher grade. The study of mechanical properties of geopolymer concrete were carried out [1].Teja Kiran Kumar et.al, investigated the behavior of coir fiber as a replacement in geopolymer concrete. Low- calcium fly ash used as the production of geopolymer concrete .Fibers with different percentages was taken i.e. 0%, 0.75%, 1.5%, 2.2.5%, and 3%. The various strength was tested at various ages i.e. 7,14 and 28 days [2]. Lateef N. Assi et.al, investigated the effects of activating solution type, curing procedure, and source of fly ash in relation to the resulting compressive strength of fly ash-based geopolymer concrete. The fly ash-based geopolymer paste microstructure was observed and density, absorption and voids were measured. Two activating solutions were used: a) a mixture of sodium hydroxide, silica fume, and water; b) a mixture of sodium hydroxide solution, sodium silicate, and water. The use of silica fume based activating solution resulted in higher compressive strength values as compared to similar specimens cast using sodium silicate based on activating solution [3]. Pusit Lertwattanaruk et.al investigated to develop fiber cement products made from natural materials, including coconut coir fiber and oil palm fiber, to be used as roof sheets and wall panels. The choice of material is expected to be widely used in the markets. commercially available fiber cement tiles are produced using combination of natural and synthetic fibers, which have similar properties compared with other types of roof sheets and are often more durable, with better impact resistance and heat insulation compared to asbestos cement roof sheets[4] . Libo Yan, et,al experimental work on the use of coir fibers as reinforcement in concrete and flax fibers as reinforcement for fiber reinforced polymer composites as concrete confinement for structural applications. The new FFRP-CFRC composite structure is expected to have good performance as axial and flexural structural members [5].

2. MATERIALS USED AND EXPERIMENTAL PROCEDURE

2.1 Materials

2.1.1 Fly-Ash:

It's a byproduct of coal combustion in thermal power plants. In this class F fly ash is used brought from Panyam cement industry located near Nandyal, Kurnool district Andhra Pradesh. Specific gravity of fly ash 2.20, fineness of fly ash 8.5

2.1.2 GGBS:

Ground granulated blast furnace slag (GGBS) is a byproduct of blast furnace in iron molten slag. In this GGBS is obtained from Raja Rajeshwari ready-mix plant located in Kurnool, Andhra Pradesh. Specific gravity of GGBS 2.9 and fineness of GGBS 9.

2.1.3 Alkaline Activator Solution**:** The alkaline activator solution is a major role in the geopolymer concrete. The alkaline activator solution is the combination of sodium hydroxide and sodium silicate or potassium hydroxide and sodium silicate. Sodium hydroxide pellets are used as the activator in geopolymer concrete. The solution must be prepared before 24hrs of use.

2.2 Aggregates

2.2.1 Coarse Aggregates : In this work C.A is used which were downgraded of 20mm nominal size and angular shape brought from local crushing units. Physical properties of coarse aggregate are shown below table.1.

Table.1 Properties of coarse aggregates

Property	**Result**
Bulk density	1580KN/m^3
Specific gravity	2.80
Water absorption	0.5%
Crushing value	13.4%
Impact value	13.20%

2.2.2 Fine Aggregates: In this work F.A is used which was downgraded of 4.75mm nominal size. It is collected from the bed of Tungabhadra River. Physical properties of F.A are shown below table 2.

Table .2 Properties of fine aggregates

Property	**Result**
Bulk density	1674 KN/m^3
Specific gravity	2.62
Fineness modulus	3.2%
Zone	II

2.3 Chemical Admixture: Super plasticizer is the main use of water reducing agent and improves workability factors. Poly Carboxylite ether based (Glenium B-233) S.P is used in this present study. Physical properties of S.P are shown below table 3.

Table .3 Properties of chemical admixture

Properties	**Result**
Appearance	Light brown colored liquid
Specific gravity	1.08
P.H	6.9
Type	Poly Carboxylite ether

2.4 Natural Fibers

The use of natural fibers in making concrete is recommended several types of the fibers are locally available such as sisal fiber, coir fiber, jute fiber and bamboo fiber etc. In this work sisal and coir fibers is used.

2.4.1 Sisal Fiber :Sisal fiber is extracted from the leaves of Agavaceae i.e. sisal plant. These fibers are first washed with water and dried at room temperature, and concentrated with 0.1M of NAOH, and then cut in the size of 20mm.

Fig.1 Before concentration

Fig.2 After concentration

2.4.2 Coir Fiber: Coir fibers are extracted from the husk of coconut .These fibers are first washed with water and dried at room temperature, and concentrated with 0.1M of NAOH, and then cut in the size of 20mm.

Fig.3 Before concentration

Fig.4 After concentration

2.5 Experimental Details

2.5.1 Objective: Geopolymer concrete based on GGBS and fly-ash is added with different percentages of natural fibers. GPC with natural fibers, trial mixes were carried out by using trial and error method. In this study is to achieve good mechanical properties and workability. The mix proportions of geopolymer concrete are shown below table 4.

2.5.2 Mixing, Casting, Curing: The components of GPC i.e., GGBS ,Fly ash, natural fibers, coarse aggregates and fine aggregates are added in the pan mixture and mixed for 4min. The alkaline activator and S.P is added and mixed for 2mins. After the mixing, the fresh concrete is poured in the moulds i.e. cubes, cylinders and beams. No special curing is done, the sample are just kept in room temperature.

3. RESULTS AND DISCUSSIONS

The workability, compressive strength, tensile strength and flexural strength of the plain GPC with natural fibers properties were tested. In this study, plain GPC is designed and added two different natural fibers at different percentages. The fresh and hardened properties of concrete are tested and the results are given in table.5. To find the optimum replacement of natural short fiber compressive strength of cubes, split tensile strength of cylinders and flexural strength of beams are tested at 28 days.

Table .4 Mix Proportions

Mixes		**M-1**	**M-2**	**M-3**	**M-4**	**M-5**	**M-6**	**M-7**
Designation		GPC	$GPCS_{0.5}$	$GPCS_{1.0}$	$GPCS_{1.5}$	$GPCC_{0.5}$	$GPCC_{1.0}$	$GPCC_{1.5}$
GGBS(Kg/m^3)		331.2	331.2	331.2	331.2	331.2	331.2	331.2
FLYASH(Kg/m^3)		220.8	220.8	220.8	220.8	220.8	220.8	220.8
NAOH(Kg/m^3)		52.57	52.57	52.57	52.57	52.57	52.57	52.57
NA_2SIO_3(Kg/m^3)		131.43	131.43	131.43	131.43	131.43	131.43	131.43
C.A(Kg/m^3)		979.44	979.44	979.44	979.44	979.44	979.44	979.44
F.A(Kg/m^3)		868.56	868.56	868.56	868.56	868.56	868.56	868.56
WATER(Kg/m^3)		-	-	-	-	-	-	-
S.P(Kg/m^3)		5.52	5.52	5.52	5.52	5.52	5.52	5.52
N.FIBER %	**S.F**	-	0.5	1	1.5	-	-	-
	C.F	-	-	-	-	0.5	1	1.5
N.F(Kg/m^3)	**S.F**	-	2.76	5.52	8.28	-	-	-
	C.F	-	-			2.76	5.52	8.28

Table 5. Fresh and Hardened Properties of GPC using N.F

Mixes	**Fibres percentage**		**Designation**	**Workability (compaction factor)**	**Compressive Strength (N/mm^2)**	**Tensile Strength (N/mm^2)**	**Flexural strength (N/mm^2)**
	Sisal	**Coir**					
M-1	-	-	GPC	0.92	58.55	3.06	4.90
M-2	0.5	-	$GPCS_{0.5}$	0.942	71.25	3.105	3.68
M-3	1	-	$GPCS_{1.0}$	0.956	73.81	4.24	5.45
M-4	1.5	-	$GPCS_{1.5}$	0.958	63.40	3.283	2.34
M-5	-	0.5	$GPCC_{0.5}$	0.943	73.63	3.99	5.065
M-6	-	1	$GPCC_{1.0}$	0.955	71.25	3.71	3.75
M-7		1.5	$GPCC_{1.5}$	0.96	66.81	3.21	2.49

From the above tabular column, the optimum is selected and natural fibers are added at different volume percentages. In the above mixes it is observed that sisal fiber content of 1% and 0.5% of coir fiber got better workability compared to other mixes and also in the hardened properties as shown above.

3.1 Workability

Workability may increase or decrease when fiber is added to plain concrete. Workability of GPC with natural fibers, 0.5% coir and 1% of sisal fiber has better workability compared to other percentages of sisal and coir fiber. The variation is shown in below fig.5

3.2 Compressive Strength

Compressive strength of GPC using natural fibers is shown below fig. Mix-1 is plain GPC and Mix-2 is addition of 0.5% S.F shows little improvement in compressive strength when compared to plain GPC. Mix-3, addition of 1% S.F shows better improvement when compared to Mix-2. Mix-4 is addition of 1.5% S.F has decreased when compared to other mixes. Mix-5 is addition of 0.5% C.F shows good improvement when compared to Mix-6 i.e. 1% C.F. By addition 1.5% C.F reduces the strength when compared to other mixes. Compressive strength variations are shown in fig 6.

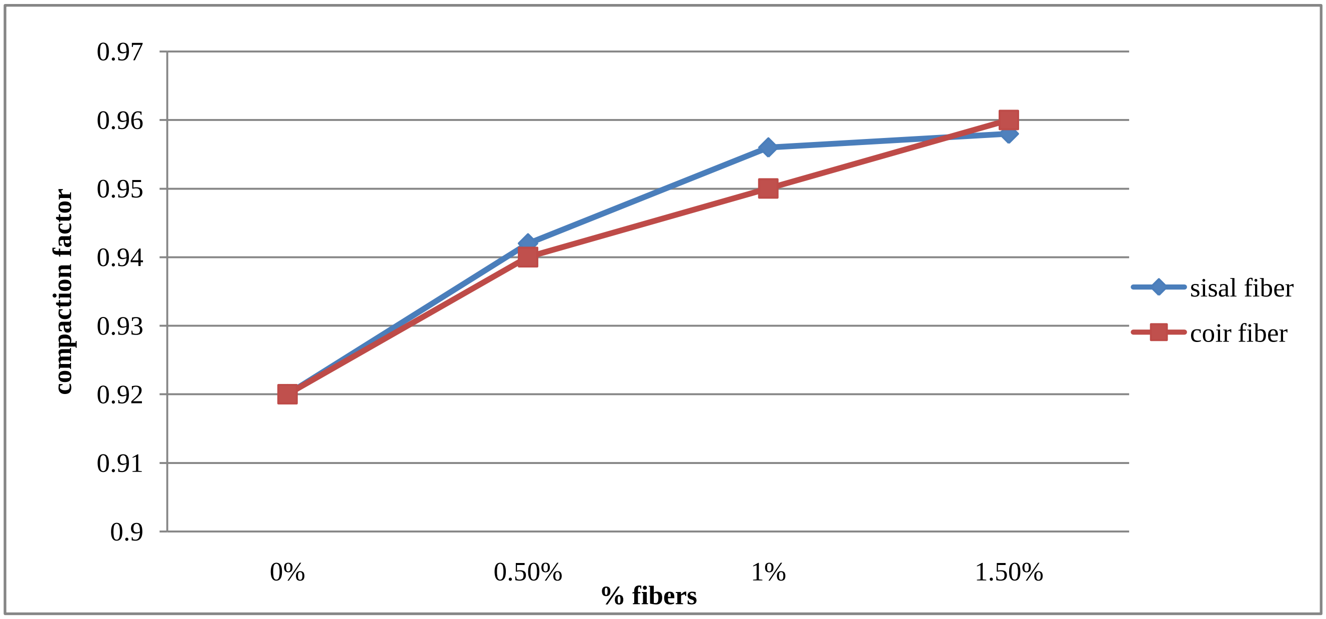

Fig 5.Compaction factor variation with different percentages of fibers

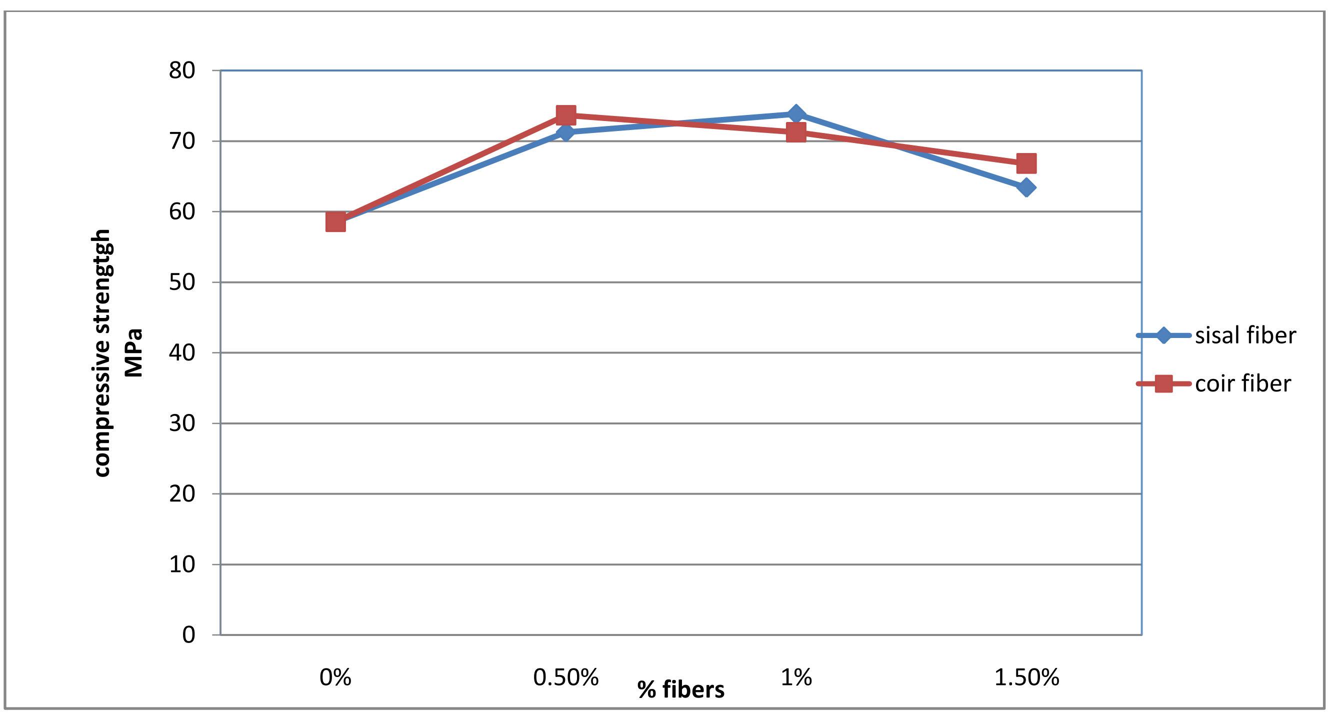

Fig 6.Compressive strength variation of sisal and coir fibers

3.3 Tensile Strength

Tensile strength of GPC using natural fibers is shown below fig. Mix-1 is plain GPC and Mix-2 is addition of 0.5% S.F shows little improvement in tensile strength when compared to plain GPC. Mix-3, addition of 1% S.F shows better improvement when compared to Mix-2. Mix-4 is addition of 1.5% S.F has decreased when compared to other mixes. Mix-5 is addition of 0.5% C.F shows good improvement when compared to Mix-6 i.e. 1% C.F. By addition 1.5% C.F reduces the strength when compared to other mixes. Tensile strength variations are shown in table no.7

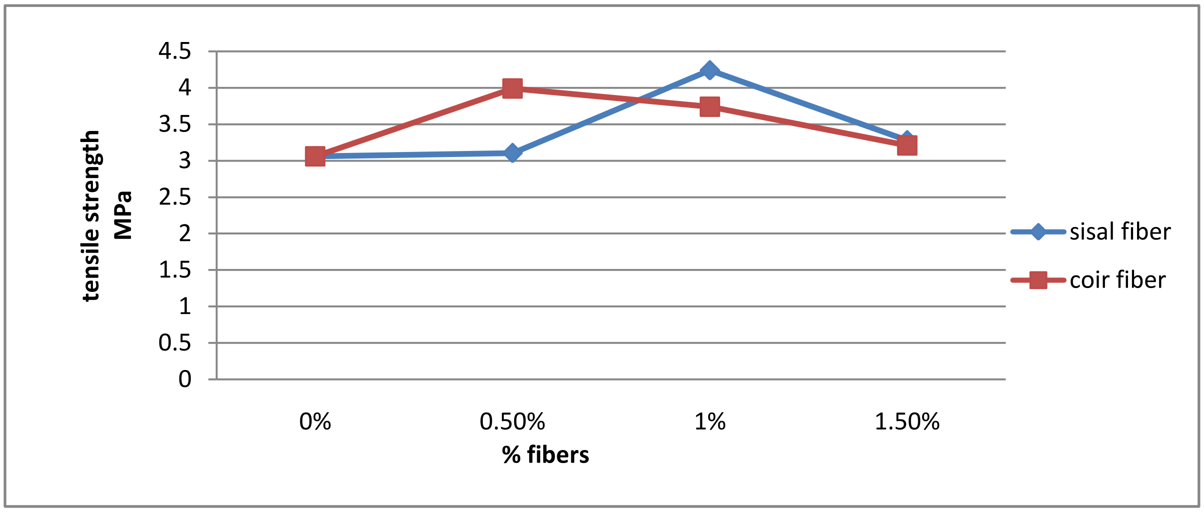

Fig 7.Tensile strength variation of sisal and coir fibers

3.4 Flexural Strength

Flexural strength of GPC using natural fibers is shown below fig. Mix-1 is plain GPC and Mix-2 is addition of 0.5% S.F shows little improvement in flexural strength when compared to plain GPC. Mix-3, addition of 1% S.F shows better improvement when compared to Mix-2. Mix-4 is addition of 1.5% S.F has decreased when compared to other mixes. Mix-5 is addition of 0.5% C.F shows good improvement when compared to Mix-6 i.e. 1% C.F. By addition 1.5% C.F reduces the strength when compared to other mixes. Flexural strength variations are shown in fig .8.

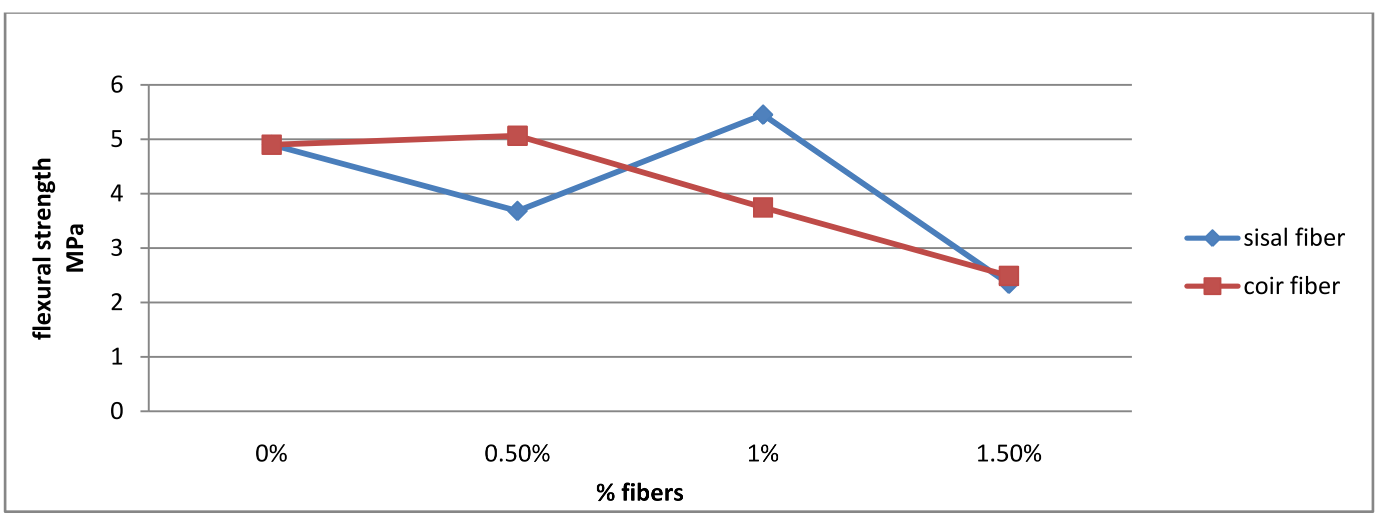

Fig 8. Flexural strength variation of sisal and coir fibers

4. CONCLUSION

Geopolymer concrete with natural fibers have been produced and tested. The following conclusions are given below.

- By adding 0.5% S.F to concrete shows the brittle improvement on mechanical properties.
- The addition of 1% S.F to concrete shows the better improvement of mechanical properties. When compared to 0.5% of S.F
- By adding 1.5% S.F to concrete shows the reduction of mechanical properties.
- By adding 0.5% C.F shows better improvement on mechanical properties of concrete when compared to 1% C.F.
- By addition 1.5% C.F to GPC shows the reduction of mechanical properties.
- 1% Sisal and 0.5% Coir fibers shows good mechanical properties, compared to plain GPC
- These results show that it is possible to propose a composite with natural fibres that combines good mechanical properties.

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