Experimental Analysis on Effect of Steel Fibers on High Strength Geopolymer Concrete

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Abstract

Not only is cement production very energy intensive, it also consumes a significant amount of natural resources. On the other hand, a large volume of volatile flyash is already creating around the world, most flyash are not effectively used, and much of it is deposited in landfills both issues are addressed in this paper. This study gives the resultants of an experimenting research on the mechanical properties of geopolymer compounds contain 70% flyash, 30% GGBFS, alkali fluids & steel fibers. The review analyzes effects of steel fibers on mechanical properties tests of FRGPC. The blends were prepared with an alkali solution to binder ratio of 0.4 with 30% flyash supplanted by GGBFS on a massive basis. Steel fibers were added to blend in the volume fractions of 0.5%, 0.75%, 1%, 1.25% and 1.5% by volume of cementitious material. The results of the mechanical tests obtained after 7 and 28 days of environmental curing indicate that included incorporation of fiber in GPC there is only a light increase in the compressive strength. In contrast, SplitTensile strength and flexure strength increase significantly and the water penetration experiment also shows that the FRGPC specimen is durable. The two limitations of GPC, such as the retard in setting time & the need for temperature hardening to increase strength were also eliminated by replacing 30% of fly ash per GGBFS in the GPC mixture.

Keywords: Geopolymer, Fly ash, Ground Granulated Blast Slag, Aggregates, Steel fibers, Ambient Curing

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I. INTRODUCTION

Geopolymer concrete (GPC) is an innovative, ecofriendly construction material. It is utilized as substitution of cement concrete. In GPC, cement is not utilized as binding material. Flyash, silica fumes, Ground granulated blast furnaces slag (GGBFS), rice-husk along with alkali solution are utilized as binders. Where utilizing of OPC is most consumed commodity in the world after water. OPC additionally the most vitality concentrated material. Cement production leads to high CO2 discharges. 1Ton of CO2 is produced for energy, 1Ton of cement. OPC produced by calcination of limestone & burning of fossil fuels.

II. EXPERIMENTAL DETAILS

A. *Materials:*

Fly ash used for geopolymer concrete was low-calcium fly ash (ASTM class F) which was obtained from raichur thermal power plant. Ground granulated blast slag was collected from nearest steel plant. Aggregates constitute 75 to 80% of the mass of G.P.C. Coarse aggregates taken for these experimental works were 20mm down size. The aggregates were kept in water for saturation and saturated surface dry conditioned aggregates were used while casting the specimens. Fine aggregates passing from 4.75mm sieve size were taken for this experimental work and fine aggregates conforms to IS-383-1970 comes under zone II. Aggregates were taken from locality of Bidar district. Sodium Hydroxide was obtained in the form of flakes and is made to solution using water. Sodium silicate was obtained in the form of solution which was made to mix with sodium hydroxide. The sodium silicate solution with a ratio of SiO2 to Na2O is 2.0 was used. steel fibers was used in the GPC by varying percentage 0.5%,0.75%,1%,1.25% and 1.5% by weight of cementitous material. The Conplast SP 430, it used to enhance the workability of the concrete, this was obtained from SV Enterprises, Secunderabad Hyderabad.

B. *Preparation of solution for Geopolymer concrete:*

Sodium hydroxide which was obtained as a pellet was made to a solution using tap water. Based on the previous works the molarity for sodium hydroxide was set to 14M [8]. To prepare sodium hydroxide solution of 14 Molarity (14M), 560 gram of sodium hydroxide flakes was dissolved in one litre of tap water. Reaction of sodium hydroxide with water liberates heat. Sodium silicate solution is added to the prepared sodium hydroxide solution after 15 minutes and is well stirred to form a complete mix.

C. Mix Proportioning:

Fly ash was replaced in the range of 30% by GGBS of total binder content. The ratio of sodium silicate to sodium hydroxide was 2.5 and kept constant. The ratio of alkaline activator to the total binder was made to keep constant at 0.4. The above ratio was used for all the replacement mixtures. Water was added if workability was required.

Alkaline Sloution to Binder ratio (L/B)	*(flyash+GGBS) = 394.285 kg/m^3*	*Fine Aggregate = 554.4 kg/m^3*	*Coarse Aggregates = 1293.6 kg/m^3*
0.4	*1.46*	*2.47*	*0.45*

D. Mixing and Casting:

The alkaline activator was prepared a day before mixing of the solution. First the flyash, slag, % of steel fibers and aggregates were dry mixed for 2-4 minutes. The prepared alkaline activator was then mixed with dry mix and wet mixing was done for about 5 minutes. Extra water was only when workability was demanded. Then the geopolymer concrete was poured into the moulds and was compacted with tamping rod/vibrating table machine. Then the top surface is well finished. The sizes of the moulds used were cube (150mm x150mm x150mm), cylinder - (150mm dia and 300 mm height), prism - (500 mm x 100 mm x 100 mm).

E. Curing:

The moulds were then demoulded after 24 hours and were placed in room temperature until testing, it's the ambient curing.

III. RESULT AND DISCUSSIONS

A. Compressive Strength:

Compressive experiment is the most widely recognized of all tests on harden concrete. It is used to calculate the potential strength of concrete. In this study, GPC &FRGPC are used to test the compression strength. The load at which sample finally fails is recorded as accordance to IS:516-(1959). [9]

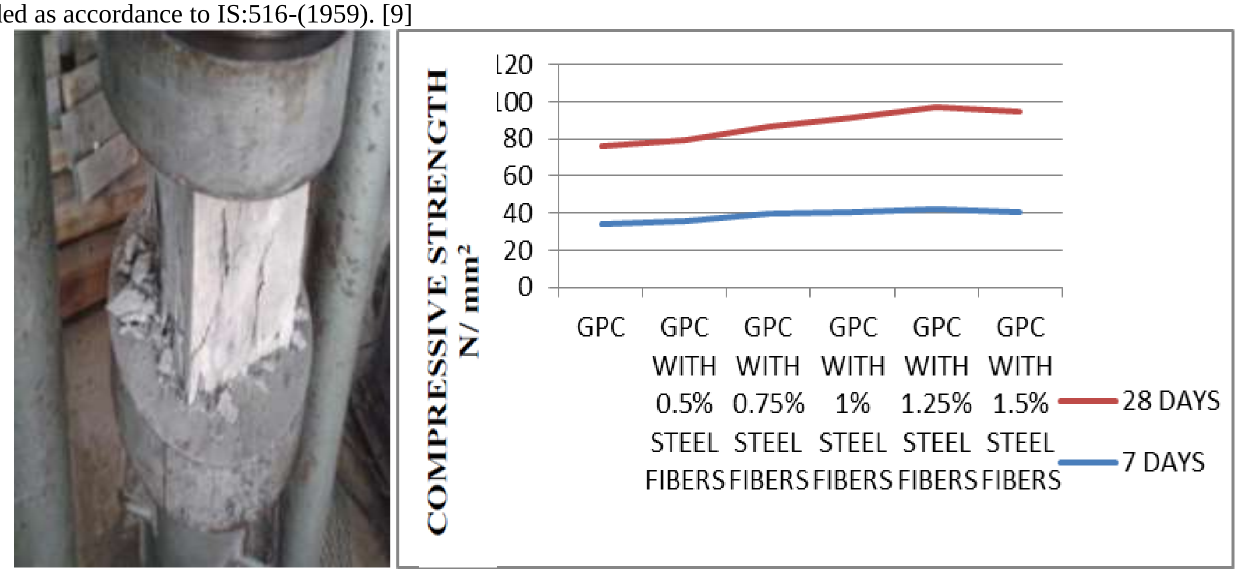

Fig. 1: Graph shows the comparison of 7 and 28 days of compression strength

B. Split Tensile Strength:

Split Tensile Strength is one of essential & vital characteristics of concrete. Information of its esteem is needs for designs of concrete structural components subjected to transverse shear, torsional, shrinkage & heat impacts, dimension of experiment sample utilized is 150mm diameter & 300mm deep. Samples were tried according to IS-5816-1970. Load at which regulate sample extremely failure is recorded.

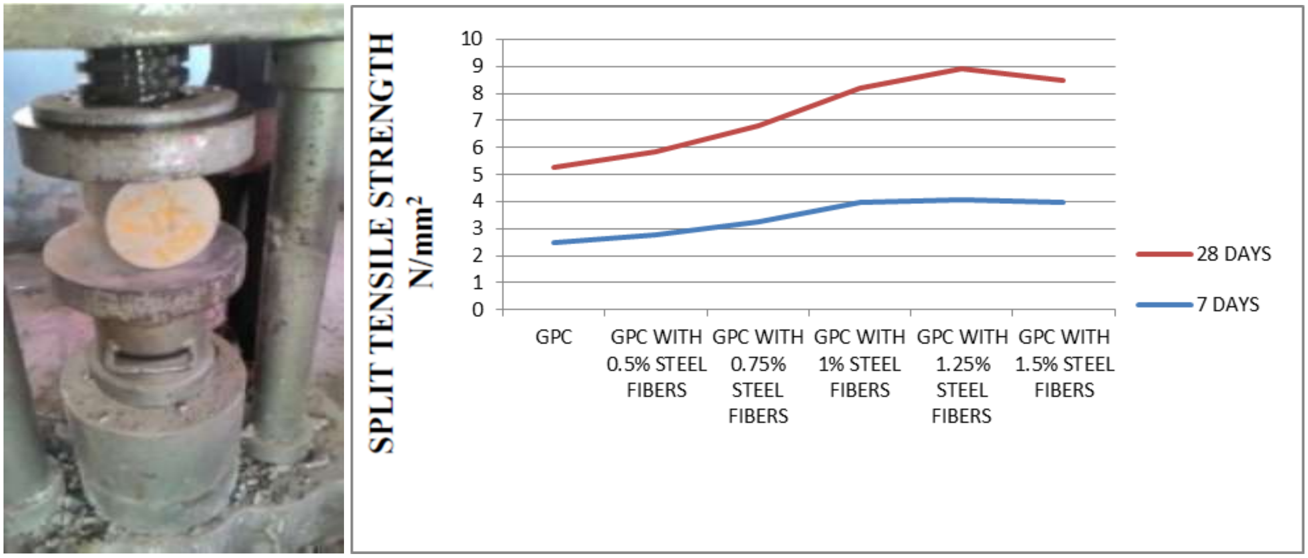

Fig. 2: Graph shows the comparison of 7 and 28 days of split tensile strength

C. Flexural Strength:

The Flexural Strength experiment is done according with IS – 516 - 1959. As per code size of the specimen used is 10*10*50 cm. [9]

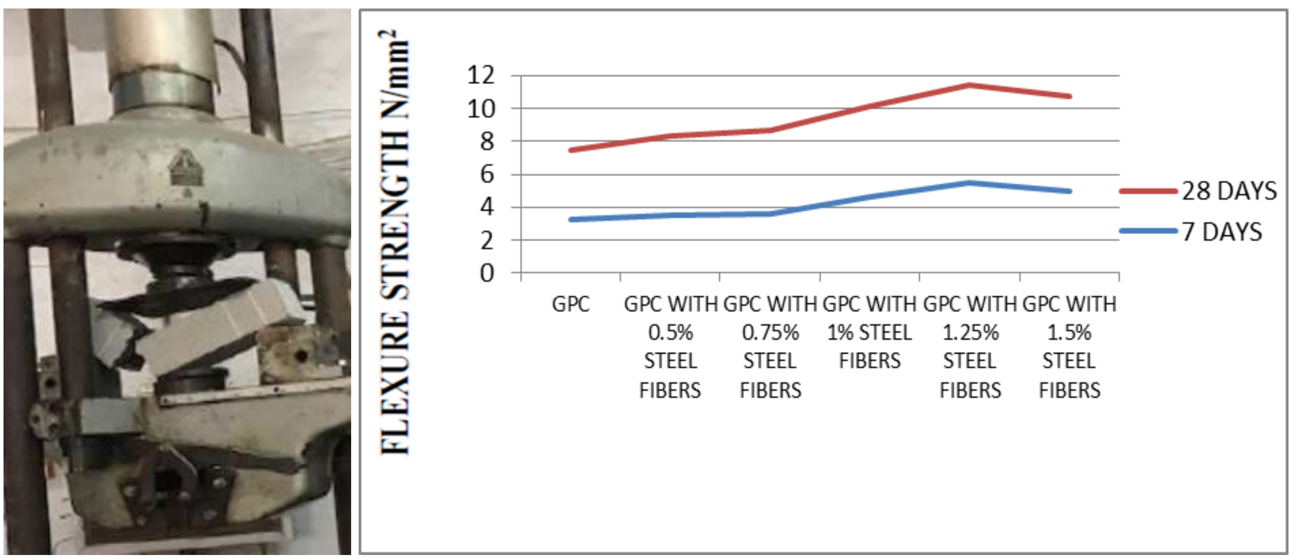

Fig. 3: Graph shows the comparison of 7 and 28 days of flexure strength

D. Water Penetration Test:

The water is connected under weight to the surface of the hardened concrete. The sample is separated and the depth of penetrates of the coastline is measured. Water pressure can be applied to the sample surfaces from the top. The hermetic seal must be provided, made of rubber pad, etc. The sample indicates approximate 1/2 the length edge. The water pressure should be kept 5kg / cm2. The maximum depth of penetration expressed in mm is the result of the test. If maxi. height of penetration is more than 25mm, sample is not durable. If depth of penetration is less than the 25mm, the specimen is said to be durable as per BS EN 12390-PART 8:2009 or as per german standard (DIN):(Part-5):(1048).

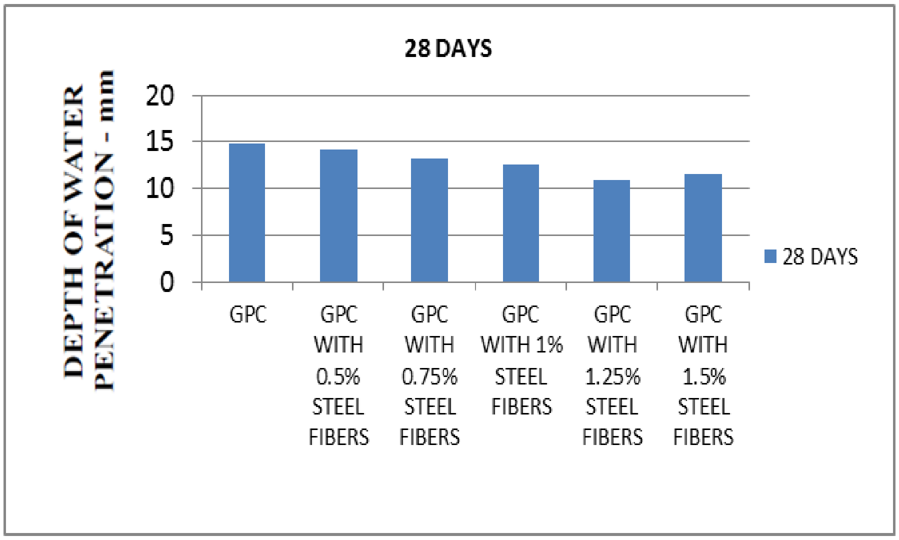

Fig. 4: Graph water penetration test

IV. Conclusion

1) From the experimental investigation with GGBFS replaced 30% by flyash, along with additional steel-fibers varies 0.25%, 0.5%, 0.75%, 1%, 1.25% and 1.5% with the Geopolymer concrete(GPC).
2) Maximum strength results were obtained from GPC with 1.25% of steel fiber.
3) The optimum/maximum compressive strength was 42.39 N per mm2 at 7 days and 55.18 N per mm2 at 28 days curing.
4) The increase in optimum compression strength was 25.22% at 7 days curing and 29.56% at 28 days curing when it is compared to GPC without Steel-fibers.
5) The optimum/maximum split tensile strength was 4.09 N per mm2 at 7 days and 4.81 N per mm2 at 28 days curing.
6) Increases of split tensile strength were 64.91% at 7 days curing and 73.64% at 28 days curing when it is compared to GPC without Steel fibers.
7) The optimum/maximum flexure strength was 5.47 N per mm2 at 7 days and 5.93 N per mm2 at 28 days curing.
8) Maximum flexural strength results were also obtained at GPC with 1.25% of steel fibers and the increases optimum flexure strength was 69.34% at 7 days and 38.87% at 28 days curing
9) The optimum/maximum water permeability test was 11.0 mm at 28 days curing and kept under penetration cell for 3 days.
10) The two limitations of GPC such as Delay in setting time and Necessity of heatcuring to gain strength and cementitious material was eliminated by replacing 30% of flyash by GGBFS in GPC mix.
11) Fiber Reinforced Geopolymer Concrete (FRGPC) mixes and cured at ambient temperature are able to produce the high compressive strength of 40MPa & 50Mpa
12) Tensile strength and flexural strength of FRGPC marginally increases as a compressive strength.
13) It is clear that there is no need to expose GPC to a high temperature to achieve maximum strength. If 30% of the flyashes is replaced by GGBFS

V. Future scope

1) Study of the corrosion aspect of the geopolymer concrete is failing for its use in the construction of RCC forms
2) From this study, GPC is very comfortable for prefabricated forms due to quality control over the needs of the curing process and requires expert management of the man with care
3) Environmental curing should be done to GPC without any heat treatment
4) The durability study can be analyzed with organic acids, since most contain more organic acids.
5) Elastic properties such as Poissons Ratio and modulus elasticity can be studied beyond the elastic limit
6) Requires less experience in design and handling during construction.

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