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"COMPARITIVE STUDY OF MECHANICAL PROPERTIES OF GEOPOLYMER CONCRETE WITH STEEL FIBERS AND POLYPROPYLENE"

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ABSTRACT: This paper presents the relative results of an experimental investigation on the mechanical properties of Geopolymer concrete (GPC), Geopolymer Concrete Composites (GPCC) containing 30% Fly ash (FA), 70% Ground Granulated Blast Furnace Slag (GGBS). Sodium based alkaline liquid is used as an activator. The study also analyses the impact of steel fibers and polypropylene fibers on the workability and mechanical properties of GPCC. Steel fibers were added to the mix in the volume fractions of 0.25%, 0.5%, 0.75% ,1%,1.25% and 1.5% volume and polypropylene fibers 1% to 5% of the concrete. From the results it is observed that as the age of concrete increases the mechanical properties of GPCC are found to be improving significantly. Inclusion of steel fibers resulted in improved compressive and flexural strengths at the early ages. However tensile strength is found to be improved significantly at later stages.

Keywords- geopolymer, compressive strength, tensile strength, flexural strength, steel fibers.

I. INTRODUCTION

Ever growing applications of concrete in theareas of infrastructure, transportation, and habitation have greatly prompted the development of civilization, economic progress, stability and the quality of life . It is well known fact that concrete consumes huge quantities of virgin materials, production of its principal binder, cement leading to emission of green house gases. The structures suffer from lack of durability. These problems rendered the concrete construction industry to search for sustainable resources. During the last couple of decades alkaliactivated binders are increasingly receiving the worldwide interest in light of the ongoing emphasis on sustainability. Zongjin Li *et al.*, termed the geopolymers as sustainable cementitious materials due to their being energy efficient and environment friendly.

The source materials used for producing geopolymer composites could be natural minerals such as kaolinite, clays, etc. or industrial by-products such as fly ash, silica fume, slag, etc. Hardjito. D and Rangan B.V have explored extensive investigation on the development and properties of fly ash geopolymer concrete. Not only the mechanical properties of geopolymer concrete are superior to the conventional concrete but it undergoes low creep and very little drying shrinkage. Geopolymer concrete is found to be excellent in resisting acid attack. Previous researchers also proved that heat cured geopolymers exhibits better resistance to sulphate attack. Studies by Li and Xu proved that geopolymer exhibits better durability and excellent mechanical properties.

1.1 OBJECTIVES

- To study the effect of alkaline to fly ash ratio.
- To study the effect of varying molarity of NaOH.
- To study the effect of addition of steel fibres to Geopolymer concrete.
- To study the durability characterstics of Geopolymer concrete by conducting various tests.

II. METHODOLOGY

In the present study, the materials used wereClass F Fly ash and GGBS collected from locally available source NTPC Visakhapatnam, India and Toshali Cements Pvt. Ltd, Visakhapatnam, A.P, India, respectively.

2.1. Materials characterization

The physical properties and chemical composition of the fly ash and GGBS are given in Table 1. and Table 2. respectively. For preparing activator solution, Sodium hydroxide (pellets 97-98% purity) and Sodium silicate solution with specific gravity of 1.39 is used. The chemical composition of sodium silicate solution is: Na2O= 10.2%, SiO2 = 27.3% and water 62.5% by mass.

Locally available sand and aggregates are used. Specific gravity of fine and coarse and fine aggregates is in the range of 2.66 and 2.67 respectively. Tap water was used in preparing alkaline solution. Steel fibers used in this investigation are
of flat crimped cross section with 1.2mm thick and 60mm long.

Physical Property	Fly ash	GGBS
Specific gravity	1.91	2.9
Fineness (m2/kg)	365	416

Table-1: Physical properties of fly ash and GGBS.

Chemical composition (%)	fly ash	GGBS
Al_2o_3	32.4	16.3
Fe_2o_3	4.04	0.68
Sio_2	58.1	34.4
Mgo	0.71	8.83
So_3	0.12	1.44
Na_2o	0.17	0.22
Chlorides	0.02	0.01
L.O.I[a]	0.85	0.19
Cao	1.4	34.6

Table-2: Chemical composition of fly ash and GGBS.

2.2 Mix design of GPC

For all geopolymer concrete mixes M40 grade mix proportions are considered according to the mix design procedure adopted by B V RANGAN.,. The mix proportions used for M40 grade are given in Table 3.

Mix No	Fly ash Kg/m³ (30%)	GGBS Kg/m³ (70%)	Sand Kg/m³	Coarse aggregates kg/m³	NaOH Kg/m³	Soduim silicate	Alkaline to fly ash	Water/ GPS
1	121	285	554	1294	49	97	0.35	0.2
2	118	276	554	1294	53	105	0.4	0.215
3	114	266	554	1294	57	115	0.45	0.237

Table-3: Mix proportions of GPC.

For preparing geopolymer concrete composites (GPCC) the ingredients used are fly ash, ground granulated blast furnace slag (GGBFS), coarse and fine aggregate, activator solution consists of sodium silicate and sodium hydroxide solution of concentration 16M and some excess water. 30% of fly ash used for making GPC is replaced by slag. Mix prepared with 30% fly ash and 70% GGBFS is designated as GPCC. The steel fibers and polypropylene fibers are added in the volume fractions of 0.25%, 0.5%,0.75%, 1%,1.25% and 1.5% volume of the concrete. The corresponding mixes are designated as GPCC1, GPCC2 and GPCC3, GPCC4 and GPCC5 respectively.

2.3 Mix design of GPCC

For all geopolymer concrete composite mixes M40 grade mix proportions are considered. The mix proportions used for M40 grade of GPCC mix are detailed in Table 4.

Mix No	Fly ash (30 %)	GGBS (70 %)	sand	aggregates	NaOH		Soduim silicate	Alkaline to fly ash	Water to GPS
					mass	molarity			
1	121	285	554	1294	49	8	97	0.35	0.2
2	121	285	554	1294	49	12	97	0.35	0.18
3	121	285	554	1294	49	16	97	0.35	0.162
4	118	276	554	1294	53	8	105	0.4	0.215
5	118	276	554	1294	53	12	105	0.4	0.198
6	118	276	554	1294	53	16	105	0.4	0.195
7	114	266	554	1294	57	8	115	0.45	0.237
8	114	266	554	1294	57	12	115	0.45	0.22
9	114	266	554	1294	57	16	115	0.45	0.202

Table-4: Mix proportions of GPCC with different molarity.

2.4. Curing regime

Mixes prepared with the combinations of fly ash and slags are cured at ambient temperature.

III. RESULTS AND DISCUSSION

3.1 Compressive strength

From Figure 1. it can be observed that at the age of 3days the development of strength in GPCC under ambient curing is very less compared to GPC under heat curing. The rates of increase in the compressive strengths of GPC and GPCC from 3 days to 7 days are found to be 21%, 187%, respectively. 28 days compressive strength of GPCC is greater than compressive strength GPC under heat curing. The increment in the compressive strength of GPC and GPCC from 7 days to 28 days is found to be 12% and 91%, respectively. So here an attempt is made to include fibers to increase the strength of GPCC even at early ages.

Mix No	Compressive strength		Special features	
	3 days	7 days	molarity	AL/FA
1	17.11	23.86	NaOH(8M)	0.35
2	28.21	32.84	NaOH(12M)	0.35
3	30	39.15	NaOH(16M)	0.35
4	18.22	21.73	NaOH(8M)	0.4
5	27.2	31.24	NaOH(12M)	0.4
6	31.6	38.65	NaOH(16M)	0.4
7	15.95	20.10	NaOH(8M)	0.45
8	26.31	30.54	NaOH(12M)	0.45
9	32.63	36.40	NaOH(16M)	0.45

Table-5: Compressive Strength.

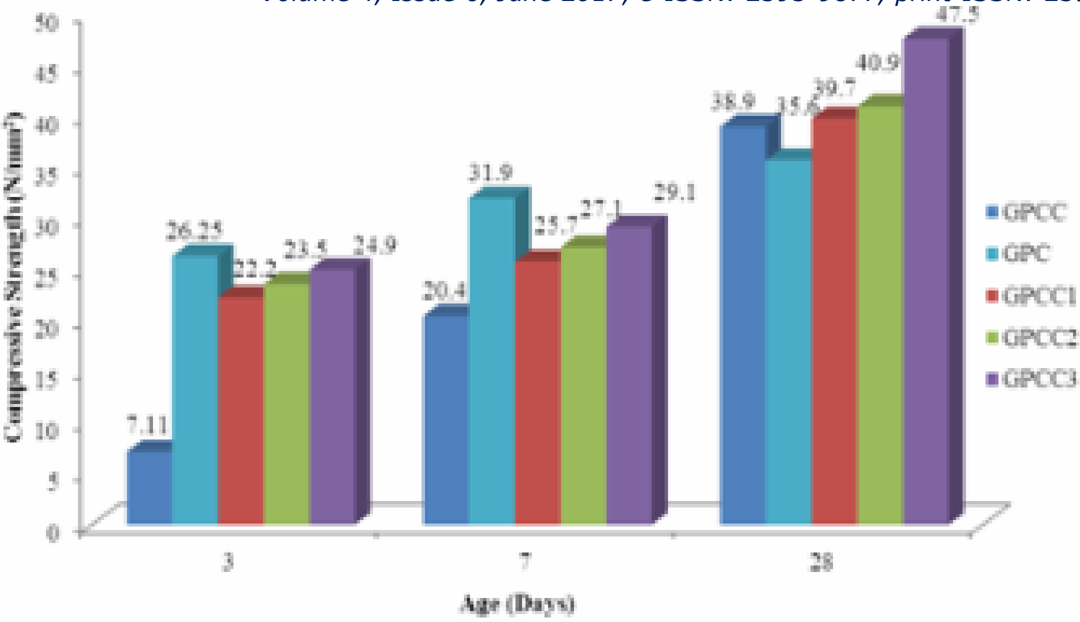

Figure-1. Effect of inclusion of steel fibers on compressive strength.

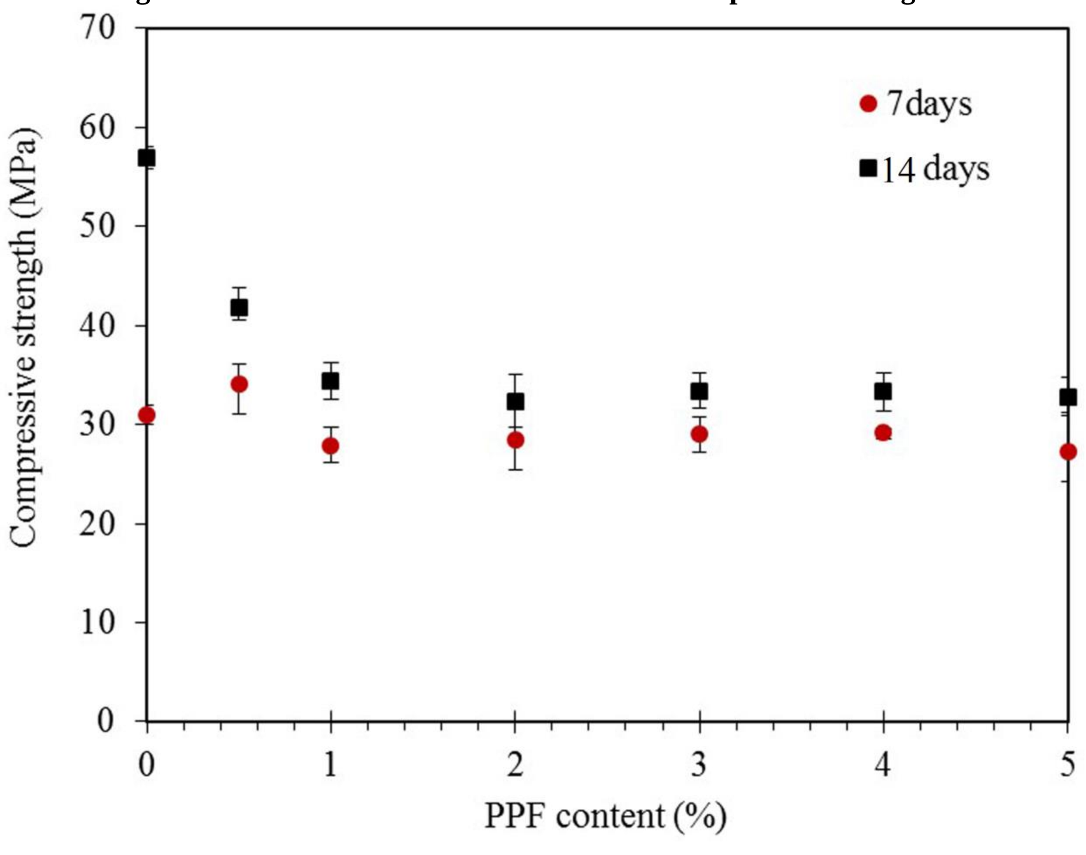

Fig 2. Compressive Strength variation

IV. CONCLUSION

- From the experimental investigation it can be concluded that Geopolymer concrete can perform well even under ambient conditions and hence the limitations of GPC specifically delay in setting time and heat curing regime can be overcome by replacing 30% fly ash and 70% GGBS.
- Replacing320% fly ash and 70% of GGBS improved the mechanical properties such as compressive, tensile and flexural strengths. Compared to GPC the compressive, tensile and flexural strength are enhanced at the rate of 10%, 2.3%, and 6.3%,respectively.

- Addition of steel fibers in volume fraction of 0.75% enhanced the compressive, tensile and flexural strengths at the rate of 33%, 52% and 41%, respectively with reference to GPC under heat curing

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