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Original Research Article

Mechanical Performance of Steel Fiber Reinforced Geopolymer Concrete

Maddula Rama Manikantha[1*], M. Sophia[2]

[1]Ph.D Scholar, Department of Civil Engineering, School of Engineering & Technology, CMR University, Bangalore, India
[2]Assistant Professor & Head, Department of Civil Engineering, School of Engineering; Technology, CMR University, Bangalore, India

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***Corresponding author:** Maddula Rama Manikantha
Ph.D Scholar, Department of Civil Engineering, School of Engineering & Technology, CMR University, Bangalore, India

Abstract

Concrete is used more than water worldwide. The need for Conventional concrete rises in tandem with the demand for concrete as a building material. According to estimates, cement production rose from 1.5 billion tons in 1995 to 4.5 billion tons in 2020. Finding a substitute for Cement concrete, whose production uses the most resources, is therefore inevitable. Researchers have been inspired to create an alternative binder paste to totally replace cement paste by the use of supplemental cementing ingredients such fly ash, silica fume, granulated blast furnace slag, and rice-husk ash. These inorganic amorphous binders will chemically react to form geo polymer concrete, a cutting-edge building material. We use additional cementitious materials in this that react with alkaline activators to create an Al-O-Si-O gel that has a comparable bonding strength to C-S-H gel. Because geopolymer concrete is already somewhat brittle, increasing its flexural and tensile strength is necessary. There are fibres included. In this study, the mechanical properties of geopolymer [M50] concrete with steel fibres were examined by curing it in an ambient condition.

Keywords: Concrete, Substitute, Geopolymer, Mechanical Properties.

1.0 INTRODUCTION

According to some estimation, cement concrete (CC) is the second most commonly utilised material in the building sector after water. Ordinary Portland Cement (OPC) and other naturally occurring raw materials make up the bulk of the cement concrete. Because an equivalent quantity of carbon dioxide is discharged into the atmosphere with every tonne of cement produced, and because approximately 50% of the raw materials purchased are deemed unsuitable for the manufacturing of OPC, the process of making OPC is environmentally intrusive [1-4]. These result in a number of environmental issues, including global warming, landfill leaching, the depletion of natural resources, excessive mining, etc. This made it necessary to adapt eco-friendly resources, industrial leftovers, waste materials, etc. to produce concrete with comparable or superior qualities to CC. Waste products including Flyash (FA), Rice-Husk Ash (RHA), Sugarcane Bagasse Ash, Silica Fume, Ground Granulated Blast Furnace Slag (GGBS), etc., have been utilized to create Geopolymer Concrete (GPC) or alkali-activated slag concretes either in place of cement or as an independent material [5-8]. Fiber integration also improves the post-cracking behavior of concrete, enhancing the structural integrity of GPC [9-13]. In order to fill this study gap, the mechanical characteristics of the concrete with steel fibres have been examined. The majority of GPC are flyash-based and blended fly ash and GGBS have limited information in the literature review.

2.0 EXPERIMENTATION

2.1 Materials Utilized in the study

In this study, the GGBS and class F flyash are combined 50:50 as the binder to create geopolymer concrete. The GGBS was obtained from the Visakhapatnam Steel Plant, and the flyash was obtained from the VTPS Thermal Power Plant. Table 1 shows the chemical characteristics of the binder as determined using X-Ray fluorescence. For the fine and coarse aggregates, respectively, manufactured sand (M-Sand) and 20 mm down angular granite were purchased from locally accessible sources.

To make steel fiber-reinforced geopolymer concrete, hook-end steel fibres with an aspect ratio of 80 were purchased from Chennai. The mix proportion is furnished in Table 2. The sodium-based activator employed was a combination of sodium hydroxide (10 M) and sodium silicate solution. The sodium silicate employed in the investigation has a water glass modulus of around 2.34. The 97% pure NaOH flakes used to make the sodium hydroxide solution were used. The sodium hydroxide solution to sodium silicate ratio was held constant at 2.5. In this, the GPC mixes are cast with steel fibers with an increment of 0.5% and the mechanical strength characteristics are studied and presented.

Table 1: Chemical Characteristic of the Ingredients

Material	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O
Class F-FA	66.81	24.52	4.1	1.52	0.46	0.41
GGBS	39.19	10.19	2.01	32.83	8.53	1.2

Table 2: Mix Ingredients of GPC concrete

S. No.	Constituents	M50 grade Quantity(kg/m^3)	
1.	Binder (FA+GGBS) (50%+50%)	410	
2.	Na_2SiO_3	117.14	
3.	NaOH	46.86 (10M)	
4.	Fine aggregate	554.4	
5.	Coarse aggregate	1294	20mm----776.16Kg 12mm----517.44Kg

The geopolymer concrete's mix proportion was created in accordance with ACI: 211-4R (Reaffirmed 93) and the mix proportion taken into consideration for the study are shown in Table 2. This mix proportion produced concrete with excellent compressive strength, flexural stability, and tensile characteristics. Utilizing a slump test in accordance with IS 1199-1959, the fresh characteristics of the concrete were assessed (1959).

In order to test the compressive strength, flexural strength, and split tensile strength of geopolymer concrete, specimens were constructed in line with IS 516. The specimens were cast and left at room temperature for 24 hours before being demolded. According to IS 516-1959, the specimens underwent tests for compressive strength after 14 and 28 days, flexural strength after both days, and split tensile strength after 28 days (1959) [14].

3.0 TEST RESULTS & DISCUSSION

3.1 Compressive Strength of GPC mixes

Steel fiber with a weight equivalent to 0.5-2% with an increment of 0.5% of the binder content was added to Flyash and GGBS to prepare fiber reinforced geopolymer concrete. Utilizing the slump test, concrete's ability to flow and resistance to segregation were evaluated. In Table 3, the slump values for several experiments are compiled. From the test results, it is conferred that with the increase in percentage of steel fibers, the slump values are found to be decreased and According to IS: 516-1959 specifications, the compression test was performed using a compression testing machine with a 2000 kN capacity.150x150x150 mm Dimension cubes, 300x150mm cylinder specimens and 700x100x100 mm beam specimens were cast and cured in an ambient condition.

The specimens underwent various mechanical strength test after seven and twenty-eight days. Table 3 presents the findings. From the findings, it can be shown that the mechanical strength characteristics have increased from 7 days to 28 days. The use of GGBS as the binder material enables the development of significant compressive strength during the first seven days.

Table 3: Fresh and Hardened properties of GPC

Mix	Slump (mm)	Compressive Strength(MPa)		Split-tensile Strength (MPa)		Flexural Strength (MPa)	
		14 days	28 days	14 days	28 days	14 days	28 days
M1-Control GPC mix	100	43.21	50.16	4.16	4.44	4.24	4.59
M2-0.5% STF	85	45.49	52.83	4.36	4.62	4.42	4.67
M3-1% STF	80	46.58	53.18	4.64	4.71	4.69	4.78
M4-1.5%STF	75	47.87	55.69	4.74	4.89	4.83	4.91
M5-2% STF	65	46.75	54.25	4.59	4.63	4.62	4.46

a b c

Fig. 1: (a, b, c) Failure Pattern of GPC specimens

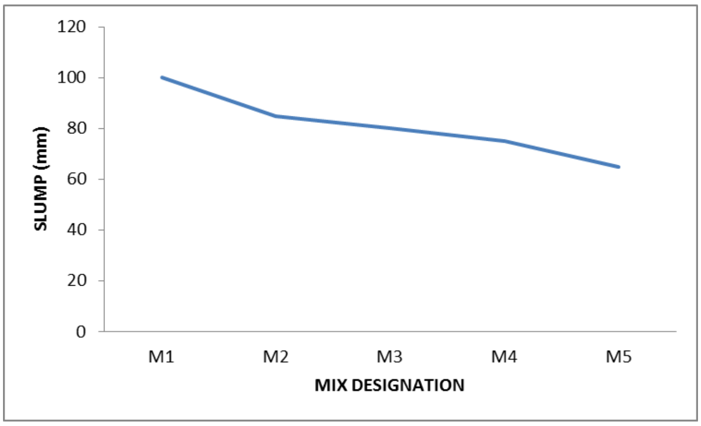
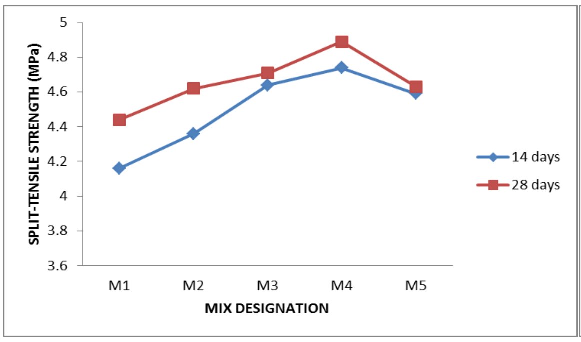
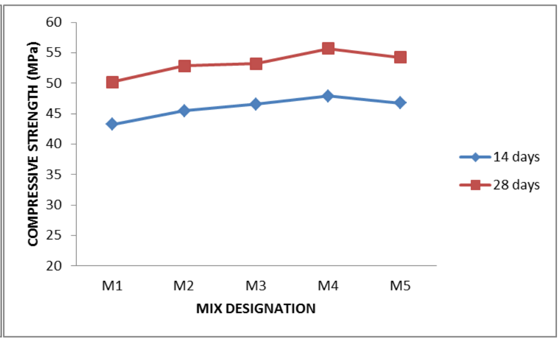
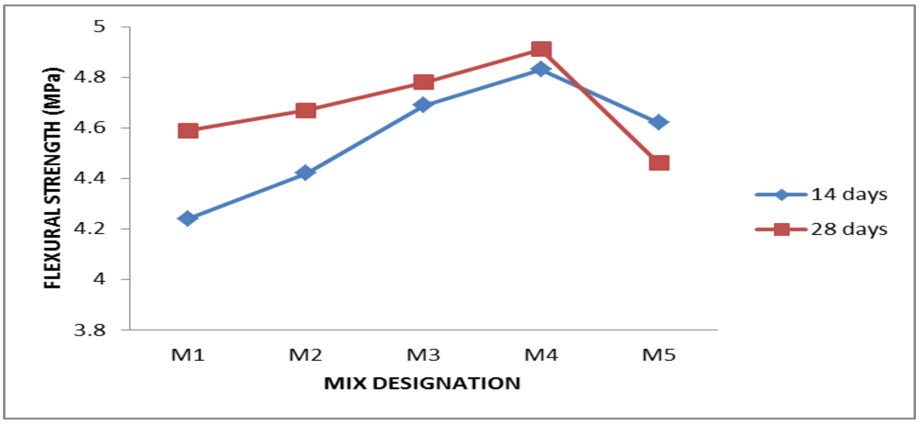


Fig. 2: Slump values for prepared GPC mixes





a b



c

Fig. 3: (a, b, c) Mechanical Strength Characterstics of GPC Mixes

From the above test results i.e., from fig.3(a, b, c) , it can be conferred that the mechanical strength characteristics of M50 grade GPC with 1.5% dosage of steel fibers achieved higher mechanical strength characteristics when compared with other mixes.

4.0 CONCLUSIONS

This work used an experimental design to determine the effects of GGBS on fly ash and GGBS-based GPC that was dried at room temperature. From this research, the following major findings have been drawn:

1. The workability of GPC mixes was negatively impacted by adding more steel fiber, which lowered the workability of GPC high strength grade mixtures.
2. The mechanical strength of GPC mixes was increased by adding 1.5% SF, but their workability was decreased.
3. Early on, as the fibre content of GPC mixtures grew, so did their mechanical strength. The mechanical strength did, however, decrease when the volume percentage of STF went from 1.5% to 2%.

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