Effects of Carbon Fibre and Glass Fibre on Strength of Geopolymer Concrete

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Abstract— The use of geopolymer concrete using fly ash and slag can reduce the emission of CO_2 in the atmosphere. This study analysis the impact of with Carbon Fibres and Glass Fibres on split tension, flexural strength of hardened geopolymer concrete. The use of fragmental fibres with the 0.3 percentage of volume of geopolymer- binder material was used in the mix. The effect of the geopolymer binder on fracture characteristics of concrete has been investigated by one point bending on beam specimens. The fracture behavior of Geopolymer concrete (GPC) is mainly because of its higher tensile strength.

Key words: Alkaline Activator, Carbon Fibre (CF), Fly ash, Geopolymer binder (GPB), Glass Fibre (GF), Geopolymer Concrete

I. Introduction

Plain concrete suffers from various demerits like low tensile strength, brittleness, crack propagation and low cracking resistance. The addition of Glass Fibres and Carbon Fibres in plain cement concrete improves its mechanical and elastic properties. Hence, Fibre reinforced concrete has been proved as a reliable and promising composite construction material having superior performance characteristics compared to conventional concrete.

The rate of production of CO_2 is increasing day by day due to the huge production of Portland cement. A tonne of Portland cement produces 1 tonne of CO_2 in the atmosphere causing greenhouse effect. On the other side, fly ash is the waste material of coal based thermal power plant. With silicon and aluminium as the main constituents in fly ash and slag has great potential as a cement replacing material in concrete.

II. Related Mechanism

Generally, OPC concrete develops strength through the formation of hydrates such as CSH (calcium silicate hydrate), which is produced by the hydration reaction of water and the ordinary Portland cement typically used as a binder. Moreover, the hardening of fly ash based geopolymer is achieved by dissolving the Alumina and Silica components by alkaline activator known as geopolymerisation. The geopolymerisation process, indicates a chemical reaction between Al-Si oxides which form the three-dimensional polymer chain Si-A-O-A-Al-A-O, was proposed by Davidovits in 1978. The hardening of the geopolymer is believed to be due to the polycondensation of hydrolyzed aluminate and silicate species. The alkaline activator, which is generally used are sodium hydroxide (NaOH), potassium hydroxide (KOH), sodium carbonate ($NaCO_3$) or sodium sulfate (Na_2SO_4) containing alkaline metal ions such as Na, K and Ca, serving as an accelerator in speeding up the activating Al and Si through a reaction with the binder. The dissolution of water which accelerates the geopolymerisation which provides discontinuous gel Nano pores to the paste, resulting in a further improvement of the performance of the paste depicting the hardening mechanism.

III. Experimental Programme

Experimental work is aimed to study the effect of glass and carbon fibres on mechanical and elastic properties on geopolymer the materials used for making geopolymer concrete of grade (M-25). Composite specimens are low-calcium fly ash, course and fine aggregates, Glass Fibre, Carbon Fibre, alkaline solution, and water.

A. *Fly ash*

Fly ash is the residue from the combustion of pulverized coal collected by mechanical or electrostatic separators from the flue gases of thermal power plants. The spherical shape of particle improves the flow ability and reduces the water demand. In this experimental work, the fly ash used is obtained from the Eklahare Thermal Power Station, Nashik, India, which is of low calcium, Grade II. Low calcium fly ash makes substantial contributions to the workability, chemical resistance, and reduction in thermal cracking. Table 1 shows the chemical composition.

Sr. No.	Chemical Composition	Percentage
1	SiO_2	77.10
2	Al_2O	17.71
3	$Fe2O_3$	1.21
4	MgO	0.90
5	SO_3	2.20
6	Na_2O	0.80
7	CaO	0.62
8	Total chlorides	0.03
9	Loss of ignition	0.87

Table 1: Chemical Composition of Fly Ash

B. *Alkaline Solution*

Sodium hydroxide (NaOH) in the form of flakes and sodium silicate are used as alkaline activators to give a good binding solution for the geopolymeric mix.

C. *Aggregates*

Locally available river sand sieved through 4.75mm is used as fine aggregates and crushed stones of nominal Max. Size 20mm coarse aggregates is used.

D. *Glass Fibres*

Use of fragmental fibres having 0.3 percentage of volume of geopolymer- binder material.

E. *Carbon Fibres*

Use of fragmental fibres having 0.3 percentage of volume of geopolymer- binder material.

IV. TEST SPECIMENS AND TESTING

Split tensile test were tested on cylinder specimens (150*300mm) and flexure test were conducted on beam specimens (150*150*300mm) for desired batch of mix.

The ends of the test specimen were placed on the supporting rollers at a span of 50 mm. The split test were conducted on compression testing machine having capacity 2000kN. For flexure test the setup was put on universal testing machine having capacity 1000kN with an accuracy of 0.001 kN and a digital strain gauge measuring the vertical displacement with an accuracy of 0.001 mm. A loading rate of 10kN/min was used in the tests of this study.

V. TEST RESULTS AND DISCUSSION

A. Mechanical Test

The mechanical properties of the geopolymer concrete were tested as per the standard in 3rd, 7th and 14th day for the duration of 6 hours and 24 hours for each. The split tension test were conducted on cylinder specimen after 3rd, 7th and 14th days. The flexure test conducted on beam specimens after 3rd, 7th and 14th days showed higher results because of the addition of Glass Fibres and Carbon Fibers. Table 4 briefly explains the test analysis values.

Identification Mark	Temperature(°C) and Duration		Split Tensile Strength in MPa		
			3	7	14
GPC-GF	70°C	6	4.23	4.89	7.73
		24	7.27	9.20	11.62
GPC-GF	90°C	6	5.12	6.50	8.56
		24	10.02	12.39	15.78
GPC-GF	120°C	6	13.38	16.23	17.35

Table 2: Split tensile Strength of GPC

Identification Mark	Temperature(°C) and Duration (hours)		Flexural Strength in		
			3	7	14
GPC-CF	70°C	6	2.78	3.39	7.53
		24	3.20	4.20	10.31
GPC-CF	90°C	6	4.58	6.12	7.86
		24	7.73	7.97	10.33
GPC-CF	120°C	6	7.29	9.37	12.35

Table 3: Flexural Strength of GPC

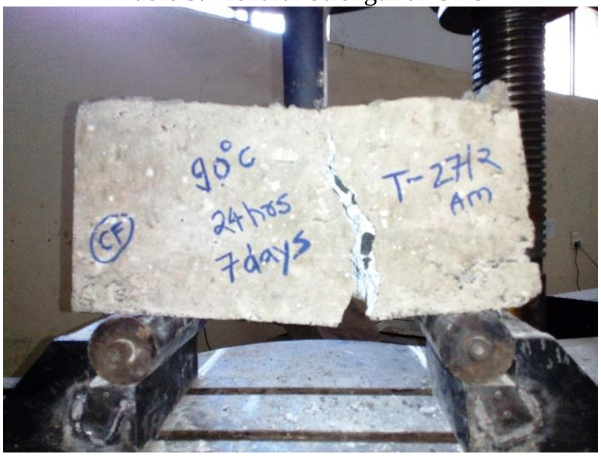

Fig. 1: Flexural test on Universal testing machine


Fig. 2: Split tensile test on Compression testing machine

VI. CONCLUSION

This study investigated the fracture behaviour of geopolymer concrete with respect to its compressive strength. One point bending test was conducted on beams for desired batch of geopolymer concrete specimens.

1) With the addition of Glass fibres and Carbon Fibres in geopolymer concrete reduced the workability of concrete mix.
2) The requirement of water content ratio is less as compared to other concrete.
3) The addition of fibers reduces the crack propagation in concrete and reaches higher peak value.
4) Glass fibres give more strength in cracking propagation as compare to the Carbon fibres.

VII. FUTURE SCOPE

For avoiding the cracking propagation in geopolymer concrete Glass Fibres and Carbon Fibres plays an important role. Also the strength of concrete increases with the addition of Glass Fibres and Carbon Fibres.

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