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Mechanical Properties Of Polypropylene Fiber Based Geopolymer Concrete

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Abstract

The second most consumed product in the world is Cement, which is main reason for the carbon dioxide emission. Geo polymer concrete (GPC) is becoming a special type of eco-friendlier concrete &alternative to Ordinary Portland Cement (OPC). This project deals with the effect of class F fly-ash & ground granulated blast furnace slag (GGBS) on the mechanical properties of Geo Polymer Concrete (GPC) by volumetric fractions of 0%, 0.1%, 0.2% & 0.3% of POLYPROPYLENE Fiber (PPF). The effects of inclusion of POLYPROPYLENE fiber on compressive strength, flexural strength & Split tensile strength of hardened Geo polymer concrete are being studied. Fly ash to GGBS ratio was fixed to 50:50 with 100% replacement of OPC by fly ash and GGBS. Alkaline liquid consists of sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) solutions. Additional super plasticizer is being used for high workability. POLYPROPYLENE fibers were added to the mix with the lengths of 6mm POLYPROPYLENE fibers is mixed in volume of concrete. The mix design which has been used is M30 grade of concrete. Main purpose of this project is to bring out the advantageous results of Geo polymer concrete comparing with fiber-based Geo polymer concrete.

Keywords: ***Geo polymer, POLYPROPYLENE, OPC, Mechanical properties***

1. INTRODUCTION

The major problem in now a day is global warming for which one of the major reasons is production and usage of cement. Then Geo polymer concrete (GPC) came into the picture to reduce the emission of carbon dioxide. Geo polymer concrete is also called as an Eco-friendly material for construction. GPC revolutionizes the building construction. Materials are also economical. Aleem et al., (2012) reported that, Geo polymer concrete can be used in the precast industries, so that production can be done in a short period of time and the transportation can be carried out easily. Don Wimpenny et al. -- explained that Fiber reinforced Geopolymer concrete can perform better than the Portland cement-based with respect of flexural strength, shrinkage and durability and reduces the carbon di-oxide emission up to 70%.

2. MATERIAL AND METHODS

Fly-ash

The fly-ash used is of Class F category. Obtained from the JSW Energy Ltd. Jaigad through Ultra-Tech Cement Limited. This fly-ash is pozzolanic in nature, and the amount of lime (CaO) is less than 10%. It requires a cementing agent same as Portland cement, Hydrated lime, quick lime and contains a very less percentage of carbon dioxide.

Table 1: Test results of fly-ash

Test Name	Value
Fineness	2.7
Specific Gravity	2.6

Ground Granulated Blast Furnace Slag

Obtained from the JSW Cement Limited, Bilakalagudur, Hyderabad. It comprises of Cao (30-50%), SiO_2 (28-38%), Al_2O_3 (8-24%), and MgO (1-18%). The main uses of GGBS is in production of quality-improved slag cement and also in ready-mix concrete. There is no Indian Standard on GGBS. For reference BS specification is given. Granulated Slag used for JSW Steel Ltd., GBS conforms to IS 12089:1987.

Table 2: Specification of GGBS

S. No	Characteristics	Requirement as per BS:6699	Result
1.	Colour	White	
2.	Fineness (M^2/Kg)	275	441
3.	Insoluble Residue (%)	1.5	0.36
4.	Magnesia Content (%)	14.0	6.82
5.	Sulphide Sulphur (%)	2.00	0.26
6.	Sulphite Content (%)	2.50	0.36
7.	Loss of ignition (%)	3.00	-0.26
8.	Chloride Content (%)	0.10	0.028
9.	Moisture Content (%)	1.00	0.09

Fine aggregate

Locally available sand is used. Fine aggregate is sieved through 4.75mm IS Sieve. It consists of natural sand and crushed stone.

Table 3: Test Results of Fine aggregate

Test Name	Value
Specific Gravity	2.8
Fineness Modulus	4
Water Absorption	1%

Coarse Aggregate

Locally available crushes aggregates have been used. Size of the aggregates are 12.5mm and 20mm.

Table 4: Test Results of Coarse Aggregate

Test Name	Value
Specific Gravity	2.75
Fineness Modulus	5.80
Water Absorption	0.8%
Impact Value	11.2%
Flakiness Index	70%
Elongation Index	14%
Crushing Value	23.9%
Abrasion Value	34.76%

Alkaline Solutions

A combination of sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) were used for making the Geo polymer concrete. The sodium hydroxide is in pellets form (3mm) & solution is prepared by mixing the pellets in the water.

1. NaOH

Table 5: Chemical Composition sodium hydroxide

Composition	Value
P^H	8.2
Specific Gravity	2.130
Purity	98%
Assay of Na_2O	28%
Assay of SiO_2	7.5
WT. per ml (g/ml)	1.385

2. Na_2SiO_3

Table 6: Chemical composition of sodium silicate

Composition	Value
Na_2O	14.33%
SiO_2	33.10%
Water (by mass)	52.57%

Super Plasticizer

In this project Sulphonated Naphthalene Formaldehyde (Conplast SP430) is used in the solution form. It provides excellent wetting, dispersing & workability because of its economical and versatile nature. It improves the flow properties of the mix. Specifications are mentioned below:

Table 7: Compositions of Superplasticizer

Composition	Value
Appearance	Dark tan coloured liquid
Specific Gravity at 30^OC	1.235
Minimum P^H	7-9
Sulphate ash	15-18%
Solid	30-50%

POLYPROPYLENE Fiber

In this project POLYPROPYLENE of 12mm length is used. It helps to resist the attack from alkalinity. It is allowed for thin and light weight concrete. The tensile strength of this fiber is higher than of steel, and is significantly less elastic than concrete.

Table 8: Properties of POLYPROPYLENE fiber

Properties	Value
Shape	Triangular
Cut Length	6 mm
Effective Diameter	25 – 40 microns
Specific gravity	0.9 – 0.91
Tensile Strength	550 – 750 MPa
Density	0.91g/cc
Colour	White

Preparation of geopolym First the sodium hydroxide solution will be prepared by adding the pellets into the distilled water and kept for 24 hours before the mixing. Later the sodium hydroxide solution was mixed with sodium silicate to get the desired alkaline solution. Then the constituents of Geopolymer mix (i.e. fly-ash, GGBS, alkaline solution, POLYPROPYLENE fiber, superplasticizer, coarse aggregate, fine aggregate) were dry mixed for some time. Then

alkaline solution and superplasticizers were added to dry mix thoroughly to get the homogeneous mix. Then fibers were added as per the requirement. Later, the cubes, beams and cylinders were casted to determine the compression, flexural and split tensile strength of the Geo polymer concrete. Lastly the casted cubes, beams and cylinders were kept for ambient curing.

3. RESULTS AND DISCUSSION

3.1 Compressive strength

Below table shows the compressive strength of Geo polymer concrete with different percentage of fibers (i.e. 0%, 1%, 2% and 3%) at different curing periods.

Table 9: Test Results for Compressive strength

Days	Mix Type			
	0%	0.1%	0.2%	0.3%
7	22.56	32.19	33.99	31.33
14	25.48	39.37	43.17	37.05
28	30.2	42.06	45.87	39.05

Without using fiber i.e. with 0% of fiber in Geo polymer concrete, a significant increment in compressive strength at different curing period (7, 14 and 28 days) have been noticed. On 7^{th} day the compressive strength value if only 22.56MPa which is increased to 30.2MPa on 28^{th} day. Similarly, a significant increase in the value is being noticed till addition of 0.2% of POLYPROPYLENE fiber. But at 0.3% a drastic fall in the compressive strength value is being noticed. From the Graph 1, A sharp reduction has been noticed at 0.3% of fiber

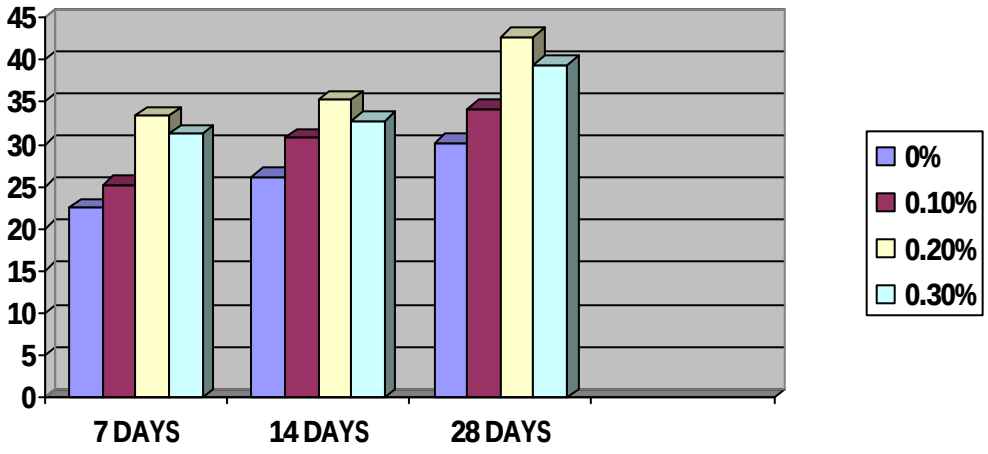

Figure 1: Comparison of compressive strength (MPa) at intervals with different fiber proportions.

3.2 Split tensile strength

Below table shows the Split tensile strength of Geo polymer concrete with different percentage of fibers (i.e. 0%, 1%, 2% and 3%) at different curing periods.

Table 10: Test Results for Split-tensile strength

DAYS	Mix Type			
	0%	0.1%	0.2%	0.3%
7	2.37	2.41	3.41	2.44
14	3.05	3.29	3.96	3.14
28	3.61	3.89	4.26	3.74

Without using fiber i.e. with 0% of fiber in Geo polymer concrete, a significant increment in compressive strength at different curing period (7, 14 and 28 days) have been noticed. On 7th day the compressive strength value if only 2.37MPa which is increased to 3.61MPa on 28th day. Similarly, a significant increase in the value is being noticed till addition of 0.3% of POLYPROPYLENE fiber. But at 0.3% a drastic fall in the compressive strength value is being noticed. From the above figure, a drastic fall in split tensile value has been noticed at 0.3% of fiber.

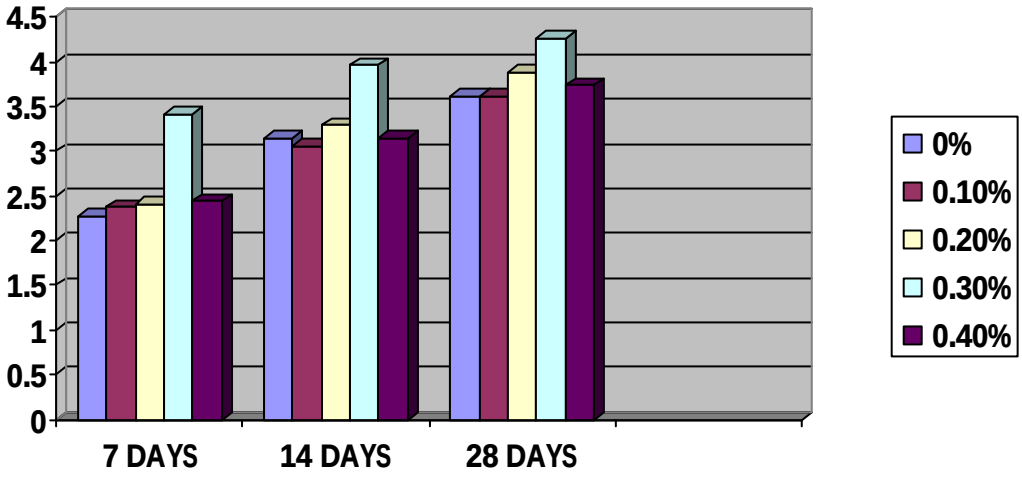

Figure 2: Comparison of Split-tensile strength (MPa) at intervals with different fiber proportions.

III Flexural Strength

Below table shows the Flexural strength of Geo polymer concrete with different percentage of fibers (i.e. 0%, 1%, 2% and 3%) at different curing periods.

Table 11: Test Results for Flexural Strength

DAYS	Mix Type			
	0%	0.2%	0.4%	0.6%
7	3.38	3.56	3.91	3.44
14	3.71	3.87	4.16	3.64
28	3.94	4.13	4.53	3.99

Without using fiber i.e. with 0% of fiber in Geo polymer concrete, a significant increment in compressive strength at different curing period (7, 14 and 28 days) have been noticed. On 7th day the compressive strength value if only 3.38MPa which is increased to 3.94MPa on 28th day. Similarly, a significant increase in the value is being noticed till addition of 0.2% of POLYPROPYLENE fiber. But at 0.3% a drastic fall in the compressive strength value is being noticed. From the above figure, a drastic fall in split tensile value has been noticed at 0.3% of fiber

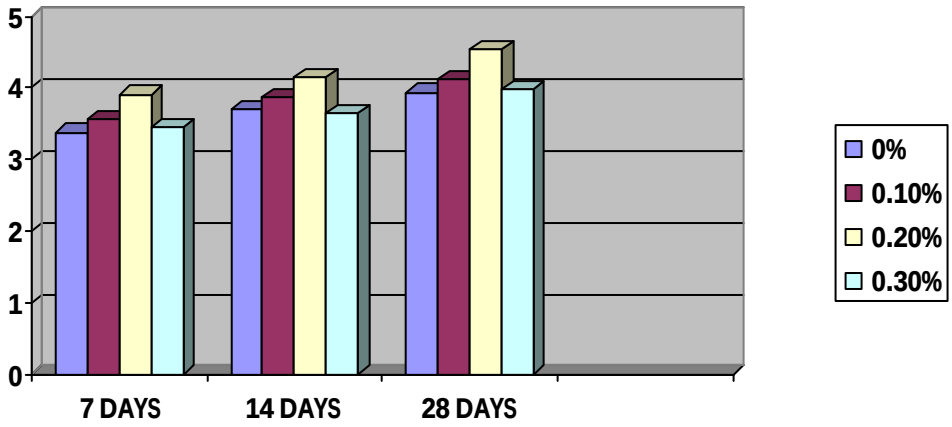

Figure 3: Comparison of Split-tensile strength (MPa) at intervals with different fiber proportions.

4.CONCLUSIONS:

Based on the experimental work reported in this study, we consider 50:50 (fly-ash: GGBS), 4% of super plasticizers and 0.1%, 0.2% and 0.3% of POLYPROPYLENE fibers are considered. From the above observations we can conclude that:

1. Significant increment in compressive strength is noticed with the percentage of POLYPROPYLENE fiber from 0% to 0.2%.
2. But at 0.3%, a sudden fall in Compressive strength, Flexural strength and Split-tensile strength was noticed respectively. (Refer Graphs)
3. With 0.1% and 0.2% of fiber the strength of Geo polymer was increased when compared with 0% of fiber.
4. Addition of POLYPROPYLENE fiber up to 0.2% by volume of concrete enhances the compressive, flexural and split-tensile strength respectively.
5. Addition of POLYPROPYLENE fiber helps in the improvement of mechanical properties of the Geo polymer concrete.
6. Higher the ratio of sodium silicate to sodium hydroxide ratio by mass, higher is the compressive, flexural and split-tensile strength.
7. The addition of superplasticizer (Naphthalene Sulphonate) up to 4% by mass, results in the improvement of workability of the concrete.
8. Hence, the optimum percentage of POLYPROPYLENE fiber was found to be 0.2%.
9. Hence, at 0.2% the POLYPROPYLENE fiber-based Geo polymer gives the highest results in compressive strength, flexural strength and split-tensile strength which can be seen in the above graphs.

References

[1] Davidovits J, Davidovits M. Geopolymer: Ultrahigh temperature tooling material for the manufacture of advanced composites. SAMPE. 1991

[2]G. Ravichandran et al. (2018), “Performance of glass fiber reinforced geopolymer concrete under varying temperature effect”. Research Scholar, PRIST University, Thanjavur. Pp 1316-1323.

[3] Hardjito D, Rangan BV. Development and properties of low calcium fly-ash based geopolymer concrete, Research Report GCI, Pert, Australia: Faculty of Engineering, Curtin University of Technology, 2005.

[4] J. Roop Kumar et al. (2016), “Development and strength properties of synthetic fiber reinforced concrete”. Department of Civil Engg., Sree Rama Educational Society group of institutes, Tirupati.

[5] Li Z, Zhang Y, Zhou X. Short fiber reinforced geopolymer concrete manufactured by extrusions. J.Mater. Civ. Eng. (ASCE). 2005; 17(6):624-631p.

[6]Majumdar, A.J. (1974), “The role of the interface in glass fiber reinforced cement”, Building Research Establishment, 1974, Current Paper (cp 57-74).

[7]M. W. Fordyce and R. G. Wodehouse, “GRC and building”, First Edition 1983.

[8] P. Perumal and Dr. J. Maheswaran, "Behavioural study on the effect of POLYPROPYLENE fiber reinforced concrete", NBW and CW, October 2006, pp 174-180.
[9] Perumelsamy N. Balaguru and Surendra P. Shah, "Fiber reinforced cement composites", February 1992, Chapter 13, (pp 351).
[10] U. M. Ghare, "Manufacture of Glass Fiber Reinforced Concrete Products", Unit1. Division of YOGI group-UAE, August 2008.