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A study on mechanical properties of Geopolymer concrete made with 100% GGBS

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Abstract*- It is well known fact that construction industry is prevailing largely based on OPC. The OPC has its drawbacks as the manufacturing process produces large amounts of greenhouse gases which is impacting the environment adversely. As the advancement of technology increased day by day new alternatives are preferred in making concrete. These alternatives include by-products like fly-ash, GGBS. silica fumes etc. in this present study GGBS is considered for making geopolymer concrete by completely replacing cement and using alkaline liquids for polymerisation process to take place. The mechanical properties of this geopolymer concrete made with 100% GGBS (G.G.C) are studied to understand its behaviour under compression, tension and flexural loads. The geopolymer concrete is made by considering three molar concentrations on NaOH solution used in alkaline liquids. A comparison has been made between these molar concentrations. The compression, tensile and flexural strengths showed a maximum value at 12 molar concentrations when compared with 8M and 10M solutions.

Keywords- Initials in Capitals; Separate with Semicolons

1. INTRODUCTION

In the construction industry usage of concrete made up of Portland cement (OPC) was observed to be increased in this past decade at an exponential rate resulting in an increase of cement production industries drastically. This, in turn, had a tremendous effect on the environment as the production of cement involved the emission of greenhouse gasses. The materials needed for the manufacturing of concrete are non-renewable and quickly exhausting. Yet, different mechanical and organic by-products are produced in excess with inherent cement characteristics.

However, they are usually dumped into sites. The use of the outcomes, such as solutions to cement, preserves the environment, preserves funds and takes care of the problem of by-products dumping. The impact of OPC production is very large in the setting, particularly in India, where the interest in concrete constantly develops, in order to rapidly meet the demand for the building sectors.

As a result, control of the use of the OPC by generating possible replacements is urgently necessary. In that distinctive situation, more research is being carried out all around the globe to produce distinct results of the use of OPC concrete replacement materials. One such alternative is the GPC which completely excludes OPC in its manufacturing of geopolymer concrete.

2. EXPERIMENTAL INVESTIGATION

The study deals with mechanical properties of GPC made with 100% GGBS (GGC). Experiments were conducted on GGC cubes for compressive strength and on cylinders for split tensile strength and on beams for flexural strength. The test samples were prepared in standard moulds and cured at ambient room temperature. The GGC was prepared by considering three different molar concentrations like 8M,10M and 12M.

2.1 Materials used in the Study

1. GGBS
2. Fine Aggregate
3. Coarse Aggregate
4. NaOH solution
5. Na_2SiO_3 solution
6. Water
7. Superplasticizer

The mix proportions were calculated by considering the density of concrete as 2400 kg/m^3 and aggregate percentage was assumed as 77%.

Table 2.1 Proportions of materials for GGC

Mix ID	GGB kg/m	FA kg/m	CA kg/m^3	NaOH Solution kg/m^3	Na_2SiO_3 Solution kg/m^3	Extra Water kg	SP kg/m
8M	368	555	1294	46	138	85	3.7
10M	368	555	1294	46	138	82	3.7
12M	368	555	1294	46	138	80	3.7

3. RESULTS AND DISCUSSION

3.1 Workability of G.G.C

The workability properties of G.P.C with 100% GGBS were known by conducting Compaction factor test as per Indian standard for concretes. The compaction factor test was conducted on geopolymer concrete with 100% GGBS and their results are tabled in table 4.1. The workability of GGC varied with concentration of NaOH. The workability at three different molarities namely 8 molar, 10 molar, 12 molar mixes was conducted separately and the pattern of workability at different molar concentrations was observed as below.

Table 3.1 Compaction factor results of G.G.C

S.no	Mix ID	Molarity	Workability (compaction factor)
1	G.G.C 8	8 M	0.87
2	G.G.C 10	10 M	0.90
3	G.G.C 12	12 M	0.92

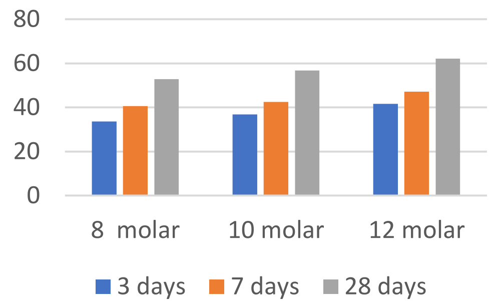
From the table 3.1 the compaction factor value for GGC at 12 Molarity was observed to be 0.89 and the value was observed to be decreasing for 10 M and 8 M mixes.

3.2 Compressive strength of G.G.C

Compressive strength of GGC was conducted in a compression testing machine and the load at which the cube is crushed is noted and the test is conducted on 3 cubes for each mix and their average has been calculated. The test was conducted for GGC mix with three molar concentrations 8molar, 10molar, 12molar. As the impact of curing age is very important for strength gain. To study the nature of strength parameters in concrete the cubes must be cured for different ages and their proportions of strength gain for corresponding respective ages. The percentage increase in strength is compared between these ages so that the geopolymer concretes behaviour can be studied properly for its use in commercial manner. The test was conducted for 3, 7 and 28 days and their results have been tabulated and charts are drawn to graphically represent these results.

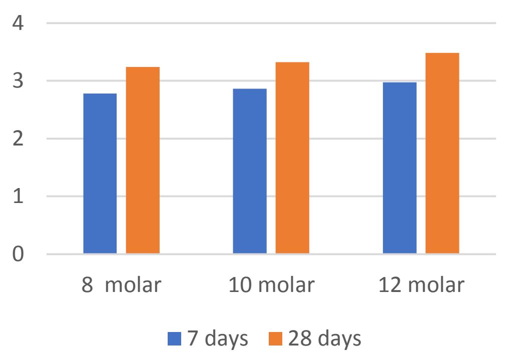
From figure 3.1 it is evident that the strength in compression of GGC is increasing with increase in molarity concentration.
For 8 molar GGC mix the strength in compression for 3 days was above 63% when compared with 28 days. The 14 days strength for this mix is about 75% that of 28days. For 10 molar GGC mix the strength in compression for 3 days was above 65% when compared with 28 days. The 14 days strength for this mix is about 75% that of 28days.
For 12 molar GGC mix the strength in compression for 3 days was above 67% when compared with 28 days. The 14 days strength for this mix is about 76% that of 28days. Of these three molarity concentrations 12molar mix had the maximum strength in compression at 28 days which is 62.1 MPa.

Fig 3.1 Compressive strength of GGC

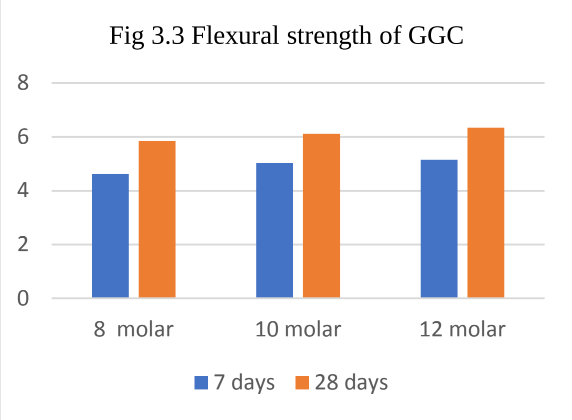


The behaviour of GGC under split-tensile strength is seen in fig 3.2. This test is conducted for 8molar, 10molar and 12molar concentrations. The split-tensile strength increased with increase in molarity. The maximum split tensile strength was obtained at 12 molar concentration at 28 days curing period.
For GGC8 mix the tensile strength gain for 7 days was around 85% that of 28 days strength with a strength of 3.24 MPa.
For GGC10 mix the tensile strength gain for 7 days was around 86% that of 28 days strength with a strength of 3.32 MPa.
For GGC12 mix the tensile strength gain for 7 days was around 85% that of 28 days strength with a strength of 3.48 MPa.

Fig 3.2 Split tensile strength of GGC



3.3 Flexural strength of G.G.C



The flexural strength of GGC at three different molar concentrations for 7 days and 28 days have been conducted and the results showed that the flexural strength of GGC increases with increase in molar concentration.

From Fig 3.3 it is evident that the mix GGC 8 which had no fibers and molar concentration of 8 showed flexural strength of 5.84 MPa at days. At 7 days the beams gained a flexural strength of 79 % of 28 days strength.

the mix GGC 10 which had no fibers and molar concentration of 10 showed flexural strength of 6.11 MPa at days. At 7 days the beams gained a flexural strength of 82 % of 28 days strength.

the mix GGC 12 which had no fibers and molar concentration of 12 showed flexural strength of 6.34 MPa at days. At 7 days the beams gained a flexural strength of 81 % of 28 days strength.

4. CONCLUSIONS

- The experimental investigations conducted on G.G.C showed that the workability is increasing with increase in molar concentration.
- The compressive strength of GGC showed a maximum value of 62.1 MPa at 12 molar concentration.
- The split tensile strength was maximum at 12 molar concentration with a value of 3.48 MPa.
- The flexural strength of GGC was observed at 12M and showed a strength of 6.34 MPa.

5. REFERENCES

[1] F.F Barbosa, Valeria & Mackenzie, Kenneth & Thaumaturgo, Clelio. (2000). "Synthesis and Characterisation of Materials Based on Inorganic Polymers of Alumina and Silica: Sodium Polysialate Polymers". International Journal of Inorganic Materials. 2. 309-317. 10.1016/S1466-6049(00)00041-6.

[2] Ganapati Naidu. P, A.S.S.N.Prasad , S.Adiseshu , P.V.V.Satayanarayana (2012). "A Study on Strength Properties of Geopolymer Concrete with Addition of G.G.B.S". International Journal of Engineering Research and Development eISSN : 2278-067X, pISSN : 2278-800X, www.ijerd.com Volume 2, Issue 4 (July 2012), PP. 19-28.

[3] K Turner, Louise & Collins, Frank. (2013). "Carbon dioxide equivalent (CO 2 -e) emissions: A comparison between geopolymer and OPC cement concrete". Construction and Building Materials. 43. 125-130. 10.1016/j.conbuildmat. 2013.01.023.

[4] Manugunta Manoj. (2015). "Experimental Studies on Strength Characteristics of 12M Geopolymer Mortar Based on Flyash and GGBS". International Journal of Innovative Research in Science, Engineering and Technology. 4. 2911-2919. 10.15680/IJIRSET.2015.0405034.

[5] Mithanthaya, I.R & Bhavanishankar Rao, N. (2015). Effect of Glass Powder and GGBS on Strength of Fly Ash Based Geopolymer Concrete. International Journal of Engineering Trends and Technology. 19. 66-71. 10.14445/ 22315381/ IJETT-V19P213.

[6] V. Supraja, M. Kanta Rao (2010). "Experimental study on Geo-Polymer concrete incorporating GGBS". International Journal of Electronics, Communication & Soft Computing Science and Engineering ISSN: 2277-9477, Volume 2, Issue 2.

[7] B.W.Xu, Biwan & Shi, H.S.. (2009). Correlations among mechanical properties of steel fiber reinforced concrete. Construction and Building Materials - constr build mater. 23. 3468-3474.

[8] Meusel, J. W., and Rose, J. H., (1983) "Production of Granulated Blast Furnace Slag at Sparrows Point, and the Workability and Strength Potential of Concrete Incorporating the Slag," Fly Ash, Silica Fume, Slag and Other Mineral By-Products in Concrete, SP-79, American Concrete Institute, Detroit, , pp. 867-890.

[9] Y.Naresh Babu, H. Sudarsana Rao, Vaishali G Ghorpade "Strength and Durability Studies on Geopolymer Concrete Blended with GGBS and Phosphogypsum" International Journal of ChemTech Research, CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555 Vol.10 No.6, pp 987-994, 2017.

[10] Verdolotti, Letizia & Iannace, Salvatore & Lavorgna, Marino & Lamanna, Raffaele. (2008). Geopolymerization reaction to consolidate incoherent pozzolanic soil. Journal of Materials Science. 43. 865-873. 10.1007/s10853-007-2201-x.

[11] V. Supraja, M. Kanta Rao (2010). "Experimental study on Geo-Polymer concrete incorporating GGBS". International Journal of Electronics, Communication & Soft Computing Science and Engineering ISSN: 2277-9477, Volume 2, Issue 2.

[12] Palomo, Angel & Grutzeck, M.W. & Blanco-Varela, M. (1999). Alkali-Activated Fly Ashes - A Cement for the Future. Cement and Concrete Research. 29. 1323-1329.

[13] W.K.W. Lee, J.S.J. van Deventer, Chemical "Interactions between siliceous aggregates and low-Ca alkali-activated cements", Cement and Concrete Research, Volume 37, Issue 6,2007, Pages 844-855, ISSN 0008-8846.