International Journal of Current Trends in Engineering & Research (IJCTER)
e-ISSN 2455–1392 Volume 2 Issue 5, May 2016 pp. 404 – 410
Scientific Journal Impact Factor : 3.468
http://www.ijcter.com

EXPERIMENTAL INVESTIGATION OF GEOPOLYMER CONCRETE USING FLY ASH AND GGBS

Manjunatha M Katti[1], B M Jagadeesh[2], Naveen M Katti[3]

[1,3]*Department of civil engineering, UBDTCE*
[2]*Department of civil engineering, SJMIT*

Abstract— This experimental study was undertaken to study the strength characteristics of Geopolymer concrete. This experiment involves study to reduce the greenhouse gas emissions by implementing use of alternative material to cement. Five to eight percent of the world's man- made greenhouse gas emissions is from the cement industry itself. It is an established fact that the greenhouse gas emissions are reduced by 80% in Geopolymer concrete compared to conventional Portland cement manufacturing, as it does not involve carbonate burns etc. Thus Geopolymer based Concrete is highly environment friendly and the same time it can be made a high-performance concrete. In the present study, 100% replacement of conventional ordinary Portland cement is made by using ASTM class F fly ash, Ground granulated blast furnace slag and catalytic liquids (or AAS) to prepare Geopolymer concrete mixes. In our present study we evaluated strength characteristics of Geo polymer concrete by varying the molar concentration (6M, 8M, and 10M) and varying percentage of binding material. The work has been done to structural specimen like cylinders and cubes and evaluated compressive, split tensile strength for different binding material proportions and solution concentration.

Keywords: Geopolymer concrete, Fly ash, Ground Granulated Blast Furnace Slag (GGBS), Alkaline activator, compressive strength, Split tensile strength.

I. INTRODUCTION

In the authors' experimental work, geopolymer is used as the binder, instead of cement paste, to produce concrete. The geopolymer paste binds the loose coarse aggregates, fine aggregates and other un reacted materials together to form the geopolymer concrete. The manufacture of geopolymer concrete is carried out using the usual concrete technology methods. As in the Portland cement concrete, the aggregates occupy the largest volume, that is, approximately 75 to 80% by mass, in geopolymer concrete. The silicon and the aluminum in the fly ash are activated by a combination of sodium hydroxide and sodium silicate solutions to form the geopolymer paste that binds the aggregates and other un reacted materials.

II. NEED FOR ALTERNATE CONCRETES

Continuous technological upgrading and assimilation of latest technology has been going on in the cement industry. Presently, 93%of the total capacity in the industry in India is based on modern and environment friendly process technology and only 7% of the capacity is based on old wet and semi-dry process technology. There is a scope for waste heat recovery in cement plants and thereby in cement plants and thereby reduction in emission level.

The cement production is highly energy insensitive next only to steel aluminium (also consumes significant amount of non-renewable natural sources such as lime stone deposits, coal, etc.). The 'EE' of P-C being about 1.3Wh/kg, is a very high quantity. A tonne of P-C production involves emission of about a tonne of CO_2, which is green house gas causing global warming. More than 7% of the world CO_2 production is attributed towards production of P-C. Moreover, among the greenhouse gases, CO_2 contributes about 65% of global warming [McCaffery, 2002]. Therefore, the

Portland cement industry does not fit the contemporary desirable picture of a suitable industry. There is an urgent need to find an alternate to P-C in order to make the construction industry eco-friendly. However, the new binder material should also possess satisfactory strength and durability characteristics which are comparable, preferably superior to those 'conventional concretes' (CCs) based on P-C.

III. AIM AND OBJECTIVES

The aim of the research is to evaluate the performance and suitability of fly ash and slag based geopolymer as an alternative to the use of ordinary Portland cement (OPC) in the production of concrete.

To evaluate the different strength properties of geopolymer concrete mixture with G.G.B.S replaced in percentage to flyash. Making workable, high strength and durable geopolymer concrete containing G.G.B.S (Slag) without usage of ordinary Portland cement

- The primary objective of this project is to study the strength characteristics of geo polymer concrete using fly ash& sodium silicate, sodium hydroxide.
- To determine the effect of fly ash and GGBS as a replacement for cement Concrete.
- Evaluation of the performance of FA-based Geopolymer and AAS concrete with respect to the strength properties.

IV. MATERIALS AND METHODOLOGY

4.1 FLY ASH

Class F fly ash collected by electrostatic precipitator, obtained from Thermal Power Corporation at raichuru, Karnataka, used in the present study. It may be observed that they appear as plain spherical particles of varying diameters. The surface of fly ash particles appears smooth and clean. Specific gravity= 2.21

4.1.1 CHEMICAL CHARACTERISTICS

TABLE 4.1

SL.NO.	Characteristics	Requirement	
		Siliceous Pulverized Pulverized	Calcareous Pulverized Pulverized
i.	Silicon dioxide (SiO_2) plus aluminium oxide (Al_2O_3) plus iron oxide (Fe_2O_3) percent by mass, Min	70.0	50.0
ii.	Silicon dioxide (SiO_2), percent by mass, Min	35.0	25.0
iii.	Reactive silica in percent by mass, Min	20.0	20.0
iv.	Magnesium oxide(MgO), percent by mass, Max	5.0	5.0
v.	Total sulphur as sulphur trioxide (SO_3), percent by mass, Max	3.0	3.0
vi.	Available alkalies, as sodium oxide (Na_2O), percent by mass,Max	1.5	1.5
vii.	Total chloride in percent by mass, Max	0.05	0.05
viii.	Loss on ignition, percent by mass, Max	5.0	5.0

4.1.2 PHYSICAL REQUIREMENTS

TABLE 4.2

SL.NO	Characteristics	Requirement
i.	Fineness-Specific surface in m^2/kg by blaine's permeability method, min	320
ii.	Particles retained on 45 micron IS sieve (wet sieving) in percent, max	34
iii.	Lime reactivity- Average compressive strength in N/mm^2, min	4.5
iv.	Compressive strength at 28 days in N $/mm^2$, min	Not less than 80% of the strength of corresponding plain cement mortar cubes
v.	Soundness by autoclave test expansion of specimens, percent, max	0.8

4.2 GGBS (Ground granulated blast furnace slag)

Many researchers confirmed that GGBS had the ability to reduce the deleterious expansion caused by alkali aggregate reaction (AAR), especially when GGBS was used to replace Portland cement of high alkali content. Specific gravity= 2.20

4.2.1 CHEMICAL CHARACTERISTICS

TABLE 4.1

COMPONENT	PORTLAND CEMENT %	GGBS %
SiO2	21.07	35.35
Al2O3	5.00	14
Fe2O3	2.92	0.36
CaO	64.40	41.41
MgO	2.07	7.45
SO3	2.65	0.1
K2O	0.59	–
Na2O	0.26	–
LOI	1.19	0.31
Insoluble	0.41	0.21
Cl	0.05	0.02
Free Lime	1.70	–
% Glass	–	97

4.2.2 PHYSICAL REQUIREMENTS

TABLE 4.2

SL NO.	PARAMETER	VALUE
1	Appeareance	Very Fine Powder
2	Particle Size	25 Microns-Mean
3	Colour	White
4	Odour	Odourless
5	Specific Gravity	2.90

4.3 Fine aggregate:

The sand used in this investigation is ordinary river sand. The sand passing through 4.75 mm size sieve is used in the preparation of specimens. The sand conforms to grading ZoneII as per IS: 383-1970. The properties of sand such as fineness modulus, water absorption and specific gravity were determined as per IS: 2386-1963.
The sand used for the experimental program is locally procured and confirming to zone- The specific gravity of fine aggregate is found to be 2.60.The water absorption test on coarse aggregate is found to be 0.45%.

4.4 Natural coarse aggregate:

The coarse aggregate used in the investigation is 20 mm down size locally available crushed stone obtained from quarries. Specifications for coarse aggregate are included in IS: 383-1970. The physical properties have been determined as per IS: 2386-1963.The specific gravity of coarse aggregate is found to be 2.65. The water absorption test on coarse aggregate is found to be 0.29%.

4.5 Alkaline activators:

A mixture of sodium hydroxide and sodium silicate solution was chosen in the present study as alkali activators. Commercial grade sodium hydroxide in pallets (purity 97%; specific gravity 2.13) and sodium silicate solution (Na2O=18.2%, SiO2=36.7%, water=45.1%; specific gravity=1.53) were used to prepare the solution. The mass of NaOH pallets in a solution varied according to molar strength M.

V. MIX PROPORTION

Molarity	6M	8M	10M
Flyash + GGBS Kg/m^3	466	466	466
Alkali solution/binder ratio	0.5	0.5	0.5
Alkali solutionKg/m^3	233	233	233
Fine AggregateKg/m^3	805.16	805.16	805.16
Course AggregateKg/m^3	805.16	803.90	805.16
Super plasticizer %	0.4	0.4	0.4

5.1 Tests on hardened concrete and Results

5.1.1Compressive strength test:

Specimens of dimensions 150x150x150mm were prepared. They are tested on 2000kN capacity compression testing machine as per IS 516-19

COMPARISON BETWEEN 6M, 8M, 10M COMPRESSIVE STRENGTH FOR 50-50% FLY ASH & GGBS RATIO

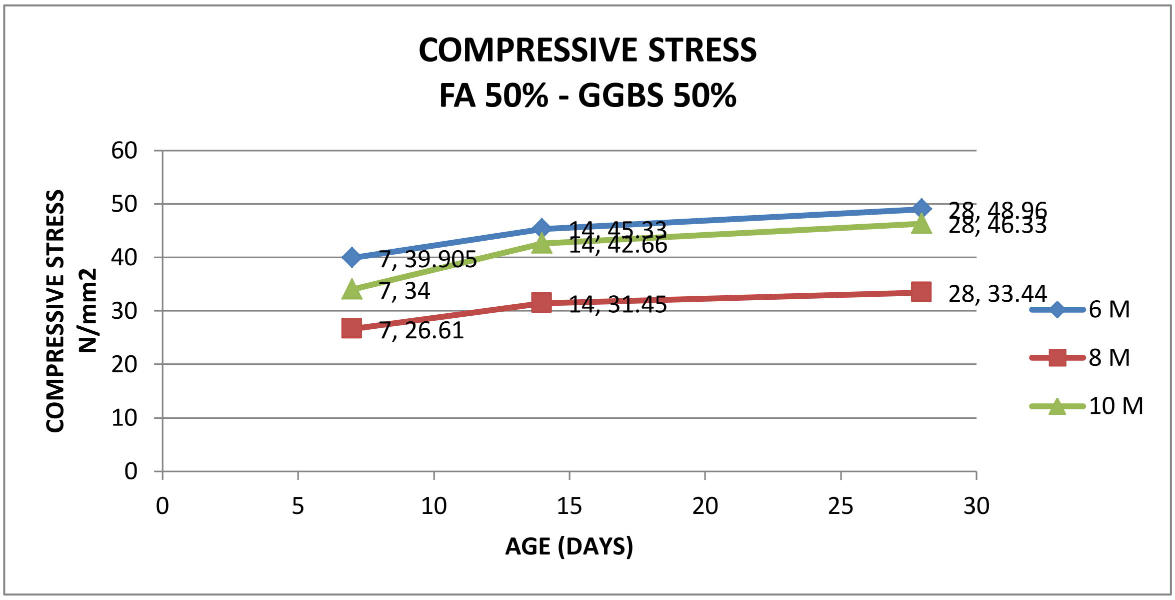

Figure 1.

COMPARISON BETWEEN 6M, 8M, 10M COMPRESSIVE STRENGTH FOR 20-80% FLY ASH & GGBS RATIO

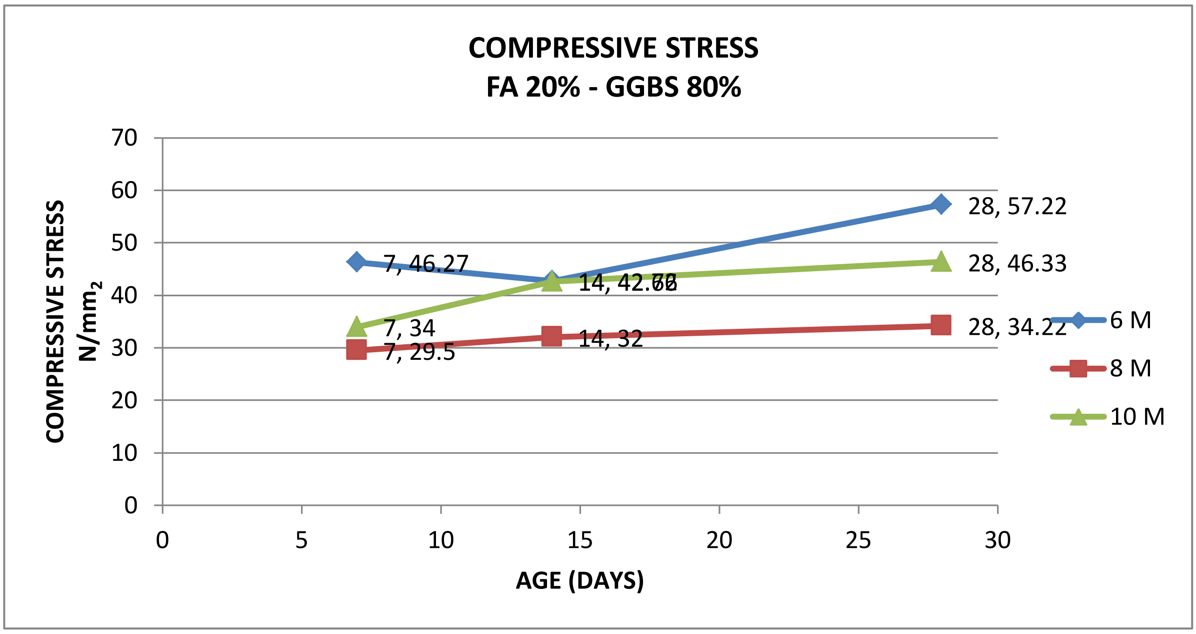

Figure 2.

The comparison graph shows in Fig.1the compressive strength of cubes shows for different molarities. For water curing of specimens 6M which gives more strength compare to the other 8M and 10M solutions. The maximum strength achieve within 7 days curing.

The comparison graph shows the Fig. 2 compressive strength of cubes shows for different molarities for 20-80% FA and GGBS. By increasing GGBS quantity we can achieve more strength. For water curing of specimens 6M which gives more strength compare to the other 8M and 10M solutions. The maximum strength achieve within 7 days curing.

5.1.2 Split tensile strength test:

Cylindrical specimens of diameter 150mm and length 300mm were prepared. Split tension test was carried out on 2000 kN capacity compression testing machine as per IS 5816-1999.

COMPARISION BETWEEN 6M, 8M, TENSILE STRENGTH FOR 50-50% FLY ASH & GGBS RATIO

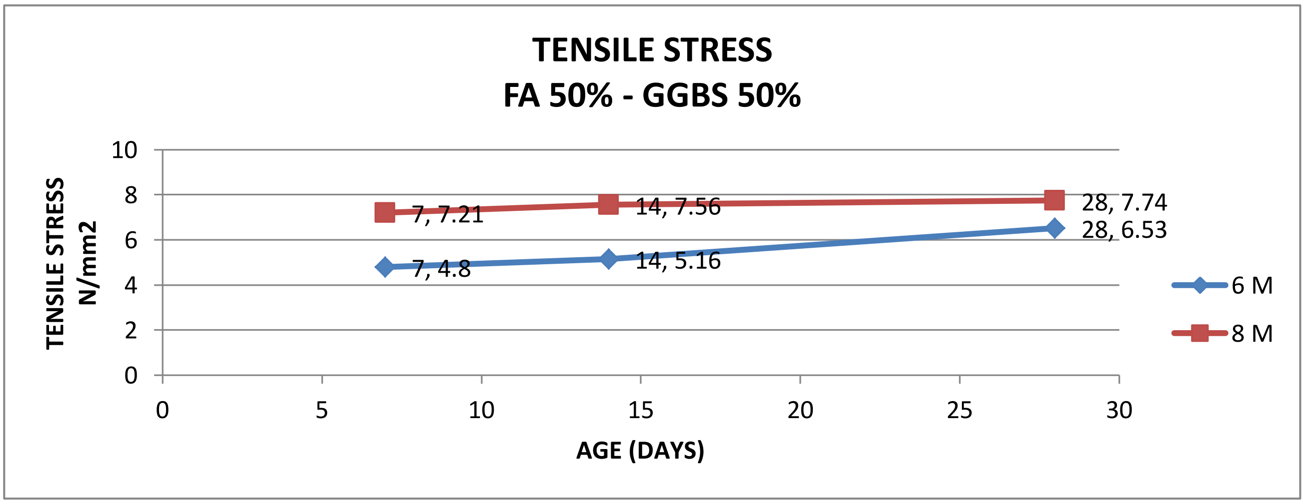

Figure 3

COMPARISION BETWEEN 6M, 8M, TENSILE STRENGTH FOR 20-80% FLY ASH & GGBS RATIO

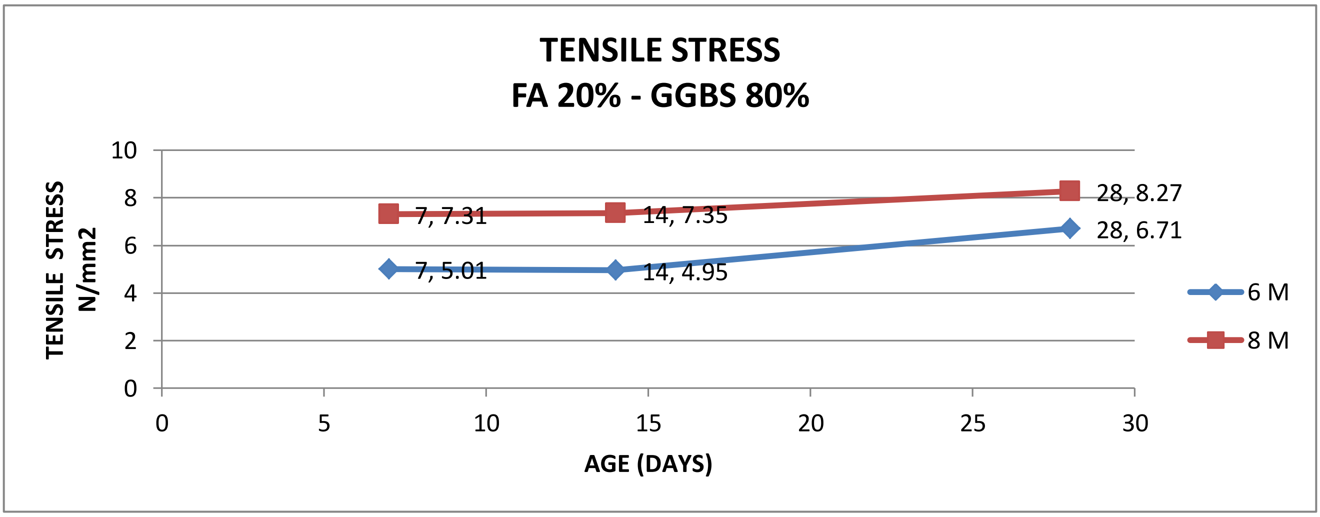

Figure 4.

The comparison graph shows in Fig. 3 the tensile strength of cylinder shows for different molarities. For water curing of specimens 6M which gives less strength compare to the other 8M solutions. The maximum strength achieve within 7 days curing.

The comparison graph shows the Fig. 4 tensile strength of cylinders shows for different molarities for 20-80% FA and GGBS. By increasing GGBS quantity we can achieve more strength. For water curing of specimens 8M which gives more strength compare to the other 6M solutions. The maximum strength achieve within 7 days curing.

VI. CONCLUSION

. User-friendly geopolymer concrete can be used under conditions similar to those suitable for ordinary Portland cement concrete. These constituents of Geopolymer Concrete shall be capable of being mixed with a relatively low-alkali activating solution and must be curable in a reasonable time under ambient conditions. The production of versatile, cost-effective geopolymer concrete can be mixed and hardened essentially like Portland cement. Geopolymer Concrete shall be used in repairs and rehabilitation works.

- As the GPCs do not contain any Portland cement, they can be considered as less energy intensive (i.e., low Embodied energy') apart from less energy intensiveness the GPCs utilize the industrial waste for producing the binding system in concrete.
- Compressive strength for 6M is more, compared to 8M and 10M.**(Fig. 1and 2)**
- While Molarity of solution decreases the strength is increases for water curing.
- The increase in GGBS quantity increases the strength.
- The split tensile strength is more in 8M compared to 6M. **(Fig. 3 and 4)**
- User-friendly geopolymer concrete can be used under conditions similar to those suitable for ordinary Portland cement concrete.
- The production of versatile, cost-effective geopolymer concrete can be mixed and hardened essentially like Portland cement.

REFERENCES

[1] R. Anuradha, v.Sreevidya, R Venkatasubramani & B V Rangan: Relationship between compressive and tensile strength of geopolymer concrete. (Page no 18-23 The Indian concrete journal 2011)
[2] B.V Rangan, Djwantoro Hardjito, Steenie E.: Studies on of fly ash based geopolymer concrete.(page 133-137 Curtain University of technology.)
[3] Pratap Kishanrao: Design of Geopolymer concrete (Page no 1841-1844 international journal of innovative research in science. 2013)
[4] M. I. Abdul Aleem, P. D. Arumairaj: GEOPOLYMER CONCRETE- A REVIEW (page no 118-122 International Journal of Engineering Sciences & Emerging Technologies 2012)
[5] Ganapati Naidu. P, A.S.S.N.Prasad, S.Adiseshu, P.V.V.Satayanarayana: A Study on Strength Properties of Geopolymer Concrete with Addition of G.G.B.S (page no 19-28 International Journal of Engineering Research and Development 2012)
[6] Rajan Bhattacharjee, Aminul Islam: RHEOLOGICAL BEHAVIOR OF FLY ASH BASED GEOPOLYMER CONCRETE (35th Conference on OUR WORLD IN CONCRETE & STRUCTURES: August 2010, SingaporeArticle)
[7] Djwantoro Hardjito, Steenie E. Wallah, Dody M. J. Sumajouw, and B.Vijaya Rangan : On the Development of Fly Ash-Based Geopolymer Concrete (Page no 467 – 472, ACI Materials Journal/November-December 2004)