International Journal For Technological Research In Engineering
Volume 4, Issue 2, October-2016 *ISSN (Online): 2347 - 4718*

AN EXPERIMENTAL STUDY ON GEOPOLYMER CONCRETE USING FLYASH (40%) AND GGBS (60%)

J.B.S.Bharathi[1], Chintada.Vinod Kumar[2]
[1]M.Tech (structural engineering), [2]Assistant professor,
Department of Civil Engineering, Gokul Institute Of Technology And Sciences

ABSTRACT: The major problem that world facing today is environmental pollution. Mainly in the construction industry with the production of portland cement causes the emission of pollutants (carbon-di-oxide) results in environmental pollution. We can reduce the pollution effect on the environment, by increasing the usage of industrial by-products in our construction industry. Geopolymer concrete is such a one and in the present study, to produce the geopolymer concrete the portland cement is replaced with flyash and GGBS and alkaline liquids are used for the binding of materials. The alkaline liquids used in this study for the polymerisation are the solutions of sodium hydroxide(NaOH) and sodium silicate(Na2Sio3).In the present study the comparison is done by taking different alkaline liquid to fly ash, ggbs of geopolymer concrete in three different ratios 0.3,0.35,0.4 respectively.
The tests conducted were compressive strength test, split tensile strength and flexural strength test. The obtained results shows there is a significant increase in strength of the specimen in harden concrete tests.

I. INTRODUCTION

The geopolymer technology was first introduced by Davidovits in 1978. His work considerably shows that the adoption of the geopolymer technology could reduce the emission caused due to cement industries. Geopolymers are members of the family of inorganic polymers. The chemical composition of the geopolymer material is similar to natural zeolitic materials, but the microstructure is amorphous. Any material that contains mostly silicon (Si) and aluminium (Al) in amorphous form is a possible source material for the manufacture of geopolymer. Metakaolin or calcined Kaolin, low calcium ASTM class flyash, natural Al-Si minerals, combination of calcined minerals and non- calcined minerals, combination of flyash and metakaolin, combination of granulated blast furnace slag and metakaolin have been studied as source materials. The most common alkaline liquid used in geopolymerisation is a combination of sodium hydroxide or potassium hydroxide and sodium silicate or potassium silicate. In the past few decades, it has emerged as one of the possible alternatives to OPC binders due to their reported high early strength and resistance against acid and sulphate attack apart from its environmental friendliness. The temperature during curing is very important, and depending upon the source materials and activating solution, heat often must be applied to facilitate polymerization, although some systems have been developed that are designed to be cured at room temperature. Geopolymer binders might be a promising alternative in the development of acid resistant concrete since it relies on alumina-silicate rather than calcium silicate hydrate bonds for structural integrity.

II. DEFINITION OF GEOPOLYMER

Davidovits of France first coined the term Geopolymer concrete and proposed that an alkaline liquid could be used to react with the silica (Si) and the Alumina (Al) in the source material of geological origin or in by-product materials such as flyash, GGBS and Rice husk ash to produce binders. Geopolymer cements are a class of material that combine an aluminum silicate with a chemical activator such waterglass. The chemical composition of geopolymer materials is similar to natural Zeolitic materials, but the microstructure is amorphous. The polymerization process involves a substantially fast chemical reaction under alkaline condition on Si-Al materials that results in a three dimensional polymeric chain reaction consisting a ring of Si-O-Al-O bonds. Thus the concrete is named as geopolymer concrete.

III. IMPORTANCE OF USING GEOPOLYMER CONCRETE

Geopolymer concrete is considered to be an innovative material that is a viable alternative to traditional Portland concrete or cement used in transportation infrastructures, certain constructions and offshore builds. It is very resistant to several of the durability issues that can cause traditional concretes to crack and crumble. This is accomplished by using minimally processed natural materials or industrial byproducts. Geopolymer concretes will cure more quickly than Portland concretes. They have obtained most of their strength within 24 hours. This type of concrete is starting to revolutionize concrete. It is being used more and more in highway construction projects and offshore applications. It is still a little too pricey for the do-it-yourself projects that abound, but contractors are starting to use it more and more in other construction projects.

IV. MIX DESIGN PROCESS

Calculations of Mix Proportions for M_{20} grade.
Designing the mix as per IS :10262:2009
Considering the values of specific gravity of
Fly ash = 2.2
Coarse aggregate(20mm) = 2.74
Coarse aggregate(10mm = 2.65
Fine aggregate = 2.59
Step 1: Target strength for mix proportion:
where,
f'_{ck} = target mean compressive strength at 28 days in N/mm^2

f_{ck} = characteristic compressive strength at 28 days in N/mm^2
s = standard deviation in N/mm^2
$f'_{ck} = f_{ck} + 1.65$ s
= 20 + 1.65(4)
= 20 + 6.6
= 26.6 N/mm^2
s= 4 from table 1 from assumed standard deviation value for M20 grade.
Step 2: Selection of water content:
From table 2, maximum water content for 20mm aggregate = 186 litres
Estimated water content for 100 mm slump = 186 +(6/100)*186
= 197 litres.
as an additive of super plastisizer reduced to 14%
= 197 *0.86
= 169.42
approx =170 litres.
Step 3: Calculation of fly ash:
From IS 10292:2009, the quantity of fly ash being used = 320 kg/m^3
Step 4: Calculation of volume of Coarse aggregate and Fine aggregate:
From IS 10292: 2009; volumes are been calculated
Volume of Coarse Aggregate = 0.6
Volume of Fine Aggregate = 0.4
Step 5: Mix calculations:
a) Volume of concrete = 1 m^3
b) Volume of fly ash = (mass of fly ash / specific gravity of fly ash) x (1/1000)
= (320/2.2) x (1/1000)
= 0.14545 m^3
c) Volume of water = (170/1) x (1/1000)
= 0.17 m^3
d) Volume of chemical admixture = (1.92/1.145) x (1/1000)
= 0.00167 m^3
e) Volume of all in aggregate = [a – (b+c+d)]
= [1– (0.14545+0.17+0.00167)]
= 0.682 m^3
f) Mass of coarse aggregate = e x volume of coarse aggregate x specific gravity of
Coarse aggregate x 1000
= 0.682 x 0.6 x 2.74 x 1000
= 1122 kg/ m^3
g) Mass of fine aggregate = e x volume of fine aggregate x specific gravity of fine
Fine aggregate x 1000
= 0.682 x 0.4 x 2.59 x 10000 = 707 kg/m^3
Therefore,
Fly ash = 320 kg/m^3
Coarse aggregate = 1122 kg/ m^3
Coarse aggregate (20 mm) = 1122 x 0.6 =673.2 kg/ m^3
Coarse aggregate (10 mm) = 1122 x 0.4 = 448.8 kg/ m^3
Fine aggregate = 707 kg/ m^3
Water = 170 litres
The mix proportion that has been used for M20 grade :
= Fly ash : Fine aggregate : Coarse aggregate
= 320 : 707 : 1122
= 1: 2.2 : 3.5

Mix design of fly ash geopolymer concrete with alkaline liquid ratio of 0.3 solution:
Step 1: unit weight of concrete = 2400 kg/m^3
Step 2: mass of coarse aggregate = 1122 kg/ m^3
Step 3: mass of fine aggregate = 707 kg/ m^3
Step 4: mass of fly ash = 320 kg/ m^3
Step 5: alkaline liquid / fly ash = 0.3
alkaline liquid = 0.3 * fly ash
= 0.3*320
= 96
step 6: taking Na_2SiO_3 / NaOH = 2.5
For 12Molarity, the ratio of solids to water is 35.4 : 64.6
Step 7: mass of NaOH = 96 / 2.5 = 38.4
mass of NaOH in solids form = 35.4*(38.4/100)
= 13.69
mass of NaOH in water form = 64.6*(38.4/100)
= 24.8
step 8: mass of Na_2SiO_3 = 96 - 38.4 = 57.6
mass of Na_2SiO_3 in solids form = (57.6*0.52) = 29.95
mass of Na_2SiO_3 in water form = (57.6*0.48) = 27.65
Optimized mix proportions of 0.3 solution geopolymer concrete(kg/m^3)

Solution of GPC	0.3 SOLUTION
Flyash =320(kg/m^3); (40%)	128
Fine aggregate(kg/m^3)	707
Coarse aggregate(kg/m^3)	1122
Alkaline liquid(kg/m^3)	96
NaOH(kg/m^3)	38.4
Na_2SiO_3 (kg/m^3)	57.6
GGBS (60%)(kg/m^3)	192

Mix design of fly ash geopolymer concrete with alkaline liquid ratio of 0.35 solution:
Step 1: unit weight of concrete = 2400 kg/m3
Step 2: mass of coarse aggregate = 1122 kg/ m3
Step 3: mass of fine aggregate = 707 kg/ m3
Step 4: mass of fly ash = 320 kg/ m3
Step 5: alkaline liquid / fly ash = 0.35
alkaline liquid = 0.35 * fly ash
= 0.35*320
= 112
step 6: taking Na2SiO3 / NaOH = 2.5
For 12Molarity, the ratio of solids to water is 35.4 : 64.6
Step 7: mass of NaOH = 112 / 2.5 = 44.8
mass of NaOH in solids form = 35.4*(44.8/100)
= 15.85
mass of NaOH in water form = 64.6*(44.8/100)
= 28.95
step 8: mass of Na2SiO3 = 112 – 44.8 = 67.2
mass of Na2SiO3 in solids form = (67.2*0.52) = 34.94
mass of Na2SiO3 in water form = (67.2*0.48) = 32.25

Optimized mix proportions of 0.35 solution geopolymer concrete(kg/m3)

Solution of GPC	0.35 SOLUTION
Flyash =320(kg/m^3); (40%)	128
Fine aggregate(kg/m^3)	707
Coarse aggregate(kg/m^3)	1122
Alkaline liquid(kg/m^3)	112
NaOH(kg/m^3)	44.8
Na_2SiO_3 (kg/m^3)	67.2
GGBS (60%)(kg/m^3)	192

Mix design of fly ash geopolymer concrete with alkaline liquid ratio of 0.4 solution:
Step 1: unit weight of concrete = 2400 kg/m^3
Step 2: mass of coarse aggregate = 1122 kg/ m^3
Step 3: mass of fine aggregate = 707 kg/ m^3
Step 4: mass of fly ash = 320 kg/ m^3
Step 5: alkaline liquid / fly ash = 0.4
alkaline liquid = 0.4 * fly ash
= 0.4*320
= 128
step 6: taking Na_2SiO_3 / NaOH = 2.5
For 12Molarity, the ratio of solids to water is 35.4 : 64.6
Step 7: mass of NaOH = 128 / 2.5 = 51.2
mass of NaOH in solids form = 35.4*(51.2/100)
= 18.12
mass of NaOH in water form = 64.6*(51.2/100)
= 33.08
step 8: mass of Na_2SiO_3 = 128 – 51.2 = 76.8
mass of Na_2SiO_3 in solids form = (76.8*0.52) = 39.93
mass of Na_2SiO_3 in water form = (76.8*0.48) = 36.86
Optimized mix proportions of 0.4 solution geopolymer concrete(kg/m^3)

Solution of GPC	0.4 SOLUTION
Flyash =320(kg/m^3); (40%)	128
Fine aggregate(kg/m^3)	707
Coarse aggregate(kg/m^3)	1122
Alkaline liquid(kg/m^3)	128
NaOH(kg/m^3)	51.2
Na_2SiO_3 (kg/m^3)	76.8
GGBS (60%)(kg/m^3)	192

TESTS CONDUCTED ON SAMPLES:

- Compressive strength test
- Split tensile strength test
- Flexural strength test

V. RESULTS

Results obtained for 0.3 solution of GPC

Test conducted		Open air curing		60^0 C Temp oven curing		90^0 C Temp oven curing	
		7 days (N/mm^2)	28 days (N/mm^2)	7 days (N/mm^2)	28 days (N/mm^2)	7 days (N/mm^2)	28 days (N/mm^2)
Compressive test	1.	8.66	11.32	11.11	18.39	16.88	26.22
	2.	7.55	10.16	11.55	15.55	16	26.22
	3.	7.11	9.77	9.33	14.22	16	24.88
Split tensile test	1.	-	0.56	1.27	1.41	1.69	1.9
	2.	-	0.49	1.06	1.34	1.41	1.76
Flexural test	1.	1.24	1.57	1.6	2.32	2.38	2.61
	2.	1.30	1.45	1.6	2.15	2.06	2.58

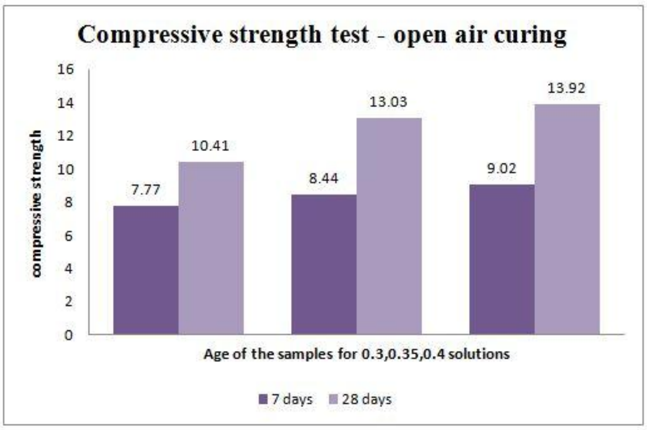
Results obtained for 0.35 solution of GPC

Test conducted		Open air curing		60^0 C Temp oven curing		90^0 C Temp oven curing	
		7 days (N/mm^2)	28 days (N/mm^2)	7 days (N/mm^2)	28 days (N/mm^2)	7 days (N/mm^2)	28 days (N/mm^2)
Compressive test	1.	8.88	14.22	15.55	24	23.11	35.55
	2.	8.44	12.88	14.22	21.7	21.33	33.77
	3.	8	12	13.33	18.66	20.44	32.44
Split tensile test	1.	0.28	0.9	1.9	2.19	1.98	2.61
	2.	0.35	0.87	1.69	2.05	1.9	2.40
Flexural test	1.	1.30	1.96	2.25	2.81	2.45	3.17
	2.	1.47	1.92	2.12	2.74	2.28	2.96

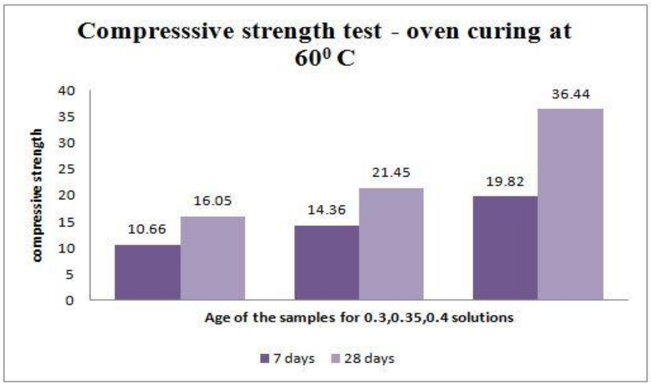
Results obtained for 0.4 solution of GPC

Test conducted		Open air curing		60^0 C Temp oven curing		90^0 C Temp oven curing	
		7 days (N/mm^2)	28 days (N/mm^2)	7 days (N/mm^2)	28 days (N/mm^2)	7 days (N/mm^2)	28 days (N/mm^2)
Compressive test	1.	9.77	15.55	20.89	37.77	28.68	46.22
	2.	8.86	13.33	19.56	36.44	25.41	44.44
	3.	8.44	12.88	19.02	35.11	23.22	44
Split tensile test	1.	0.76	1.34	2.10	2.54	2.47	3.11
	2.	0.75	1.13	1.76	2.47	1.9	2.75
Flexural test	1.	2.15	2.35	2.64	2.94	2.94	4.05
	2.	2.09	2.25	2.58	2.91	2.84	3.33

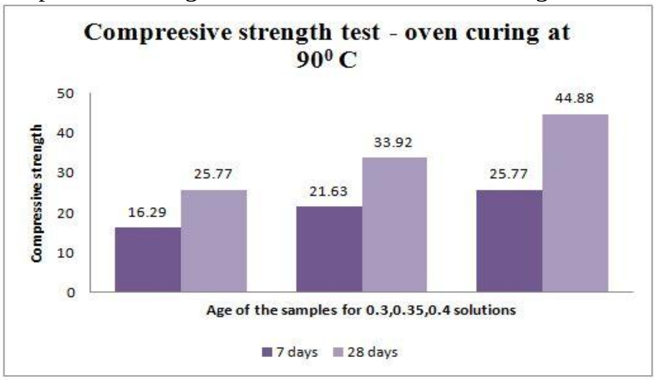
DISCUSSIONS:
COMPRESSIVE STRENGTH TEST:



Comparison of three different samples of average compressive strength values at open air curing.

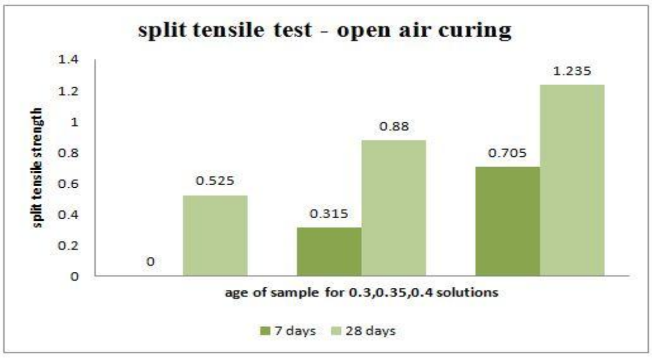


Comparison of three different samples of average compressive strength values at 60^0 C of oven curing..

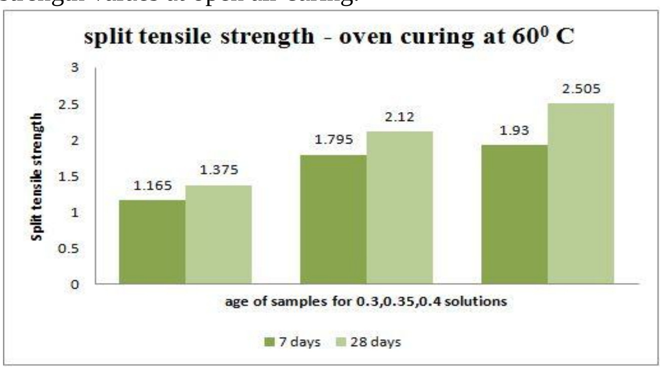


Comparison of three different samples of average compressive strength values at 900 C of oven curing..

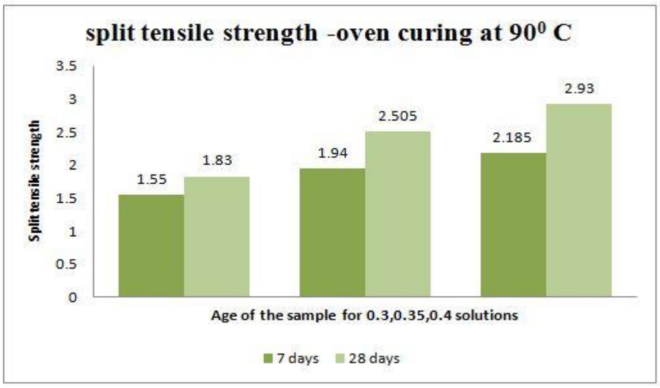
SPLIT TENSILE STRENGTH TEST:



Comparison of three different samples of average split tensile strength values at open air curing.

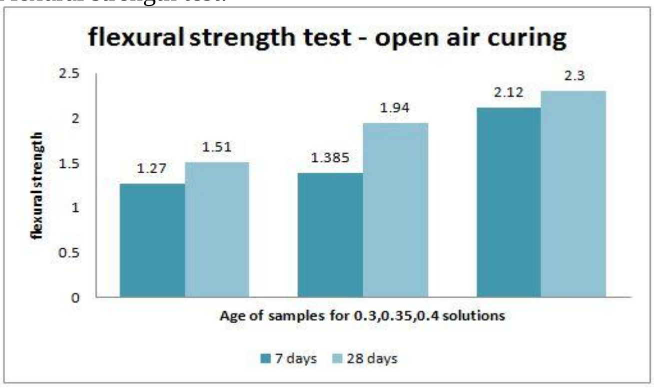


Comparison of three different samples of average split tensile strength values at 600 C of oven curing.

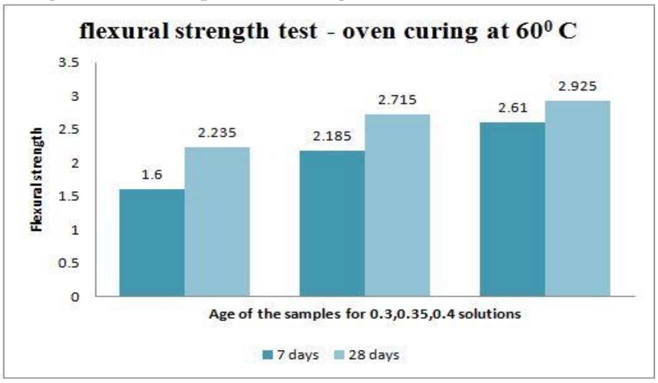


Comparison of three different samples of average split tensile strength values at 900 C of oven curing.

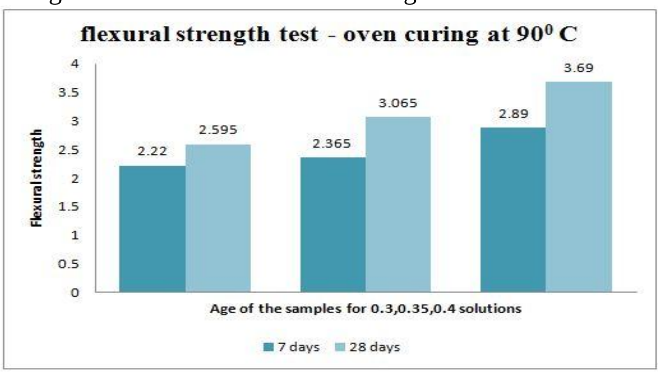
Flexural strength test:



Comparison of three different samples of average flexural strength values at open air curing.



Comparison of three different samples of average flexural strength values at 600 C of oven curing.



Comparison of three different samples of average flexural strength values at 90^0 C of oven curing.

VI. CONCLUSIONS

Study was done on geopolymer concrete using fly ash and GGBS. Based on the test results, the following conclusions are drawn:

- In compressive strength of concrete, there is an increase in the strength compared to 0.35 and 0.4 solution with respect to 0.3 solution for different cases like open air curing,60^0 C,90^0 C temperatures for both 7 days and 28 days.
- In split tensile strength of concrete, there is a slight increase in the strength compared to 0.35 and 0.4 solution with respect to 0.3 solution for different cases like open air curing,60^0 C,90^0 C temperatures for both 7 days and 28 days.
- In flexural strength of concrete, there is an increase in the strength compared to 0.35 and 0.4 solution with respect to 0.3 solution for different cases like open air curing,60^0 C,90^0 C temperatures for both 7 days and 28 days.

REFERENCES

[1] Ammar Motorwala, Vineet Shah, Ravishankar Kammula, Praveena Nannapaneni, and Prof.D.B.Raijiwala, " alkali activated fly ash based geopolymer concrete", international journal of emerging technology and advanced engineering volume 3,issue 1, January 2013.

[2] B.Vijaya Rangan, "flyash based geopolymer concrete",proceedings of the international workshop on geopolymer cement and concrete,allied publishers private limited, Mumbai, India, December 2010.

[3] N.A.Lloyd and B.V. Rangan - Geopolymer concrete: A Review of Development and Opportunities (2010).

[4] Prof. More Pratap Kishanrao - International Journal of Innovative Research in Science, Engineering and Technology, Design of Geopolymer Concrete (2013).

[5] Ganapati Naidu. P, A.S.S.N.Prasad, S.Adiseshu, P.V.V.Satayanarayana, International Journal of Engineering Research and Development, Volume 2, Issue 4 (July 2012)," A Study on Strength Properties of Geopolymer Concrete with Addition of G.G.B.S".

[6] Malathi.V, R.Anu Radha and Dr.R.Venkatasubramani," strength study on flyash based geopolymer concrete under heat curing", international journal of emerging trends in engineering and development issue,may 2012.

