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EXPERIMENTAL STUDY ON STRENGTH AND DURABILITY OF GGBS BASED GEOPOLYMER CONCRETE

Bommena Karthik Chary[*1] & Laxminarayana A[2]
[*1]Assistant Professor, Civil Engg., Department, CMRCET - Hyderabad
[2]Student, JNTUH, Hyderabad

ABSTRACT

Cement Concrete is the most extensively used material on the planet with around six billion tones being utilized every year by discharging a vast sum of CO2 at the creation of pozzolana cement which brings about expanding of Global Warming. There have to diminish the worldwide anthropogenic carbon dioxide, this has invigorated analysts looking for natural or green building materials. GPC can control CO2 release into the environment as we utilize restricting material which are normal or byproduct materials like fly-ash, rice husk, ground granulated blast furnace slag, silica fume, red mud and so on. In this theory, the objective of the present examination is to watch the effect of Ground Granulated Blast furnace Slag based GPC by replacing of Cement for 100 %. GPC is made by utilizing hardeneder (alkaline solution) and GGBS. The alkaline solution is a mixer of Sodium Silicate and sodium hydroxide made in three variations 6 molarity, 8 molarity and 10 molarity. Calcium silicate is surrounded when GGBS gets responded with sodium hydroxide and sodium silicate. A mix blend for GPC was arranged by accepting the unit weight of 2400 kg/m3. In this thesis we made the GPC with GGBS to investigate the effects of properties like durability and strength

Keywords: *Globalwarming, Pozzolana cement, Sustaining building materials, By Product of industries, GGBS, Alkaline solution, Molarity*

I. INTRODUCTION

Primary binding material used to produce normal concrete is Portland cement. We are well aware of ecofriendly issues related with the production of OPC. The amount of the CO2 released during the production of OPC due to the calcination of limestone and burning of fossil fuel is in the order of one ton per production of one ton OPC. In the development of infrastructure / construction business, essentially the generation of Portland cement results in environmental pollution. There is need to reduce the global anthropogenic CO2 has stimulated researchers in search of sustainable building materials

GPC history

GPC is an advanced and eco-friendly building material is an substitute to Portland Cement Concrete (PCC). The GPC is made from consumption of excess materials such as fly ash, silica fume, rice-husk ash, red mud ,GGBS etc., . In 1978, Davidovits is established the binders can be produced by a polymeric reaction of alkaline solution with the silica and the aluminum basis materials of geological derivation or by-product materials from industries. Sustainable concrete is the main importance given to the current study. World is boiling due to the emission of greenhouse gases by human activities, in one of them is Co2. To take away natural well-disposed cement, these materials are replacing with byproducts of industries or naturally occurring materials such as fly ash, silica fume, rice-husk ash, red mud ,GGBS etc.,. In this thesis Cement is replaced with industrial waste like Ground Granulated Blast Furnace Slag (GGBS). The production of Ground Granulated Blast Furnace Slag requires slight external energy .

Ground granulated blast furnace slag (GGBFS)

Ground Granulated Blast Furnace Slag (GGBS) is a result of the steel business. Blast Furnace Slag is all around characterized as "the non-metallic development comprising basically of calcium silicates and different bases that are built up in a molten condition at the same time with the iron in an extreme heat." In the production of iron, blast furnace are over-burden with iron ore, fluxing agents, and coke. At the point when the iron mineral, which is comprised of iron oxides, silica, and alumina, meets up with the fluxing operators, liquid slag and iron are delivered. The liquid slag at that point experiences a specific procedure relying upon what sort of slag it will progress toward becoming. Air-cooled slag has an unpleasant complete and bigger surface zone when contrasted with totals of that volume which enables it to tie well with Portland concrete and in addition black-top blends. GGBFS is created when liquid slag is lessened quickly utilizing water planes, which delivers a granular glassy aggregate.

Table 1: Chemical composition for GGBS

S. NO	CHEMICAL CHARACTERISTICS	(GGBS) % OF COMPOSITION
1	Magnesium Oxide	8.78
2	Sulphur Content	0.41
3	Sulphide Sulphur	0.48
4	Loss on Ignition	0.68
5	Insoluble Residue	0.48
6	Chloride	0.014
7	Moisture Content	0.40
8	Manganese Content	0.20
9	Glass content	93.00
10	Chemical Module	
	a) CaO + Mgo + SiO2	77.84
	b) (CaO + Mgo)/ SiO2	1.31
	c) CaO/ SiO2	1.10

Table2: Physical Properties Of GGBS

Specific gravity	2.6
Colour	White
Surface moisture	Nil
Average particle size	4.75 mm down
Shape	Spherical

Table3: Pozzolanic Materials Physical And Chemical Properties

Chemical composition	Fly Ash (%)	GGBFS (%)	Silica Fume (%)
SiO2	35.8-42.83	32.6	90.11
Al2O3	18.0-26.9	12.8	1.63
Fe2O3	6.5-8.2	1.3	1.98
MgO	3.5-4.1	7.2	0.78
SO3	2.2-3.5	0.03	--
Na2O+K2O	--	--	1.97
P2O5	--	0.05	1.18
CaO	18.8-19.8	41.0	--
Moisture(H2O)	0.2-1.9	--	--

II. METHODS AND MATERIALS

Materials that used in this project are Fine aggregate, Coarse aggregate, Ground granulated blast furnace slag (GGBS) and Alkaline solution

Fine aggregate
The sieve analysis results are presented in table. The sand confirms zone-II. Fine aggregate ought to comprise of common sand or squashed stone sand. The residue substance ought not to surpass 4%

Coarse aggregate
Machine crinkled angular Basalt metal used as coarse aggregate. The coarse aggregate is free from clayey matter, silt and organic foams etc. The coarse aggregate is also tested for specific gravity and it is 2.68. Fineness modulus of coarse aggregate is 4.20. Aggregate of nominal size 20mm and 10mm is used in the experimental work, which is acceptable according to IS: 383-1970

Table4: Fine AggregateSieve Analysis Result

Sieve No.	Cumulative Percent passing (%)	IS: 383-1970 – Zone II requirement
	Fine Aggregate	
10 (mm)	100	100
4.75 (mm)	98.3	90-100
2.36 (mm)	94.2	75-100
1.18 (mm)	71.2	55-90
600 (μm)	47.8	35-59
300 (μm)	18.2	8-30
150 (μm)	3.12	0-10
Fineness modulus	3.11	
Specific Gravity	2.76	
Bulk Density	1378 Kg/m³	

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Table 5: Coarse Aggregate Result

Sieve Size (mm)	20 mm		12 mm	
	Requirement as per IS: 383-1970	Percentage passing	Requirement as per IS:383-1970	Percentage passing
80.00	----	----	----	----
63.00	----	----	----	----
40.00	100 %	100 %	----	----
20.00	85 – 100 %	95.12 %	----	----
16.00	----	----	100 %	100 %
12.50	----	----	85 – 100 %	97 %
10.00	0 – 20 %	12.72 %	0 – 45 %	42.53 %
4.75	0 – 05 %	2.78 %	0 – 10 %	8 %
2.36	----	----	----	----
Specific gravity		2.76	-	2.72
Water Absorption %		0.34	-	0.54
Aggregate Impact Value		9.6 %	-	9.56 %
6Bulk Density (kg/m3)		1679	-	1632
Flakiness		14 %	-	13 %
Elongation		10 %	-	10 %

Ground granulated blast furnace slag (GGBS)
GGBS got purchased from online (India Mart). The specific gravity of GGBS is 2.9. Bulk density is 1200 kg/m3 and Quality is >350m2/kg. The colour of GGBS is off-white.

Alkaline Solution
The alkaline liquid are used in GPC production, it is a combination of sodium hydroxide (NaOH) and sodium silicate (Na2SiO3). It is recommended that the alkaline liquid is prepared by the mixing both the solutions collected at least 24 hours previous to use. The sodium silicate is commercially available in different grades. The sodium silicate solutionA53 with SiO2-to-Na2O ratio by mass of approximately 2, i.e., SiO2 = 29.4%, Na2O = 14.7%, and water = 55.9% by mass is used. The sodium hydroxide is available in flacks. The solids must be melted in distilled water to make a solution with the required concentration. The concentration of sodium hydroxide solution can vary in the range among 6 Molar to 16 Molar. In this investigation 6M,8M and 10M is adopted

Experimental programme
An experimental program is conducted on “GGBS is full replacement of cement concrete.. The test program consists of resonant out compressive asset test on cubes and split tensile strength on cylinders and Flexural strength of Beams. Experimental study is accepted to investigate the compressive and flexural and split tensile strengths of concrete.

III. METHODOLOGY

Preparation of mix and alkaline solution
Unit Weight of concrete 2400, Mass of combined aggregate 77% of concrete mass. So mass of combined aggregate = (fine aggregate + coarse aggregate) = 1848 kg / m3.The Mass of GGBS and alkaline solution = 2400 - 1848 = 552 kg / m3
In this thesis we are taking (Alkaline / GGBS) =0.35
Mass of GGBS = (552)/(1+0.35)= 408 kg/m3
Mass of Alkaline liquid (Na2Sio3 + NaOH) = 552- 408 = 144 kg/m3
We here considered (Na2Sio3) / (NaOH) = 2.5
NaOH =41.14 kg/m3
Na2Sio3 = 144 - 41.14 = 102.86 =103 kg / m3
Na2Sio3 is readily available in the market with different grades here we choose A53 used the solution contain Na2O = 14.7%, SiO2 = 29.4% and water = 55.9% by mass

NaOH solution is prepare according to the molarity we require, in this thesis we have used 6M, 8M and 10M for each molarity we have to calculate weight of solids per litre

Table6: Properties of Different Molarity NaOH

NaOH (molarit)	Weight of solids	Total litres	Wt of solids/litre	of solids to soln	%of water to soln
6	40*6=240	1+0.24=1.24	240/1.24=195	195/1000=19.5	100-19.5=80.5
8	320	1.32	243	24.3	75.7
10	400	1.4	285.71	28.5	71.5

For trail mix

Water present in Sodium silicate

•% of only water in (Na2SiO3) other than solids =55.9%

•We need Na2Sio3 = 144 - 41.14 = 102.86 =103 kg / m3

•Water in Na2SiO3 = (1.3)*(55.9/100) = 58 kg

•Only solids in Na2SiO3 = 103-58 = 45 kg

Table7: NaOH solution required

NaOH (Molarity)	Solids required to prepare solution (Kg)	Water required to prepare solution (Kg)
6	(19.5/100)*41.14=8.02	41.14-8.02=33.12
8	(25/100)*41.14=10.285	41.14-10.285=30.855
10	(29/100)*41.14=11.930	41.14-11.930=29.21

GPC must be wet mixed at least four minutes and steam cured at 60 degrees centigrade for 24 hours after casting. The workability of fresh mixed concrete is moderate. If more workability is required add some superplasticizer upto 1.5% by mass of binding material

IV. PREPARATION OF SPECIMENS

It was found that the Geopolymer blend was dark in shading. The measure of water in the blend assumed a critical part on the conduct of the crisp blend. Davidovits (2002) recommended that it is desirable over blend the sodium silicate arrangement and the sodium hydroxide arrangement together no less than one day before adding the fluid to the strong constituents.

After making the mix we have to cast the required test specimen w.r.t its mould. In this thesis we are testing the compressive strength, flexural strength, split tensile strength and durability aspects like acid attack, suphate attack, Chloride attack. After gaining partial strength to concrete specimen has to be cured.

5.4 CURING METHOD adopted is AMBIENT CURING: At that point, the shapes are demoulded and kept in oven at 500 c for 3 days and 7 days. For the daylight curing, the blocks are demoulded following 1 day of throwing and they are put in the immediate daylight for 3, 7 and 28 days.

V. DURABILITY STUDY

Durability is a major factor to be considered for the structure to with stand for a long period. So, my experimental investigation take me to identify the structural behavior on different environmental like Chloride attack, Acid attack and Sulphate attack. Therefore, the results and discussions are processed as follows.

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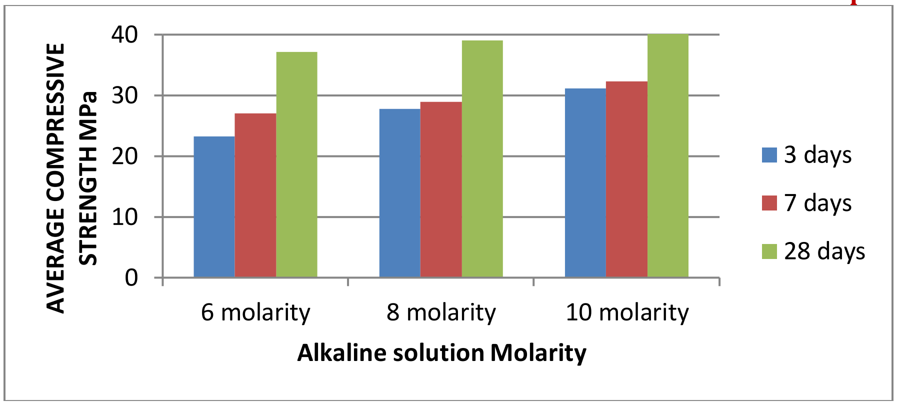
In analyzing the durability parameter of concrete the procedure involves nine polyester tubs of capacity approximately 20 litres which are filled with 2% of chemical solution in 98% distilled water. The existing cubes are preserved for 28 days with each tub three cubes. The chemicals are H2So4, MgSo4 and NaCl.

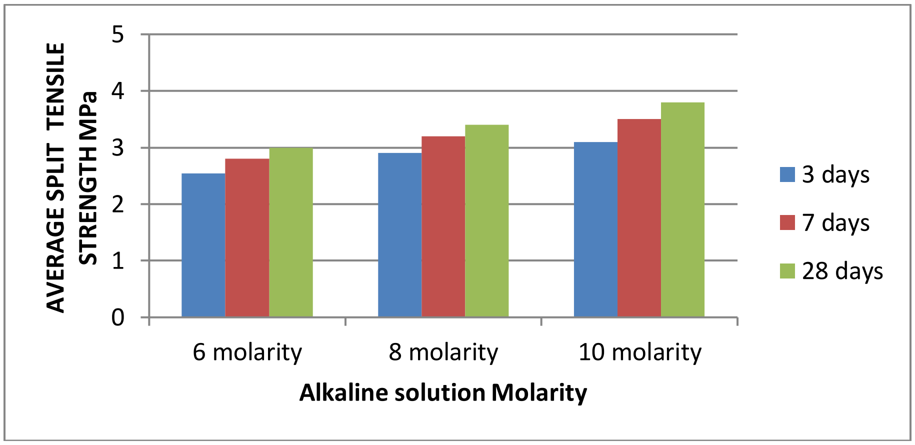
Fig.1:Chemical Curing

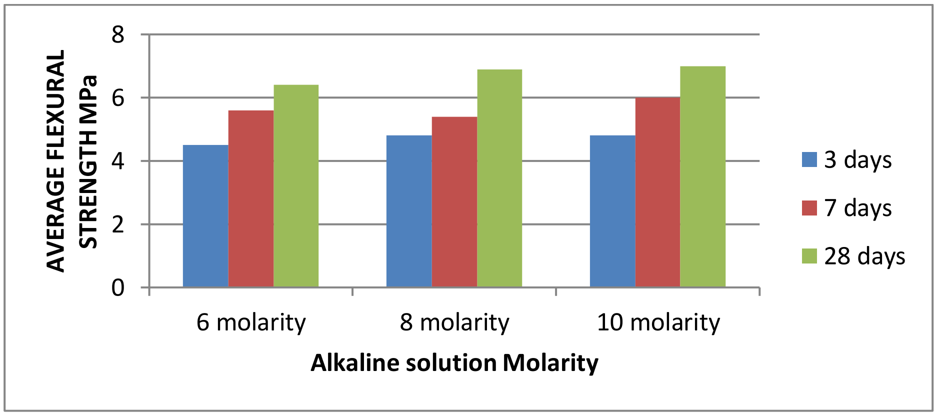
Fig2:Air dry curing at room temperature

VI. RESULTS AND DISCUSSIONS

S. No.	Molarity	Average Compressive Strength (Mpa)			Average Split tensile Strength (Mpa)			Average Flexural Strength (Mpa)		
		3days	7 days	28 days	3days	7 days	28 days	3days	7days	28days
1	6	23.2	27.02	37.2	2.54	2.8	2.99	4.5	5.6	6.4
2	8	27.8	28.9	39.1	2.9	3.2	3.4	4.8	5.4	6.9
3	10	31.1	32.3	41.2	3.1	3.5	3.8	4.8	5.9	7







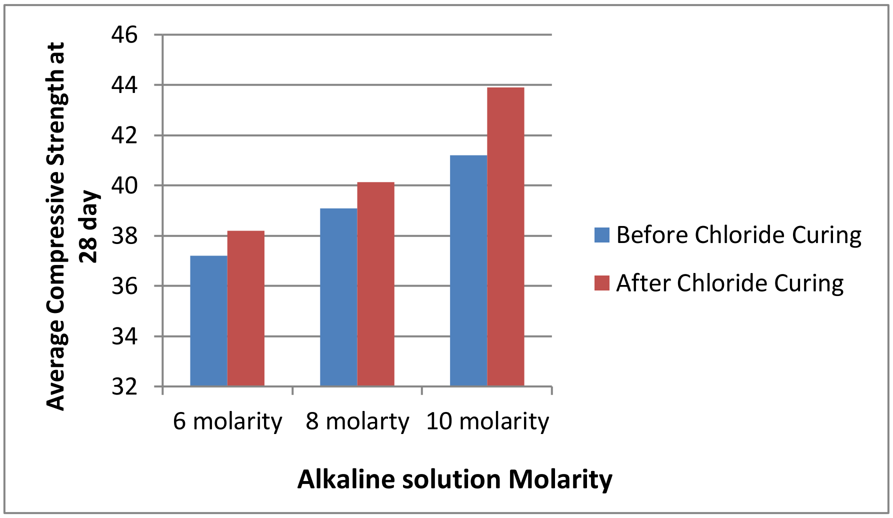
Durability parameters of GPC

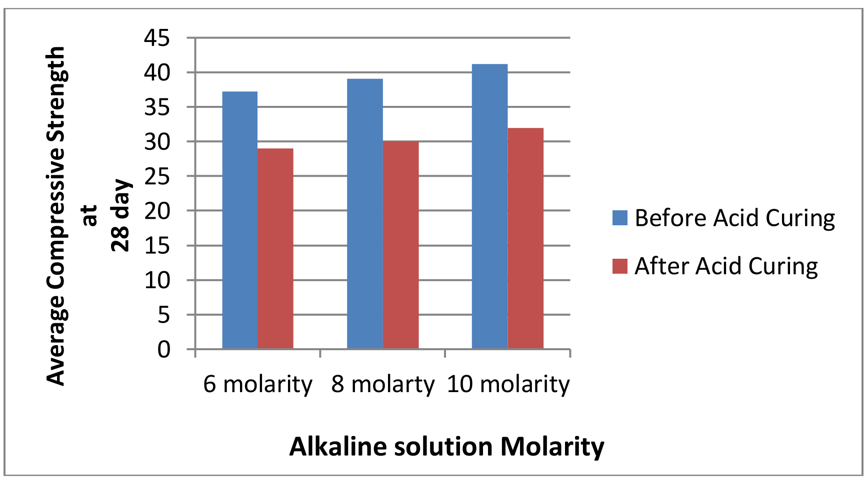
Average compressive strength at 28 day has been found after curing in different solutions of Acid (H_2SO_4), Chloride (NaCl) and Sulphate ($MgSO_4$).

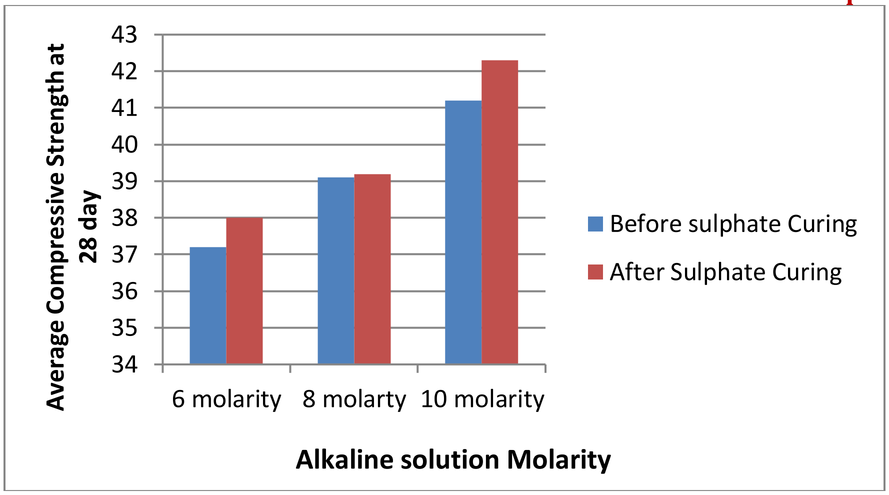
Average Compressive Strength before and after curing in different solutions

S.NO	Alkaline solution Molarity	Average Compressive Strength (MPa)			
		Before Curing	Acid Attack	Chloride Attack	Sulphate Attack

1	6	37.2	29	38.2	38
2	8	39.1	30	40.12	39.2
3	10	41.2	32	43.9	42.3







VII. CONCLUSION

- Based on experimental investigations the following were observed:
- We have noticed when molarity of alkaline solution increased there is an increment in compressive strength, spilt tensile strength and flexural strength of GPC.
- In durability point of view when GPC get in contact with magnesium sulphate (MgSo4) there is an increase in compressive strength.
- In durability point of view when GPC get in contact with hydro sulphuric acid (H2So4) there is an decrease in compressive strength.
- When GPC get in contact with sodium chloride (NaCl) there is an slight increase in compressive strength.Ultimately if we use Geopolymer Concrete there will be reductions in CO2 emissions at manufacturing of Ordinary Portland Cement.

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