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EXPERIMENTAL STUDIES ON THE GEOPOLYMER CONCRETE

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Abstract: Concrete is used more than any other man-made material in the world, in fact it is the second most consumed substance in the world after water. The production of concrete is the reason for the emission of 5% of total global emission. This is high time to think for an alternative to cement since the production of cement is the main reason for emission. There are considerable attempts which have taken place in order to replace cement with other materials. One of those is Geo-Polymer Concrete (GPC). [1] This study investigates the feasibility of using a blend of 50% ground granulated blast furnace slag (GGBS) and 50% fly ash as precursor material for geopolymer concrete production. Also fine aggregate has become very expensive and scarcity, quarry rock dust have been replaced for fine aggregate. Almost all the demolition and construction waste have been dumped without any usage which ultimately results in pollution. [2] This prime factor is considered to reutilize recycled coarse aggregate instead of coarse aggregate. A greener aided with natural friendly claim can be made only with the usage of the waste materials. To find the better combination mix, the GPC is categorized into four types as GPC-1, GPC-2, GPC-3 and GPC-4.all the above combinations of mixes fly ash is used as prime source material whereas QRD and RCA are in replaced with different combinations. Thus, this paper particularly focuses on the effect of replacement of waste materials in combination of different mixes such as FA+CA, QRD+CA, FA+RCA, and QRD+RCA in GPC. The cast specimens are cured at ambient temperature and after three days of rest period, the cast specimens are tested to determine its mechanical strength properties using standard methodology.

Index Terms - Geopolymer Concrete, Fly ash, Ground granulated blast furnace slag, Fine aggregate, Coarse aggregate, Quarry Rock Dust, Recycled Coarse aggregate

I. INTRODUCTION

Geo polymer is used as the binder, instead of cement paste, to produce concrete. The geo polymer paste binds the loose coarse aggregates, fine aggregates, and other unreacted materials together to form the geo polymer concrete. The manufacture of geo polymer 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 geo polymer 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 geo polymer paste that binds the aggregates and other unreacted materials. The term geo polymer was used by Davidovits in 1978 to describe the inorganic alumino silicate polymeric gel resulting from reaction of amorphous alumino silicates with alkali hydroxide and silicate solutions.

1.1 PROPERTIES OF GEO POLYMER CONCRETE

- It should be preferable produced from widely available waste by-products from industries
- Internal energy content (embodied energy) should be less.
- Chemical activator for generating binding system should be commonly available.
- The new binder-based concretes should similar or superior to that Portland cement-based concretes in respect of
- Processing conditions for production of fresh mixes
- Time required for demoulding or formwork removal.
- Curing regimes and periods.
- Rate of strength developments with age.
- Mechanical properties such as compressive strength, tensile strength, flexural Strength. Sets at room temperature.

II. MATERIALS USED

2.1 FLY ASH :

Class F fly ash collected by electrostatic precipitator, obtained from Thermal Power Corporation at Raichur was used in the present study.

2.2 GGBS :

Ground granulated blast furnace slag has been dried and ground to a fine powder. Iron ore, limestone, and coke are fed into the blast furnace where they reach a temperature of 1500°Candthe raw material reduced to molten iron and blast furnace slag. These are tapped off from the blast furnace and separated for processing. Molten iron is sent to the steel producing facility and slag (GGBS) is used to make concrete in combination with Portland cement. It is the glassy granular material formed when molten blast furnace slag is rapidly chilled as by immersion in water. The cementations action of a granulated blast furnace slag is dependent to large extent on the glass content. GGBS hydrates are generally found to be more gel like than the products of hydration of Portland cement, so it denses the cement paste.

2.3 FINE AGGREGATE :

The sand used in this investigation is ordinary river sand. The sand passing through 4.75mmsizesieve is used in the preparation of specimens. The sand conforms to grading Zone II as perIS: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%.

2.4 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%.

2.5 ALKALI SOLUTION :

Sodium Hydroxide (NaOH) Molecular weight: 40. Sodium Silicate (Na_2SiO_3) Molecular weight: 122.

III. METHODOLOGY :

In the present investigation M_{25} grade concrete has been used. Geopolymer concrete has emerged as one of the possible alternatives to OPC, since 50% fly ash and 50% GGBS is used instead of Portland cement.

GPC is Categorized into 4 types as:

GPC-1, GPC-2, GPC-3, GPC-4. Flyash is used as prime material and QRD&RCA are replaced with different Combination of FA&CA .We use Alkaline Activators such as NAOH & Na_2SIO_3 and we add extra water to it .Age of concrete at time of testing after rest period is 7 days,14 days,28days.

The cube specimens are tested for compressive strength, the cylinder specimens are tested for split tensile strength.

IV. RESULTS AND DISCUSSION

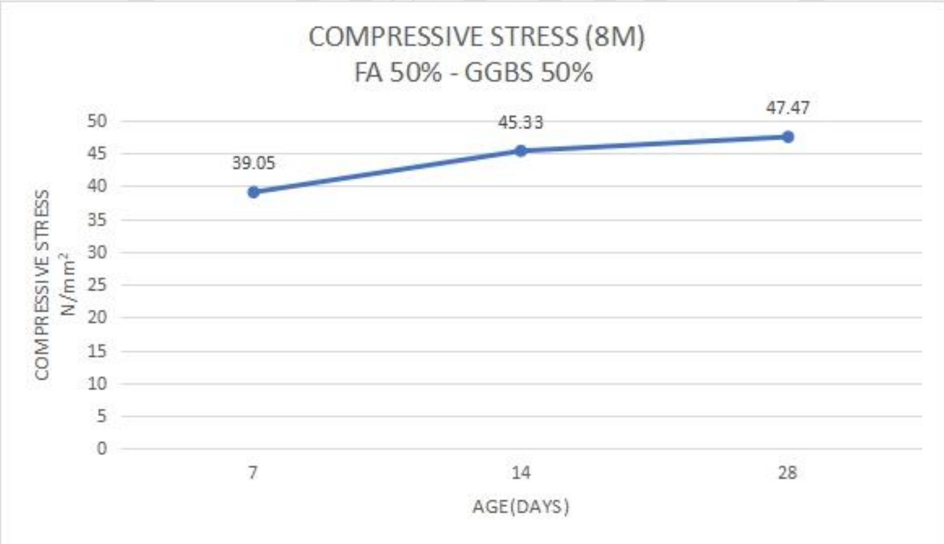
On geo polymers, a rigorous trial-and-error method was adopted to develop a process of manufacturing fly ash-based geo polymer concrete following the technology currently used to manufacture Ordinary Portland Cement concrete. After some failures in the beginning, the trail-and-error method yielded successful results with regard to manufacture of low-calcium (ASTM Class F) fly ash and GGBS- based geo polymer concrete. The optimum mix is- Fly Ash + GGBS: Fine aggregate: Coarse aggregate are 1:1.72:1.72. The comparison graph shows in Fig 5.15 the compressive strength of cubes shows for different molarities. For water curing of specimens 6M which gives more strength compare totheother8M and 10M solutions. The maximum strength achieves within 7 days of curing. Rheological properties of the fresh GPC are dependent on the type and the contents of the materials used in the mixture. As compared with the conventional Portland cement concrete mixes, GPC mixtures exhibit a different rheological behavior. The geo polymer concrete gains about 60-70% of the total compressive strength within 7 days. The Geo polymer concrete showed high performance with respect to the strength. The Geo polymer concrete was a good workable mix. High early strength was obtained in the Geo polymer concrete mix. The increase in percentage of GGBS increased the compressive strength up to the optimum level. This may be due to the high bonding between the aggregate sand alkaline solution. The compressive strength was found to be reduced beyond the optimum mix. This may be due to the increase in volume of voids between the aggregates.

4.1 Figures and Tables

4.1.1 Compressive strength test:

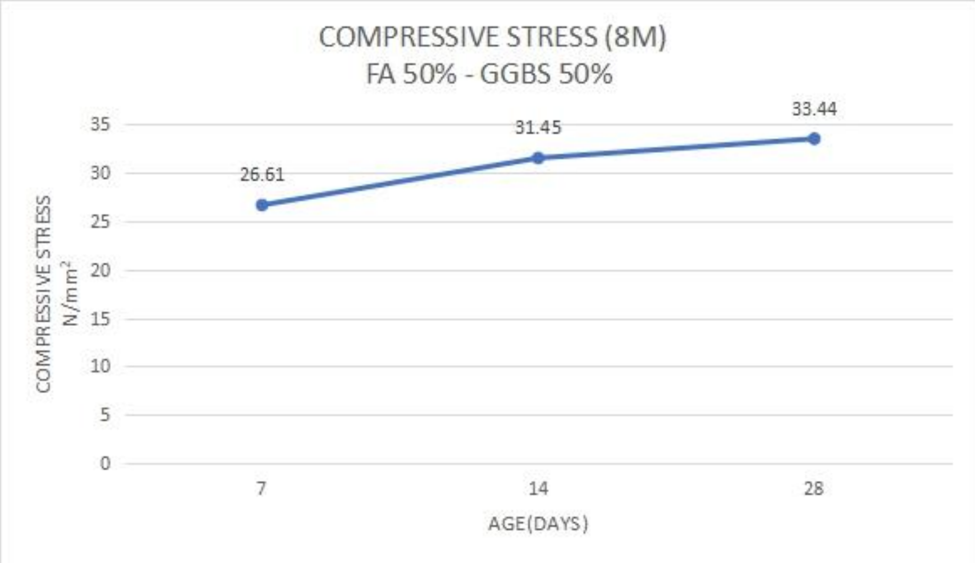
6M Fly ash 50% GGBS 50%

	6M Fly ash 50% GGBS 50%					
S.NO	7 Days		14 Days		28 Days	
	Load (KN)	Compressive stress N/mm^2	Load (KN)	Compressive stress N/mm^2	Load (KN)	Compressive stress N/mm^2
1	900	40	1140	50.66	1160	51.55
2	890	39.55	980	43.55	1155	51.33
3	850	37.77	1010	44.88	990	44
4	875	38.88	950	42.22	985	43
AVG	**878.7**	**39.05**	**1020**	**45.33**	**1072.5**	**47.47**



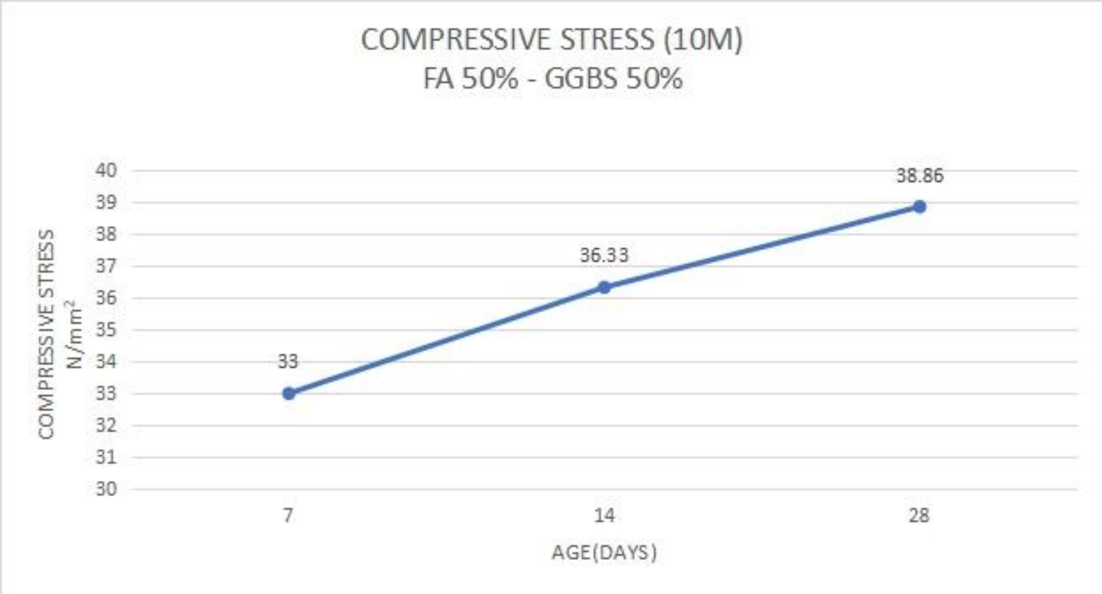
8M Fly ash 50% GGBS 50%

	8M Fly ash 50% GGBS 50%					
S.NO	7 Days		14 Days		28 Days	
	Load (KN)	Compressive stress N/mm^2	Load (KN)	Compressive stress N/mm^2	Load (KN)	Compressive stress N/mm^2
1	610	27.11	750	33.33	800	35.55
2	605	26.88	710	31.55	750	33.33
3	580	25.52	680	30.22	715	31.77
4	600	26.66	695	30.66	745	33.11
AVG	**598.7**	**26.61**	**708.75**	**31.45**	**752.5**	**33.44**



10M Fly ash 50% GGBS 50%

	10M		**Fly ash 50% GGBS 50%**			
S.NO	**7 Days**		**14 Days**		**28 Days**	
	Load (KN)	**Compressive stress N/mm^2**	**Load (KN)**	**Compressive stress N/mm^2**	**Load (KN)**	**Compressive stress N/mm^2**
1	780	34.66	900	40	920	40.88
2	800	35.55	810	36	890	39.55
3	665	29.55	795	35.33	860	38.17
4	725	32.22	765	34	830	36.84
AVG	**742.5**	**33**	**817.5**	**36.33**	**218.75**	**38.86**



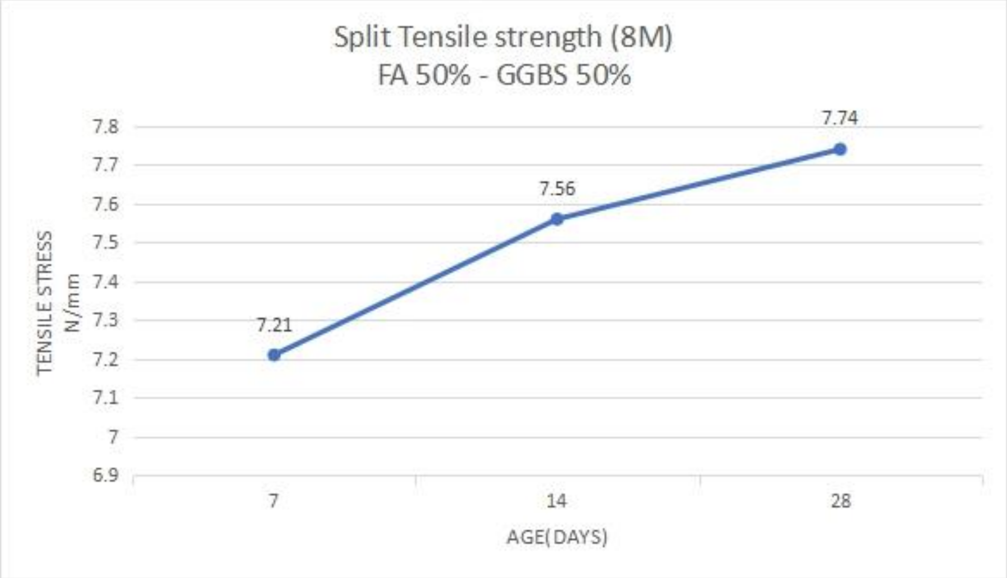
4.1.2 Split tensile strength test:

6M Fly ash 50% GGBS 50%

S.NO	6M		Fly ash 50% GGBS 50%			
	7 Days		14 Days		28 Days	
	Load (KN)	**Compressive stress N/mm^2**	**Load (KN)**	**Compressive stress N/mm^2**	**Load (KN)**	**Compressive stress N/mm^2**
1	355	5.02	380	5.37	455	6.43
2	325	4.59	350	4.95	470	6.64
AVG	**340**	**4.8**	**365**	**5.16**	**462.5**	**6.53**

8M Fly ash 50% GGBS 50%

	8M	Fly ash 50% GGBS 50%				
S.NO	7 Days		14 Days		28 Days	
	Load (KN)	Compressive stress N/mm^2	Load (KN)	Compressive stress N/mm^2	Load (KN)	Compressive stress N/mm^2
1	505	7.14	520	7.35	565	7.29
2	515	7.28	550	7.78	580	8.20
AVG	**510**	**7.21**	**535**	**7.56**	**572.50**	**7.74**



V. Conclusion

- User-friendly geo polymer concrete can be used under conditions similar to those suitable for ordinary Portland cement concrete
- 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.
- While Molarity of solution decreases the strength is increases for water curing. 70to80% of the strength is gain with in 7days
- The increase in GGBS quantity increases the strength.
- The split tensile strength is more in 8M compared to 6M.
- These constituents of Geo polymer 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 geo polymer concrete can be mixed and hardened essentially like Portland cement.

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