Comparative Analysis of Geopolymer Concrete with Conventional Concrete Using M Sand

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Abstract— World's most consumed construction material is concrete made up of cement, aggregates, water and additives as it is found to be more versatile, durable and reliable. Concrete is the second most consumed material after water, which required large quantities of Portland cement. The manufacturing process of Ordinary Portland Cement (OPC) results in destruction of the environment due to the emission of CO2 as well mining also results in unrecoverable loss to nature. The amount of carbon emissions is increasing on an alarming scale and hence, it is required to find an alternative material to the existing expensive cement-concrete. This is also a 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 other materials. Geo-polymer concrete is one of an alternative construction material which is produced by the chemical action of inorganic molecules. Fly Ash, a by-product of coal obtained from the thermal power plant is abundantly available worldwide. Fly ash which is rich with silica and alumina activated with alkaline activators form alumino silicate gel that act as the binding material for the concrete. It is an excellent alternative construction material to normal concrete without using any amount of ordinary Portland cement. Geo-polymer concrete shows a greener substitute for ordinary Portland cement concrete in some applications. This paper presents results of an experimental program on the properties of Geo-polymer Concrete such as compressive strength, split tensile strength, flexural strength. Geo-polymer concrete contains fly ash, GGBS, alkaline liquids, fine aggregate & coarse aggregate. Alkaline liquid to fly ash ratio was fixed as 0.45 with various partial and full replacement of OPC. For alkaline liquid combination, ratio of sodium silicate to sodium hydroxide solution was fixed as 2.

Keywords: Geopolymer Concrete, Fly Ash, GGBS, M Sand, Alkaline Activator Solution, Compressive Strength, Workability

I. INTRODUCTION

Construction industry is one of the fast growing industries throughout the world. Concrete is one of the widely used construction material. The primary binder used in concrete is Ordinary Portland Cement (OPC). The worldwide production of cement is high as 2.6 billion tons per year and generates nearly 7% of carbon-di-oxide which largely contributes to environmental pollution and global warming [3]. Cement production also demands huge quantity of limestone which is seen depleting. On the other hand, there is huge quantity of fly ash produced which is a by-product produced during combustion of coal and large part of it is disposed in the landfills which affect the ground water as well as surface sources of water. Hence it is of utmost importance to use alternate pozzolan materials which will utilize waste produced as well as reduce the adverse effect of construction of environment and also improve the performance of concrete [2].

Geo-polymer is an inorganic polymer. Joseph Davidovits (1978) proposed that an alkaline liquid could be used to react with silicon (Si) and aluminum (Al) as source material of geological origin or with by-product materials such as fly ash and rice husk ash to produce binders [1]. Since the chemical reaction that is taking place in this case is a polymerization process and the precursors are of geological origin, these binders were named as Geo-polymer'. Geo-polymer Concrete is gaining importance world over as the carbon emission and consequent global warming has become the major concern of the entire countries world over. One tone of cement production results in the emission of one tone of carbon dioxide. Many countries are promoting the use of fly ash as building material by granting carbon credit, which will not only reduces the production of cement and emission of carbon dioxide but also promotes the consumption of the waste material fly ash which poses a major problem for disposal world over. In India almost all the states have thermal power plants and abundant availability of fly ash. The alkaline liquids are from soluble alkali metals that are usually sodium or potassium based. The most common alkaline liquid used in geo-polymerization is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate. The alkaline solution sodium hydroxide and sodium silicates are cheap and locally available. This paper is devoted to heat-cured low-calcium fly ash-based geo-polymer concrete. Low calcium (ASTM Class F) fly ash is preferred as a source material than high-calcium (ASTM Class C) fly ash [2].

II. MATERIALS USED

The materials used for making concrete in this project were cement, fly ash, Sodium Silicate, Sodium Hydroxide, Ground Granulated Blast Furnace Slag, M-sand (fine aggregate) and gravels (coarse aggregate) .Fly Ash, an industrial by-product from Thermal Power Plants (TPPs).Ground-granulated blast-furnace slag(GGBS or GGBFS) is obtained by quenching molten iron slag(a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. Sodium hydroxide also known as lye or caustic soda has the molecular formula NaOH and is a highly caustic metallic base. It is a white solid available in pellets, lakes, granules, and as a 50%saturated solution. Sodium hydroxide is soluble in water, ethanol and methanol. This alkali is deliquescent and readily absorbs moisture and carbon di oxide in air. Sodium hydroxide is used in many industries, mostly as a strong chemical in the manufacture of pulp and paper,

textiles, drinking water, soap detergents and as a drain cleaner.

III. METHODOLOGY

A. Mix design:

The mix design of geo-polymer concrete was adopted for characteristic strength of 30Mpa (M30) and mix proportion of conventional concrete (M30) are described in Table I

Cement	Water	FA	CA
440	197	686	1081
1	0.447	1.56	2.45

B. Mix Proportions

Different mix proportions have been prepared in the laboratory for the experimental program as tabulated below:

MIX	FINE AGGREGATES		CEMENTIOUS MATERIALS		
	RIVER SAND	M SAND	CEMENT PPC (53 GRADE)	FLY ASH	GGBS
M1	100%	-	100%	-	-
M2	-	100%	100%	-	-
M3	-	100%	-	50%	50%
M4	-	100%	-	75%	25%
M5	-	100%	-	25%	75%
M6	-	100%	-	100%	-
M7	-	100%	-	-	100%

OTHER INGREDIENTS USED –
ALKALINE ACTIVATOR SOLUTION – MIXTURE OF NAOH WITH Na2SiO3 solution in the ratio 1:2

IV. RESULTS

A. Test Results:

1) Test on Geo polymer Cement Paste

Cementitious Materials			TESTS		
CEMENT	FLY ASH	GGBS	NORMAL CONSISTENCY	INITIAL SETTING TIME IN MIN	FINAL SETTING TIME IN MIN
100%			40	38	585
	100%		28	42	596
		100%	31	34	575
	50%	50%	38	36	585
	25%	75%	38	34	580
	75%	25%	39	36	590

2) Test on Fresh Concrete

Workability Test –

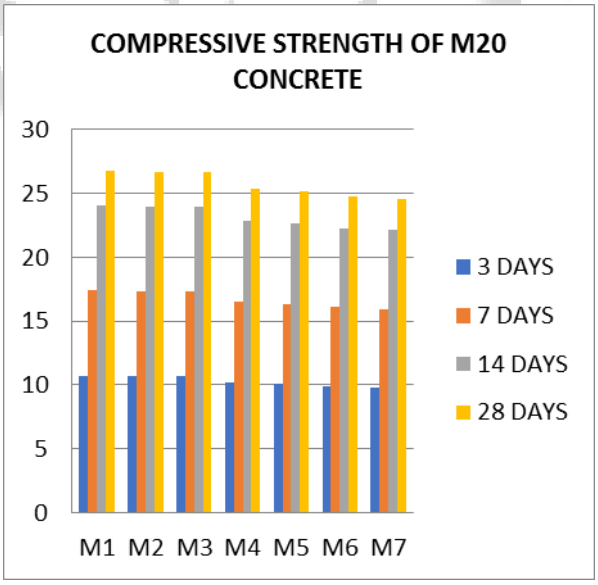
MIX	VALUE OF SLUMP in mm.		
	M20	M 25	M30
M1	105	108	115
M2	100	101	112
M3	102	103	110
M4	85	90	95
M5	77	80	82
M6	80	75	80
M7	82	85	88

3) Test on Hardened Concrete

Compressive Strength –

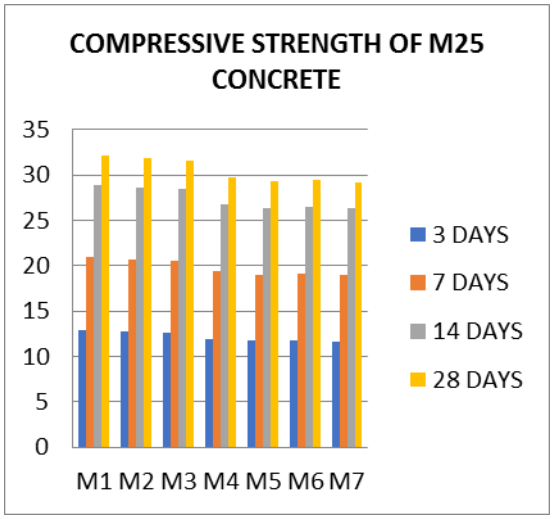
a) For M 20 Grade of Concrete

MIX	M 20			
	3 DAYS	7 DAYS	14 DAYS	28 DAYS
M1	10.7	17.4	24.07	26.75
M2	10.68	17.35	24	26.7
M3	10.67	17.33	23.96	26.68
M4	10.15	16.5	22.85	25.4
M5	10.05	16.35	22.65	25.2
M6	9.9	16.1	22.3	24.8
M7	9.8	15.95	22.15	24.6



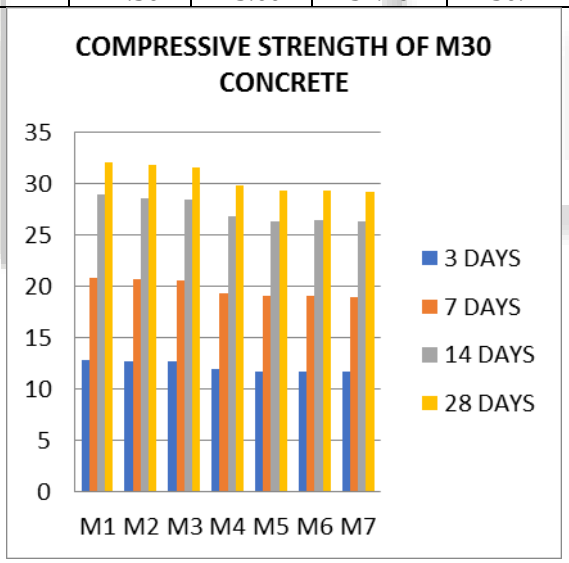
b) For M 25 Grade of Concrete

MIX		M 25		
	3 DAYS	7 DAYS	14 DAYS	28 DAYS
M1	12.86	20.9	28.95	32.15
M2	12.72	20.67	28.62	31.8
M3	12.65	20.55	28.5	31.65
M4	11.9	19.35	26.8	29.8
M5	11.75	19.05	26.4	29.35
M6	11.75	19.1	26.45	29.4
M7	11.65	19	26.3	29.2



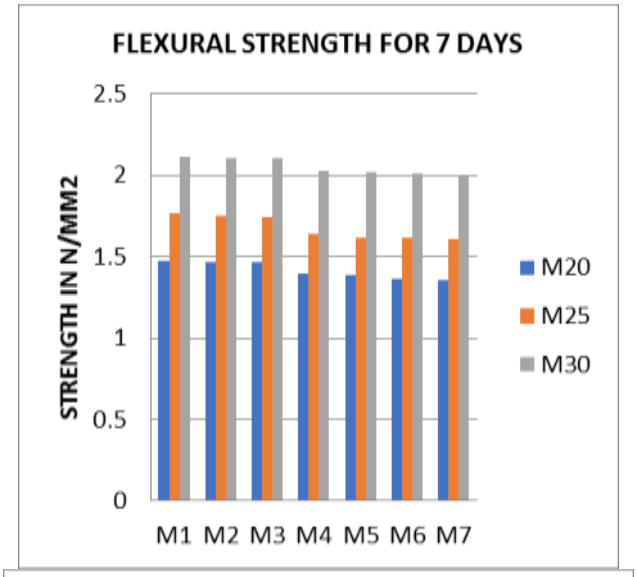
c) For M 30 Grade of Concrete

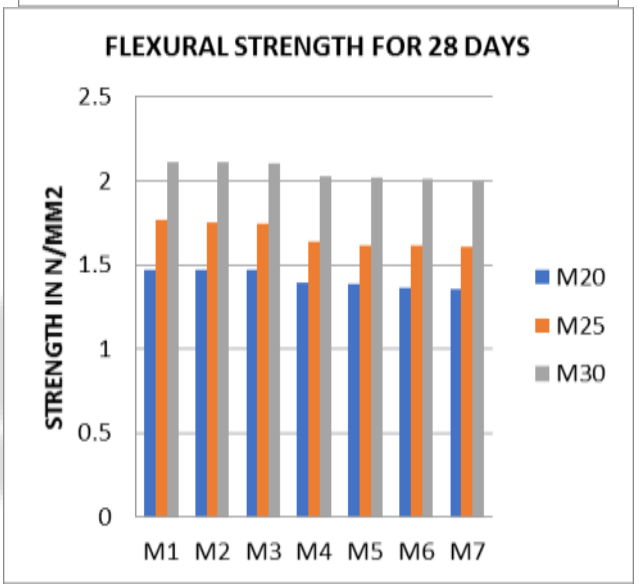
MIX		M 30		
	3 DAYS	7 DAYS	14 DAYS	28 DAYS
M1	15.34	24.9275	34.515	38.35
M2	15.328	24.908	34.488	38.32
M3	15.308	24.8755	34.443	38.27
M4	14.752	23.972	33.192	36.88
M5	14.66	23.8225	32.985	36.65
M6	14.608	23.738	32.868	36.52
M7	14.56	23.66	32.76	36.4



4) Flexural Strength –

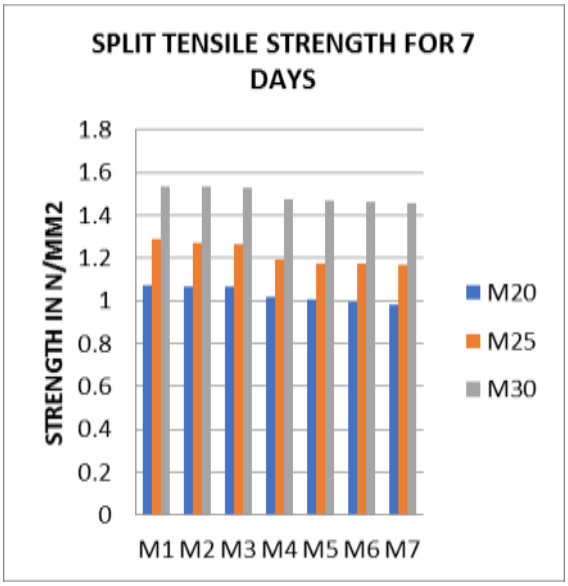
Mix	M 20		M 25		M30	
	7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
M1	1.471	3.076	1.76	3.69	2.10	4.41
M2	1.468	3.070	1.749	3.657	2.107	4.406
M3	1.467	3.068	1.740	3.639	2.104	4.401
M4	1.397	2.921	1.639	3.427	2.028	4.241
M5	1.386	2.898	1.614	3.375	2.015	4.214
M6	1.364	2.852	1.617	3.381	2.008	4.199
M7	1.353	2.829	1.606	3.358	2.002	4.186

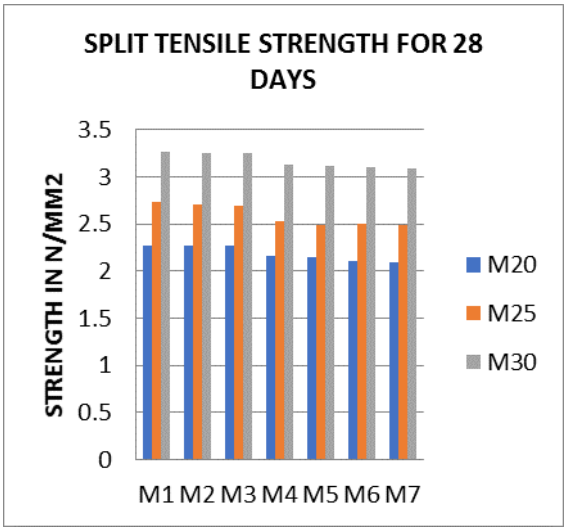




5) Split Tensile Strength –

Mix	M 20		M 25		M30	
	7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
M1	1.07	2.273	1.28	2.732	1.534	3.259
M2	1.068	2.269	1.27	2.703	1.532	3.257
M3	1.06	2.26	1.26	2.6902	1.53	3.252
M4	1.01	2.15	1.19	2.533	1.47	3.134
M5	1.00	2.14	1.17	2.494	1.46	3.115
M6	0.99	2.10	1.17	2.499	1.46	3.104
M7	0.98	2.09	1.16	2.482	1.45	3.094





6) Cost Analysis For Per Cubic Meter of Concrete of Grade M25

COST COMPARISON OF M25 GRADE CONCRETE FOR 1 M^3 CONCRETE							
S. No.	Materials	M1		M2		M3	
		QTY (KG)	AMT (Rs.)	QTY (KG)	AMT (Rs.)	QTY (KG)	AMT (Rs.)
1	CEMENT	420	2890	420	2890		
2	GGBS					210	2625
3	Fly Ash					210	1470
4	River Sand	657	887				
4	M Sand			644	644	585	585
5	Coarse Aggregates	1127	913	1127	913	1030	835
6	Alkaline Activator Sol.						1590
TOTAL			4690		4447		7105
% Cost Reduction					5.18%		-51.5%

V. CONCLUSION

The Geo polymer mix planned for this study with replacement of E-Waste found possible and economical based on previous studies. In this study the cement is fully replaced by industrial by products fly ash and GGBS. The following points are arrived from the present study.

1) It is observed that the Geo polymer concretes has been achieved an increase in strength for M3 Mix i.e. (50%Flyash+50% GGBS) replacement of cement and natural sand at the age of 28 days.
2) The degree of workability of concrete was normal with the addition of geo polymer paste and M- sand.
3) From the above experimental results, it is proved that geo polymers can be used as an alternative material for cement, it reducing the cement consumption and the M-sand can alternate to natural sand those are reducing the cost of construction. Use of industrial waste products saves the globe and conserves natural resources.
4) Geo polymer concrete is suitable for any R.C.C. structure. Strength is more as compare to conventional concrete.
5) By using Sodium silicate and Sodium hydroxide it helps to minimize carbon footprint.
6) Geo polymer concrete is more economical than conventional concrete
7) Curing is not required as we are adding admixture such as Sodium silicate And Sodium hydroxide.
8) Also useful in the areas having shortage of water.
9) It helps to prevent the corrosion of steel.

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