MECHANICAL PROPERTIES OF FLY ASH BASED GEOPOLYMER CONCRETE

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Abstract - *The major problem that the world facing today is global warming. The cement industry is one of the major reasons for emission of greenhouse gases, such as CO_2which causes global warming. A lot of energy and natural resources are consumed introduction of Ordinary Portland Cement (OPC). Geopolymer Concrete (GPC) is one of the processes that reduces cement usage and increases the usage of industrial by products in concrete. In the present study, OPC is fully replaced by pozzolanic materials (Fly Ash) and alkaline liquids such as Sodium hydroxide (NaOH) and Sodium silicate(Na2SiO3) to produce the Geopolymer concrete. This investigation describes the Mechanical Properties (Compressive strength, Split tensile strength and flexural strength) of GPC at ambient room temperature curing. The above all strengths are also based on different molarities like 4M, 6M, 8M&10M.*

Key Words: (*Geopolymer*, FlyAsh, compressive strength, Split Tensile Strength, Flexural strength)

1.INTRODUCTION

The usage of cement could produce some environmental problems equivalent to heating, inexperienced house impact etc. As a result of these issues could generate because of increasing of CO_2present within the surroundings, from the past results nearly one tone of cement releases equal amount of CO_2. So as to avoid these environmental problems related to cement, there's have to be compelled to use some alternatives equivalent to fly ash, rise husk fly ash etc. Area unit because the binders to create the eco-friendly concrete. During this respect, Davidovits [1988] planned another binder for the concrete technology and it shows an honest results. These binders area unit created by associate degree base-forming liquid reacts with the oxide (Si) and Aluminium (Al) present within the source. The technology planned by the Davidovits is often referred to as Geo-polymers or Geo-polymer technology.

1.1 Geo-polymers

In general the source and alkaline liquids area unit treated as major materials within the Geo-polymers. By mixing the two solutions, named caustic soda (NaOH) associate degreed soluble glass (Na2SO3) we will prepare an alkaline liquid that is employed in geo-polymers. The reaction takes place by caustic soda and soluble glass solutions is treated because the geo-polymerization method for our convenience. And conjointly we've got to think about that oxide (Si) and Aluminium (Al) area unit key components in geo-polymers. The proportion of Aluminium and silicon area unit to be taken into consideration within the materials that area unit used. The source like fly ash, oxide fume, slag, rice husk-fly ash etc. Area unit to be used. The supply materials choice is additionally economical.

1.2 Applications of Geo polymers

Geo polymers are used in various day to day applications such as-

- Used in industrial floor repairs.
- Airfield repairs (in war zones).
- Fireproof composite panels.
- External repair and structural retrofit for aging infrastructure.
- For storage of nephrotoxic and hot wastes.
- Potential utilizations in Art and Decoration.
- LTGS Brick, railways sleepers, electrical power poles, marine structures, waste containments etc.

2. LITERATURE REVIEW

Davidovits, created and applied the term Geo polymer. For the chemical designation of geo polymers supported silicon-aluminates, "Poly (sialate)" was prompt. Sialate is associate abbreviation for silicon-oxo-aluminate.

Polysialates area unit chain and ring polymers with Si4+ and Al3+ in IV-fold coordination with, gas and vary from amorphous to semi-crystalline. Additionally positive ions comparable to Na^{2+}, Ca^{2+}, K^{2+} and alternative aluminiferous cat ions should be present in framework cavities to balance the charge of Al^{3+}. The structural link of theSialate was shown in Figure 2.1.The amorphous to semi-crystalline three dimensional silico-aluminate structures were christened Geo polymers of the subsequent types

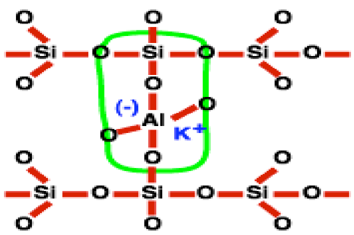

Figure 2.1. Structural link of silicate

Rangan (2008) has reportable on the fly ash-based Geo polymer concrete. He study the results of salient factors that influence the short and future properties of the Geo polymer concrete within the recent and hardened states. He describes the applications and economic deserves of Geo polymer concrete within the industry. He finally finished that the low-calcium fly ash-based Geo polymer concrete has wonderful compressive strength and is appropriate for structural applications. The salient factors that influence the short and future properties of the recent concrete and hardened concrete area unit known.

3. MATERIALS AND METHODOLOGY

The physical and chemical properties of fly ash, aggregate and water utilized in the investigation were analysed supported commonplace experimental procedures arranged down in IS, ASTM and BS codes. The experiments conducted on coarse aggregate square measure relative density and water absorption, Bulk density & Sieve analysis by victimization individual codes. The experiments conducted on fine aggregates square measure relative density, wet content, sieve analysis and bulking of fine aggregate victimization volume technique. The tests conducted on Geo polymer concrete square measure Compressive strength, Split strength, Flexural strength square measure as per the individual IS, BS and ASTM codes.

3.1Fly ash

According to ASTM C 618 (2003) the fly ash are often divided into 2 sorts supported quantity of metal present within the fly ash. The classified Fly ashes square measure class F (low-calcium) and sophistication C (high-calcium). Within the present investigation class F fly ash made from Rayalaseema Thermal station (RTPP), Muddanur, A.P was used. The chemical and physical properties square measure conferred within the Table 3.1.

Table 3.1. Chemical and Physical Properties of Class F Fly Ash

Particulars	**Class "F" fly ash**	**ASTM C 618 Class "F" fly ash**
Chemical composition		
% Silica(SiO_2)	65.6	
% Alumina(Al_2O_3)	28.0	
% Iron Oxide(Fe_2O_3)	3.0	SiO_2+ Al_2O_3+ Fe_2O_3>70
% Lime(CaO)	1.0	
% Magnesia(MgO)	1.0	
% Titanium Oxide (TiO_2)	0.5	
% Sulphur Trioxide (SO_3)	0.2	Max. 5.0
Loss on Ignition	0.29	Max. 6.0
Physical properties		
Specific gravity	2.24	
Fineness (m^2/Kg)	360	Min.225 m^2/kg

3.2 Mixture Proportions

The geo polymer concrete mixture proportions are given as follows

Table 3.5 GPC Mix Proportions

Materials		**Mass (kg/m³)**				
		M25	**4M**	**6M**	**8M**	**10M**
Coarse aggregate	20 mm	683.4	774	774	774	774
	10 mm	455.6	516	516	516	516
Fine aggregate	Slag	-	549	549	549	549
Fly ash (Class F)		-	409	409	409	409
Sodium silicate solution			102	102	102	102
Sodium hydroxide solution			41	41	41	41
Extra water		192	55	55	55	55
Alkaline solution/ (FA) (by weight)		-	0.35	0.35	0.35	0.35
Water/ geo polymer solids (by weight)		-	0.35	0.33	0.31	0.29

3.3 Compressive Strength test

Compression check is one in all the foremost common check conducted on hardened concrete, part as a result of its most vital and it's straightforward to perform additional most of the fascinating characteristic properties of concrete area unit qualitatively concerning its strength.

The compression check is dispensed on specimens like cuboidal or cylindrical in form generally prisms are used. The tip components of beam area unit left intact when failure in flexure and since of the square cross section of the beam this a part of the beam may well be well accustomed determine the compressive strength. The compressive strength of concrete is that the most vital and helpful property of Concrete. The compression check was dispensed mistreatment 2000 KN compression testing machine.

Figure 3.1. Testing of cubes for compressive strength

3.4 Split Tensile Strength test:

Splitting Tensile Strength (STS) test was conducted on the specimens for all the mixes after 28 days of curing as per code. Three cylindrical specimens of size 150 mm x 300 mm were cast and tested for each age and each mix. The load was applied gradually till the failure of the specimen occurs. The maximum load applied was then noted. Length and cross-section of the specimen was measured.

Figure 3.2. Testing of cylinders for Split tensile strength

3.5 Flexure Strength test

Flexural strength test was conducted on the specimens for all the mixes at different curing periods as per code. Three concrete beam specimens of size 100 mm x 100 mm x 500 mm were cast and tested for each age and each mix. The load was applied gradually till the failure of the specimen occurs. The maximum load applied was then noted.

Figure 3.3. Testing of prisms for Flexure strength

4. RESULTS AND DISCUSSION

This chapter describes the Compressive strength, Split tensile strength and flexural strength of GPC at ambient room temperature curing. The compressive strength values of GPC mixes were measured after 7, 14, 28, 56 and 112 days of curing. The split tensile strength values of GPC mixes were measured after 28, 56 and 112 days of curing. The flexural strength values of GPC mixes were measured at 28, 56 and 112 days of curing. The above all strengths are also based on different molarities like 4M, 6M, 8M and 10M.

4.1 Compressive Strength

Table 4.1.Compressive strength of GPC

Mechanical property	Age (days)	Mix type				
		M25	4M	6M	8M	10M
Compressive strength, f'c (MPa)	7	10.8	9.9	21	28.5	38.5
	14	22.5	15.1	26.8	37.2	44.8
	28	30.6	18.7	32.5	43.4	51.3
	56	36.1	28.2	36.2	49.2	57.2
	112	38.9	25.3	39.4	52.7	59.5

The compressive strength of GPC mixes with fly ash (FA100) at different molarities like 4M, 6M, 8M and 10M as shown in the above table. In the table we also noticed that the average strengths test specimens are calculated for 7days, 14days, 28days, 56days and also 112days. From the table we also noticed that the strengths are going to increase whenever the molarities are increased. So, Molarity of solution gives further strength to the sample after curing.

It was observed that there was a significant increase in compressive strength in the percent Fly ash 100% in all curing periods as shown in Figure 4.1. The GPC with 100% fly ash sample exhibited compressive strength values of 9.9 MPa, 21 MPa, 28.5 MPa and 38.5MPa in 4M, 6M, 8M and 10M condition for 7days. Usually 15.1 MPa, 26.8 MPa,37.2MPa, 44.8MPa in 4M, 6M, 8M and 10M conditions after 14days Similarly 18.7MPa, 32.5MPa, 43.4 MPa and 51.3 MPa strengths are attained in 4M, 6M, 8M and 10M after 28days. Similarly, for 56days the strengths are as follows 28.2 MPa, 36.2MPa, 49.2 MPa and 57.2MPa in 4M, 6M, 8M and 10M situations and similarly 25.3MPa, 39.4 MPa, 52.7 MPa and 59.5 MPa strengths are gained in 4M, 6M, 8M and 10M conditions after 112 days of curing respectively at ambient room temperature.

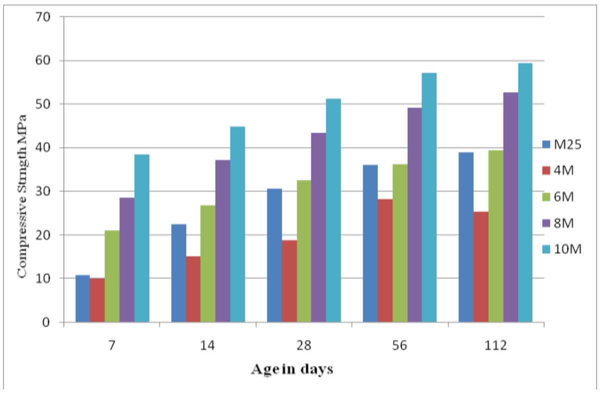

Figure 4.1. Compressive strength versus Age

4.2 Split Tensile Strength

Table 4.2 shows the split tensile strength of GPC mixes with fly ash (FA100) at different molarities like 4M, 6M, 8M and 10M at different curing periods. The tensile strengths are increased slightly based on the increasing level of molarities.

Table 4.2. Split tensile strength of GPC

Mechanical property	Age (days)	M25	Mix type			
			4M	6M	8M	10M
Splitting tensile strength, f_{ct}	28	3.72	2.31	3.88	4.86	5.49
	56	3.94	2.42	4.02	5.23	5.98
	112	4.32	2.64	4.38	5.7	6.48

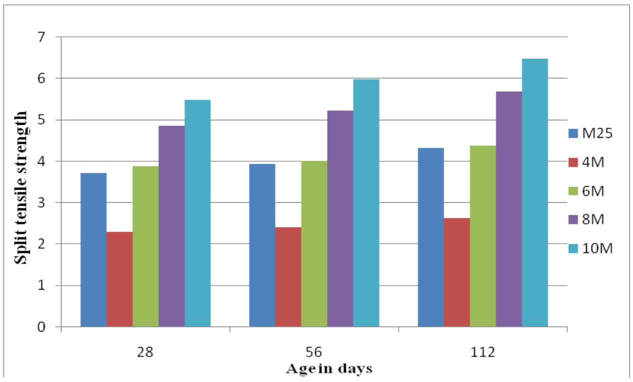

Figure 4.2. Split tensile strength of mixes

It was observed that there was a significant increase in splitting tensile strength with the percentage of 100% Fly ash in all curing periods as shown in Figure 4.2. The GPC with 100% Fly ash sample exhibited splitting tensile strength values of 2.31 MPa, 3.88 MPa, 4.86 MPa and 5.49MPa after 28days. And 2.42MPa, 4.02MPa, 5.23 MPa and 5.98 MPa strengths after 56days and 2.64MPa, 4.38MPa, 5.7MPa &6.48MPa strengths after 112 days of curing respectively at 4M, 6M,8M and 10M conditions at ambient room temperature.

4.3 Flexural strength

Table 4.3 shows the flexural strength of GPC mixes with fly ash (FA100) at different curing periods

Table 4.3. Flexural strength of GPC

Mechanical property	Age (days)	Mix type				
		M25	4M	6M	8M	10M
Flexural strength, fcr(MPa)	28	5.72	4.52	5.92	7.46	8.82
	56	6.34	4.58	6.45	7.94	9.62
	112	6.94	4.72	6.94	8.4	9.94

It was observed that there was a significant increase in flexural strength with the Fly ash as 100% in all curing periods as shown in Figure 4.2.The GPC with 100% fly ash sample exhibited splitting tensile strength values of 4.52MPa, 5.92MPa, 7.46MPa and 8.82MPa after 28days. The strengths like 4.58MPa, 6.45MPa, 7.94MPa and 9.62MPa after 56days. Similarly the strengths 4.72MPa, 6.94MPa, 8.4MPa and 9.94MPa are after 112days of curing respectively at 4M, 6M, 8M and 10M condition at ambient room temperature

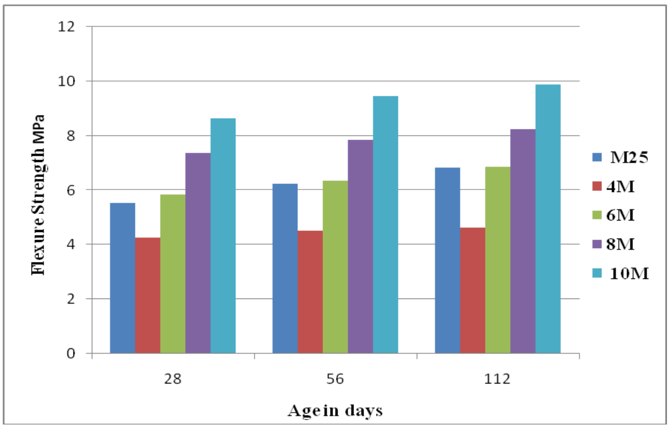

Figure 4.3. Flexural strength of mixes

From the results it is revealed that FA blended GPC mixes attained enhanced mechanical properties at ambient room temperature curing itself without the need of heat curing as in the case of only FA based GPC mixes.

5. CONCLUSIONS

The primary aim of this analysis was to develop GPC with the fine aggregate and study the mechanical properties of GPC mixes at close temperature. Supported the investigation, the subsequent conclusions are drawn.

1. There was a big increase in compressive strength whereas increasing in concentration.
2. The grade of M 25 is reminiscent of 6M.
3. Split tensile strength and flexure strength also increased while increasing in molarity.
4. From 8M strength properties area unit drastically decreases by using 4M and 6M.
5. Eco-friendly edges area unit there whereas mistreatment fly ash and slag materials

References

1) Bakharev, T. (2005c), Resistance of geopolymer materials to acid attack, cement And Concrete Research, 35(4), 658-670.
2) Balaguru P, Kurtz S, & Rudolph, (1997), Geopolymer For Repairs and Rehabilitation of Reinforced Concrete Beams. The Geopolymer Institute. Revised 3 April,2002 From the World Wide Web www.geopolymer.org

3) Benny Joseph, George Mathew., Influence of aggregate content on the behavior of fly ash based geopolymer concrete, Scientia Iranica A (2012) 19(5),1188–1194
4) Comric D.C., Paterson.J.H.,& Ritchey D.J(1988),Geopolymer Technologies in Toxic Water Management Paper Presented at the Geopolymer '88,First European Conference on Soft Mineralogy,Compiegne,France
5) Davidovits J, (1988a). Soft Mineralogy and Geopolymer. Paper presented at the Geopolymer '88, First European Conference on soft Mineralogy, Compiegne, France.
6) Gartener E (2004), "Industrially Interesting Approaches to Cements",cement and Concrete Research 34(9),1489-1498
7) Hardjito D & Rangan B.V.(2005),Development and Properties of Low Calcium Fly Ash Based Geopolymer Concrete Research Report GC1,Perth,Australia Faculty of Engineering, Curtin University of Technology
8) IS 383 (1970), Specification for coarse and fine aggregates from natural sources for concrete. Bureau of Indian Standards, New Delhi.
9) IS 456 (2000). Plain and reinforced concrete code for practice. Bureau of Indian Standards, New Delhi.
10) IS 456 (1991). Methods of tests for strength of concrete. Bureau of Indian Standards, New Delhi.