International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 14 (2015) pp 34607-34611

Mechanical and Durability Properties of Geo polymer Concrete

Mr. N. Sathishkumar
Assistant Professor
Department of Civil Engineering,
Sasurie college of Engineering, Tiruppur, Tamilnadu, India
Zip code:638056
Telephone:9842069693
Email:srinidhi.kumar5@gmail.com
Dr. E. K. Mohanraj
Professor
Department of Civil Engineering
Nandha Engineering College, Erode, Tamilnadu, India
Email:mohan8899@yahoo.co.in

Abstract- Geo polymer concrete technology has the potential to reduce globally the carbon emission , lead to a sustainable development and growth of the concrete industry. The influence of alkaline activators on the Geo polymer concrete strength and durability properties has been studied. Sodium Hydroxide is available in plenty and Sodium Silicate, both were added by the 1:2.5 ratio as alkaline activators at varying temperature in the preparation of geo polymer concrete. "F"Fly ash was procured from a local thermal power station. Durability test were performed. The results indicate that the combination of the above constituents at 60°C has a positive impact on the strength and durability properties of geo polymer concrete.

Keywords- Geo polymer concrete, Fly ash, Alkaline solution, Durability test.

1. Introduction

Portland cement is the most used material in the worldwide construction industry and has a high level of CO_2 (1 ton of cement generates 1 ton of CO_2) also its use tends to become less competitive compared to alternative ecological new binders like geo polymers . Although research in this field has been published as "alkali-activated cement, or "alkaline cement" the term "geo polymer" is the generally accepted name for this technology. Geo polymerisation involves a chemical reaction between various alumino silicate oxides with silicates under highly alkaline conditions, yielding polymeric Si–O–Al–O bonds indicating that any Si–Al materials could become sources of geo polymerization. Geo polymer binders are used together with aggregates to produce geo polymer concrete which are ideal for building, repairing infrastructures, precasting units, because they have very high early strength. Geo polymer Concrete setting times can be controlled and they remain intact for very long time without any need for repair. The properties of geo polymer include high early strength, low shrinkage, freeze-thaw resistance, sulphate resistance and corrosion resistance. These high-alkali binders do not generate any alkaline aggregate reaction. The geo polymer binder is a low-CO_2 cementious material. It does not rely on the Calcination of limestone that generates CO_2.

2. Geo Polymer Concrete Materials

A."F" Fly Ash

For this research purpose low calcium Class "F" Fly ash was collected from "Mettur Thermal Power Plant", India. It had chemical composition as given in Table-1.

Table-1 Chemical Composition of Fly ash "F" (% mass)

Chemical Compositions	Sio2	Al2o3	Fez03	Tio2	Cao	MgO	P2O5	S03	Alkaline	LOI
Fly ash	57.79	20.18	7.04	1.03	2.97	1.98	0.26	0.84	3.69	4.22

B. Alkaline Liquid

The alkaline liquid was used from the combination of sodium silicate solution and sodium hydroxide solution. The sodium silicate solution (Grade A53) comprised 14.7% of Na2O, 29.4% of SiO2, and 55.9% of water by mass. The sodium hydroxide solution was prepared by mixing 98% pure flakes in water. Both the solutions were mixed together at least 24 hours before use .The ratio of sodium hydroxide to sodium silicate solution is 1:2.5.

Table-2 Molarity Value of NaoH

Molarity	Mass Of NaoH (gm)
8M	360
10M	314
12M	361
14M	404
16M	444

Fig-1 Preparation of Alkaline Solution

C. Fine Aggregate

Ordinary sand available in Karur, Tamilnadu (Kauvery river sand) having the following characteristics has been used.

Specific gravity : 2.67

Fineness modulus : 2.60

Unit weight : 1.674 gm/cc

Water absorption : 0.44%

Bulking : 25%

D. Coarse Aggregate

Locally available black crushed stone in Uthukuli, Tamilnadu with maximum nominal size of 20 mm and 10 mm have been used as coarse aggregate. The physical properties for the coarse aggregate as found through laboratory test according to IS 2386-1963 is resulted as:

Aggregate crushing value = 24%

Aggregate impact value = 29%

Specific gravity = 2.74

Water absorption = 0.94%

Unit weight = 1.60gm/cc

Fineness Modulus = 6.15

E. Super Plasticizer

To improve the workability of the fresh geo polymer concrete, a high range water reducing (Naphthalene sulphonate- based) super plasticizer, supplied by BASF Construction Chemical Company Mumbai was used in the mixtures at the rate 1.5% of fly ash.

F. Preparation of Geo Polymer Concrete

Fly ash without blast furnace slag was mixed with predetermined quantity of activator solution for 5 minutes .The geo polymers mix exhibited a thick sticky nature with low workability. The mix was then transferred into 75x75x75 mm steel cubes by in M_{20} ratio. Table vibration was provided for 2 minutes to expel any entrapped air. After 60 minutes, the cubes were cured in an oven for a period of 24 hours at 60°C and then allowed to cool inside the oven. Specimens were demoulded and stored at room temperature at a dry place before testing. The geo polymer specimens were immersed in 10% magnesium sulphate solution for 28days after 3 days from casting. Specimens were tested for physical changes, weight changes and compressive strength changes at regular intervals. Unexposed specimens were subjected to water absorption, apparent porosity and compressive strength tests as well, to assess the pore characteristics.

3. Experiment Tests and Result

A .Compressive Strength

The cube specimens of OPC and GPC was placed in universal testing machine and the load is to be applied without shock and increased continuously then the specimen will break down. Result shows that the mixes with the Fly Ash gives consistently higher strength than the normal conventional concrete

Table-3 Compressive Strength of Concrete (OPC&GPC)

Mix Ratio	DAYS	CC	GPC
M_{20}	7	10.45	20.65
M_{20}	14	14.32	24.67
M_{20}	21	17.45	27.34
M_{20}	28	20.55	30.25

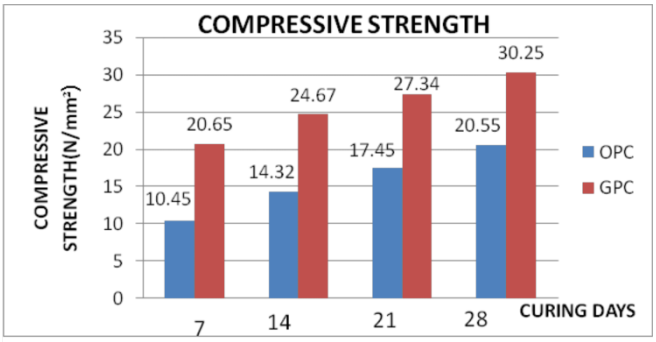

Fig-2 Compressive Strength of Concrete (OPC&GPC)

B.SPLIT TENSILE STRENGTH

The cylinder specimen is placed horizontally between the loading surface of the universal testing machine and the load is applied until the failure of the cylinder.Calculation of Split tensile strength = **2P/ πdl**.Result shows that the mixes with the Fly Ash gives consistently higher strength than the normal concrete.

Table-4 Split Tensile Strength of Concrete (OPC&GPC)

Mix Ratio	DAYS	OPC	GPC
M_{20}	7	1.85	2.5
M_{20}	14	2.25	3.05
M_{20}	21	2.9	3.75
M_{20}	28	3.5	4.23

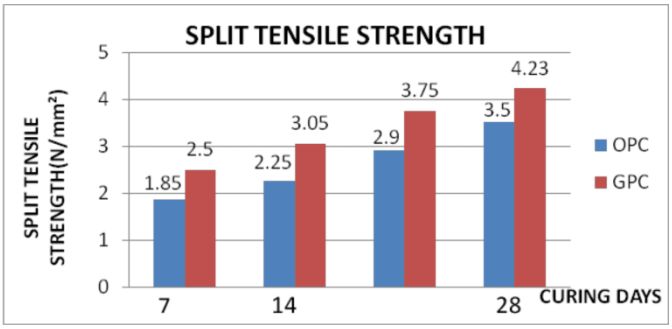

Fig-3 Split Tensile Strength of Concrete (OPC&GPC)

C. FLEXURAL STRENGTH

The prism is placed in universal testing machine and the load (two point) is to be applied without shock until the specimen fails and the maximum load applied to the specimen during the test is to be recorded. Calculation: $\mathbf{f_b = PL / bd^2}$. Result shows that the mixes with the Fly Ash gives consistently higher strength than the normal concrete.

Table-4 Split Tensile Strength of Concrete (OPC&GPC)

Mix Ratio	DAYS	OPC	GPC
M_{20}	7	2.45	3.24
M_{20}	14	3.2	4.55
M_{20}	21	3.55	4.95
M_{20}	28	3.92	5.25

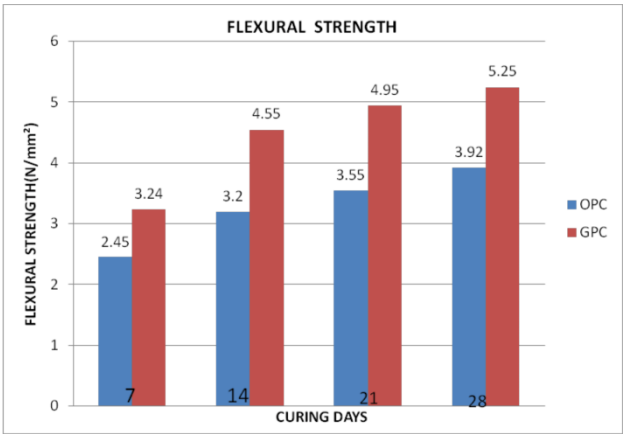

Fig-4 Flexural Strength of Concrete (OPC&GPC)

D. SULPHATE ATTACK TEST

Optical microscope, accuracy .02mm, Zoom capacity of 10X has been used to monitor the physical appearance of geo polymer specimens after exposure to magnesium sulphate solution. Geo polymer paste specimen without blast furnace slag got white crystal deposits after exposure which were very soft but with time being it became harder. Specimen containing blast furnace slag in no case got white deposits. The white reaction product may be magnesium alumino silicate. This white deposit has been also reported by some authors. Here the product has been tested through SEM .The Scanning Electron Microscopy depicts the presence of regular structure on the surface of deposits which supports the crystal nature. This indicates the existence of Magnesium, Silicon and Aluminum in this outcome.

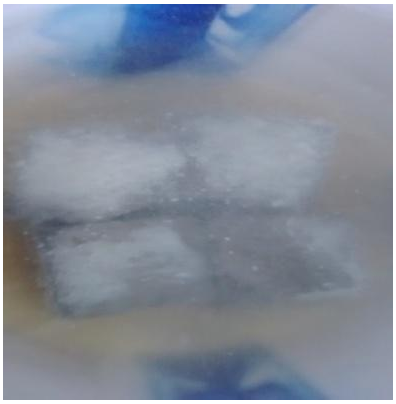

Fig-5 Geo polymer paste specimens after 6 weeks in 10% magnesium sulphate solution.

Weights for exposed specimens were measured at regular intervals in saturated surface dry condition after washing and removal of surface deposits. Specimens are cleaned in running cold water for around five minutes and wiped dry with clean lint free cloth and then blown with clean dry air for around 5 minutes. Speedy increases in weight took place for all paste specimens up to 1 week of exposure. This is due to absorption of sulphate solution into the specimens. No further increase was shown for blended specimens after the initial rise.

Weight gain continued gradually for 50 days in specimen GP1 (without blast furnace slag).It indicates continuous penetration of sulphate solution in addition to formation of reaction products due to interaction of geo polymer material with the exposure solution . Weights of specimens were remaining almost constant up to the end of test where the specimens without supplementary blast furnace slag began to decrease beyond 50 days of exposure. The drop in weight could be due to migration of alkalis from the specimens into the solution and also due to breakdown and dissolution of some reaction products. Final weight for all the samples was higher than initial one. This newly built reaction product within the internal voids is accused for weight gaining.

The sulphate attack of combined admixtures concrete after the attack was found to be less weight loss when compared with the normal concrete. Table 6.2 gives the test results obtained from sulphate attack test.

Table-5 Compressive Strength of Concrete (OPC&GPC) after Sulphate Attack

Mix Ratio	DAYS	OPC	GPC
M_{20}	0	28.9	37.82
M_{20}	7	28	37.1
M_{20}	14	29.9	37.6
M_{20}	28	25.6	36.5
M_{20}	56	22.9	34.9

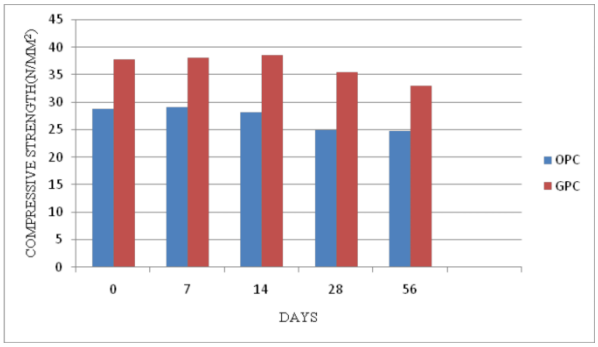

Fig-6 Compressive Strength of Concrete (OPC&GPC) after 6 weeks in 10% magnesium sulphate

E.CHLORIDE ATTACK TEST

Chloride Attack is similar to sulphate attack also there will change in appearance and weight.

The chloride attack of combined admixtures concrete after the attack was found to be the gain in weight of cube was measured when compared with the normal concrete. Table gives to test results obtain from chloride attack test.

Table-6 Compressive Strength of Concrete (OPC&GPC) after Chloride Attack

Mix Ratio	DAYS	OPC	GPC
M_{20}	0	28.90	37.82
M_{20}	7	29.23	38.10
M_{20}	14	28.30	38.60
M_{20}	28	25.00	35.50
M_{20}	56	24.90	33.02

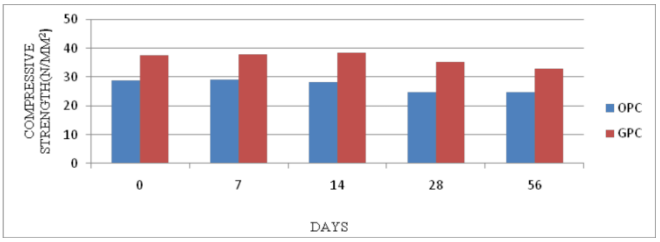

Fig-7 Compressive Strength of Concrete (OPC&GPC) after Chloride Attack

Fig-8 GPC specimen after 6 weeks of chloride attack

F.ACCELERATION CORROSION TEST

Specimen for this test prepared is cylinder of size diameter 150mm and height 300, while casting 20mm TMT bar is placed in the center of the cylinder, then the specimen is kept as like the above representation. The resistive characteristic strength is high when compared to conventional concrete.

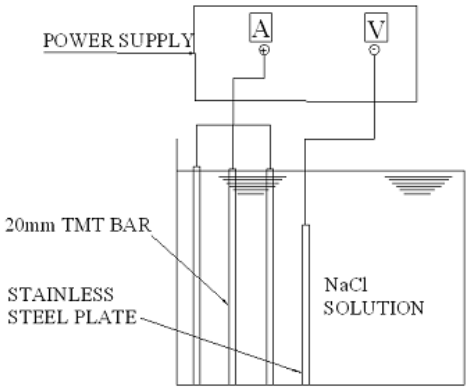

Fig- 9 Pictorial View of Acceleration Corrosion Test

4. Conclusion

- It is to be observed that replacement of fly ash in concrete gives the better strength properties of concrete than that of the conventional concrete.
- It is observed that addition of alkaline solution instead of water gives 1.5 times strength than that of conventional concrete.
- It has been observed that as the molarity increases, compressive strength also increases.
- Molarity also affects the velocity.The velocity increases with increase in molar concentration.
- The compressive strength and velocity are dependent, i.e. as the compressive Strength increases the velocity also increases or as the velocity increases the compressive strength increases.
- The choice of curing temperature and curing time affected final compressive strength of geo polymer.
- The increase in compressive strength was observed with increasing duration of heat curing and curing temperature.
- The Geo polymer binders may be treated as future environment friendly alternative to Portland cement in certain industrial applications.

5 .References

[1]] S.Thokchom, D.Dutta, S.Ghosh, Effect of Incorporating Silica Fume in Fly Ash Geo polymers,World Academy of Science, Engineering and Technology, 60 (2011) 243-247.

[2]] S. Thokchom, P. Ghosh, S. Ghosh, Influence of alkali content on performance of geo polymer mortars in magnesium sulphate, Arabian J. for Science and Engineering, Accepted for publication, 2011. *Durability Study of Geo polymer Paste Blended with Blast Furnace Slag* Song

[3] D. L.Y. Kong, J.G. Sanjayan, Effect of elevated Effect of elevated temperatures on geo polymer paste, mortar and concrete, Cement and Concrete Research, 40, (2010) 334-339.

[4] Thakur Ravindra N, Ghosh Somnath, Effect of mix composition on compressive strength and microstructure

of fly ash based geo polymer composites, 4 (4) (2009) 68-74

[5] Thakur Rabindra N , Ghosh Somnath , Fly ash based Geo polymer composites , Proceedings of 10th NCB International seminar on Cement and bulding materials , NEW Delhi , India, 3 (2007) 442-45 .

[6]] X.J. Song, M. Marosszeky, M.Brungs. Munn, Durability of fly ash based geo polymer concrete against sulphuric acid attack, 10 DBMC International conference on durability of building materials and components, (2005), Lyon, France

[7] T. Bakharev, Durability of geo polymer materials in sodium and magnesium sulphate solutions", Cement and Concrete Research, 35 (2005) 1233-1246.

[8] Frantisek Skvara , Tomas Jilek , Lubomir Kopecky, Geo polymer Materials Based on Fly Ash, Ceramics- Silicaty, 49(3) (2005) 195-204.

[9] A. Allahverdi, F. Skvara, Sulphuric acid attack on hardened paste of geo polymeric cements part 1,Mechanism of corrosion at relatively high concentrations, Ceramics-Silikaty, 49 (4) (2005).225-229.

[10] X.J , Marosszeky M , Brungs M , Munn R , Durability of fly ash based Geo polymer concrete against sulphuric acid attack , 10 DBMC International Conferences on Durability of Bulding Materials and Components, Lyon, France, (2005) 17-20 April .

[11] H. Xu, G.C. Lukey, and J.S.J. van Deventer., The activation of class C, class F fly ash and blast furnace slag using geo polymer, Fly ash, Blast Furnace Slag, Slag, and Natural Pozzolans in Concrete, Proceedings Eighth International Conference, Las Vegas, USA., (2004) 797-820.

[12] A.Palomo, M.W. Gruztek, M.T. Blanco, Alkali activated fly ashes. A cement for the future, Cement and Concrete Research, 29 (1999) 1323-1329.

[13] J. Davidovits, Properties of geo polymer cements, Proceedings of the first International conference on alkaline cements and concretes, 1 (1994) 131-149.