Experimental Investigation of Geo Polymer Concrete under Ambient Curing

[1]R. Priyanka, [2] R. Tamil Selvan, [3] V. Livingstan Arul Raj, [4]A. Surya, [5]S. Surya

[1]Assistant Professor, [2,3,4,5]UG Students
Department of Civil Engineering,
Mookambigai College of Engineering, Pudukkottai, India.

***Abstract*— Geo Polymer concrete result from the reaction of a source material that is rich in silica and alumina with alkaline liquid (Sodium Silicate and Sodium Hydroxide). Geopolymer concrete has the fastest setting time rapid development in strength and the carbon dioxide releasing from the source material is very low. Two kinds of systems were considered in this study using 100% replacement of cement by Class F fly ash with GGBS and 100% replacement of sand by M-sand. The specimens are casted for M_{25} grade with 10M. The specimens of size 150x150x150mm cubes, 300mm x150mm cylinders and500x100x100mm prism were cast and cured in the open atmosphere (Ambient Curing). The sodium silicate (Na_2 SiO_3) to sodium hydroxide (NaOH) ratio by mass is 2. The test results of geopolymer concrete of different ratio (70:30, 80:20, 90:10) were discussed in this project.**

I. INTRODUCTION

Geo Polymer is a type of concrete that is made by reacting Aluminates and Silicate bearing material with caustic activators. The chemical composition of the geopolymer material is similar to natural zeolitic materials, but the microstructure is amorphous instead of crystalline. The polymerization process involves a substantially fast chemical reaction under alkaline condition on Si-Al minerals that result in a three- dimensional polymeric chain and ring structure of Si-O-Al-O bonds are formed. Ordinary Portland cement is conventionally used as primary binder to produce concrete. Some inherent disadvantages of OPC are still difficult to overcome. Two major drawback of OPC sustainability and the contribution of OPC production worldwide to the greenhouse gas emission are to be about 5-7% of the total greenhouse gas emission to the earth's atmosphere. In fact that the production of cement adds to the pollution of environment is well known to civil engineers and environmentalists. Producing Geopolymer is a new construction which gained its popularity in recent years due to its environment friendliness and excellent mechanical and durability properties in severe environment. Ground granulate blast furnace slag (GGBS) is a by-product of iron-producing blast furnaces. GGBS is a glassy, granular, no-metallic material composed mainly of calcium silicates and aluminates. Fly-ash based geopolymer concrete has excellent compressive strength and is suitable for structural application. The geo polymer formulations exhibited fast setting, rapid strength gain, less elastic modulus and reduced post peak material ductility in compression. The compressive strength of geopolymer has reported excellent with low calcium fly ash based. In the process of polymerization, the alkaline solution undergoes through the fast-chemical-reaction which results in the formation of the three-dimensional polymeric chain. The following steps are:-

- Dissolution of Alumina and Silica ion from the source material.
- Condensation of precursor ions the monomers.
- Setting of monomers into poly structures.

It is observed that the addition of GGBS increases the strength and simultaneously there is a decrease in setting time. This study tells that ambient curing is suitable for Geo polymer Concrete.

II. SCOPE

- To evaluate the utility of Sodium silicate, Sodium hydroxide as alkaline solution to produce geo polymer concrete.
- To understand the effectiveness of 10M alkaline solution with precursor material in workability and strength development of geopolymer concrete.
- To optimize the strength of geopolymer by conducting related test like compressive strength, tensile strength, flexural strength at different ratio of FA: GGBS.

III. MATERIALS USED

1. Fly ash

Fly ash is also known as "pulverized fuel ash". During the coal combustion, the fly ash generated. In this experiment, low calcium based fly ash, Class F fly ash which obtained from the RBS ready mix concrete in Trichy was used. The chemical compositions are presented in table. The physical properties were determined as per IS: 1727-1967.

SI.No	Ingredients	Fly Ash (%wt)
1	Silica	55-65
2	Aluminium	22-25
3	Iron Oxide	5-7
4	Calcium Oxide	5-7
5	Magnesium Oxide	<1
6	Titanium Oxide	<1
7	Phosphorous	<1
8	Sulphates	0.1
9	Alkali Oxide	<1
10	Loss on Ignition	1-1.5
SI.No	Characteristic	Values
1	Specific gravity of fly ash	2.28
2	Fineness, Percentage passing on 150 µm sieve	99.2%
3	Fineness, Percentage passing on 90 µm sieve	98.2%

Table: 3.1 Characteristics of Fly Ash

2. GGBS

Ground granulated blast furnace slag is the harsh material formed when molten iron blast furnace slag is rapidly chilled (quenched) by emission in water. GGBS is generally used to make durable concrete structures with its high pozzolanic properties. Been a waste byproduct, it can be utilized to an optimum portion in a concrete to reduce the consumption of cement and also to achieve a high durability. The specific gravity of GGBS is 2.10.

SI. no	Ingredients	GGBS (%wt.)
1	Aluminium oxide	7-12
2	Calcium oxide	34-43
3	Sulphur	1.0-1.9
4	Magnesium oxide	0.15-0.76
5	Silica	27-38
6	Manganese oxide	7-15
7	Iron oxide	0.2-1.6

Table: 3.2 Characteristics of GGBS

3. Fine aggregate (M Sand)

M-sand is crushed aggregates produced from hard granite stone which is cubically shaped with grounded edges. It is used as the substitute of river sand and which is obtained from the RBS Ready Mix Concrete Mix in Trichy.

S.no	Characteristic	Values
1	Specific gravity	2.7
2	Fineness modulus	2.52
3	Bulk density	1270Kg/m^3
4	Water absorption	2.5%

Table: 3.3 Properties of Fine aggregate

4. Coarse aggregate

Crushed granite stone aggregate of 20mm maximum size used as coarse aggregate passing through 20mm and retained 16mm was used in this experiment work which is obtained from RBS Ready Mix Concrete in Trichy.

S.no	Characteristic	Values
1	Specific gravity	2.72
2	Fineness modulus	3.8
3	Bulk density	1505Kg/m^3
4	Water absorption	0.7%

Table: 3.4 Properties of coarse aggregate

5. Alkaline Solution

As alkaline solution, a combination of sodium silicate and sodium hydroxide was used. i.e (Na2O = 14.7%, SiO_2 = 29.4% and H_2O = 55.9% by mass. When the solution mixed together the both solution start to react (polymerization takes place). It produced the large amount of heat so it is recommended to leave it for about 24 hours thus the alkaline liquid is get ready as binding agent.

5. Super plasticizer

Super plasticizer is also known as high range water reducer and used in making high strength and high workability concrete. We used CERAPLAST 300 high grade super plasticizer.

IV. MANUFACTURE OF GEO POLYMER CONCRETE

Preparation of Alkaline Solution

Sodium Hydroxide obtained in pellets form and made to 10M solution and Sodium Silicate obtained in liquid form Ratio between Sodium Hydroxide was 2. Since the mixing of hydroxide with the water is an exothermic reaction which liberates heat out. Water used for maxing of solution is general tap water. Alkaline solution is prepared prior day before for casting the specimen.

Preparation of Geo polymer concrete

Preparation of geopolymer concrete is similar to that of cement concrete. The coarse aggregates, M sand, fly ash and GGBS were mixed in dry state. Then add prepared mixture solution hydroxide and sodium silicate based on water cement ratio and mix thoroughly for 3-4 min so as to give homogenous mix.

Curing of Specimens

Specimens of geopolymer concrete were immediately cured. The specimens were demoulded after 24 hours of casting. The specimens of Geopolymer concrete were kept for curing Under Ambient Curing. In ambient curing the specimens are placed in room temperature for 7, 14 and 28 days. After the end of curing the specimens were tested.

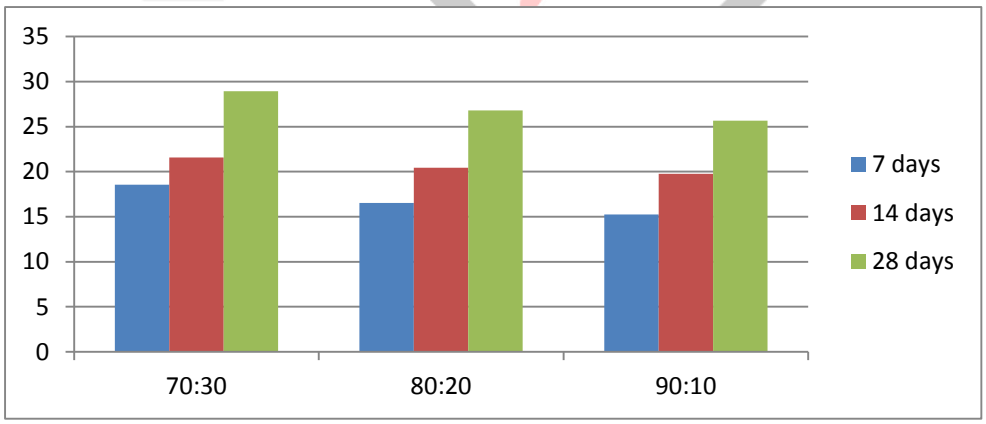
V. RESULTS AND DISCUSSIONS

1. Compressive Strength:

Table: 4.1 Compressive strengths of different ratios

S/No.	Ratio	7days (N/mm^2)	14days (N/mm^2)	28days (N/mm^2)
1	70:30	18.54	21.56	28.92
2	80:20	16.52	20.45	26.81
3	90:10	15.25	19.76	25.65

The compressive strength on cubes were conducted according to Indian Standard Specifications (IS: 516-1959). The compressive strength results of 10M have been shown in Table 4.1 .The graph is drawn between compression strength Vs Designation mixes. The maximum compressive strength obtained for 70:30 ratio of Geo polymer concrete.



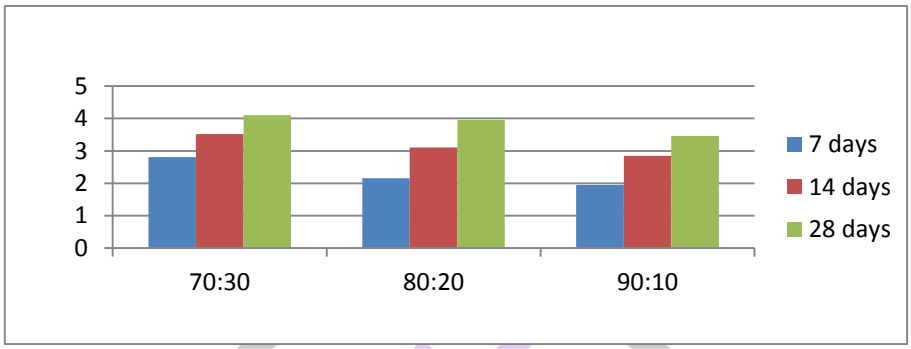
Graph: 4.1 Compressive strength tests for different ratios

2. Split tensile test:

The cylinder specimens were carried out for split tensile test after the Ambient curing. The split tensile strength results were presented in Table: 4.2. From the results, it was found that the split tensile strength obtained was good in the 70:30 ratio of Geo polymer concrete

S/No.	Ratio	7days (N/mm^2)	14days (N/mm^2)	28days (N/mm^2)
1	70:30	2.81	3.52	4.10
2	80:20	1.16	3.10	3.95
3	90:10	1.95	2.85	3.46

Table: 4.2 Split tensile test for different ratios



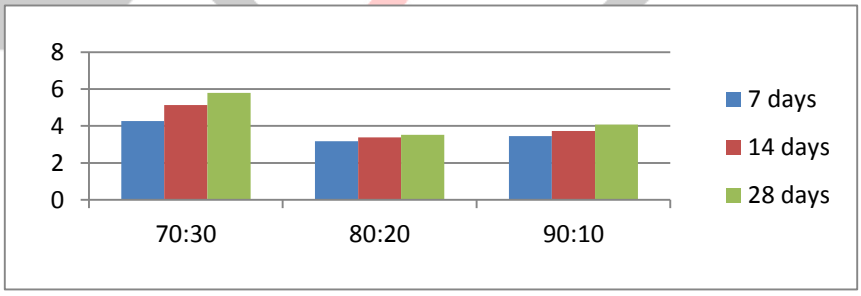
Graph: 4.2 Split tensile test for different ratios

3. Flexural Strength:

The Prism specimens were carried out for flexural test under two point loading after the ambient curing. The flexural strength results were presented in Table: 4.3. From the results, It was found that the flexural strength obtained was good in the 70:30 ratio of Geo polymer concrete.

S/No.	Ratio	7days (N/mm^2)	14days (N/mm^2)	28days (N/mm^2)
1	70:30	4.26	5.13	5.80
2	80:20	3.17	3.38	3.53
3	90:10	3.46	3.73	4.08

Table: 4.3 Flexural strengths of different ratios



Graph: 4.3 Flexural strengths of different ratios

Conclusions

- The replacement of the material in place of cement with Fly ash and GGBS can be done without any problem.
- The replacement of 70:30 ratio of Fly ash: GGBS have much better compressive strength than ordinary Portland cement.
- In the preparation of Geo polymer fly ash and GGBS can be replacement by cement. It helps in reducing the carbon dioxide emission.
- It is observed that setting time decreases with increase in GGBS and mechanical strength also increased.

.

REFERENCES

[1] Xerses N.Irani, Dr Suresh G.Patil, Rampanth "Experimental studies of Ambient Cured Geopolymer Concrete" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 14,Issue 3 Ver. (May - June 2017), PP 44-49.

[2] Mr.M.Ganeshkumar, Mr.L.Kannan "Flexural Behaviour of Potassium Based Geopolymer Concrete" International Journal of Engineering Research & Technology (IJERT) ISSN:2278-0181 Vol. 6 Issue02, February-2017.

[3] M.Saravanan, C.Aravindhan and S.Ramakrishnan "Experimental Investigation of Geopolymer Concrete" AIP Conference Proceedings 08 January 2022.

[4] M.W. Ferdous, O.Kayali and A.Khennane. "A Detailed Procedure Of Mix Design For Fly Ash Based Geopolymer Concrete"Fourth Asia-Pacific Conference on FRP in Structures (APFIS 2013), 11-13 December 2013, Melbourne, Australia.

[5] R.Srinivasan, D.Manoj. "Flexural Behaviour of Reinforced Geopolymer Concrete under Day Light Curing" International Journal of Engineering Science and Computing, Volume 7 Issue No.3, March 2017.

[6] V.Gurusakthivel, Satheesh Kumar.KPR "Fly Ash Based Geopolymer Concrete Using Potassium Hydroxide and Potassium Silicate" International Journal of Engineering Science and Computing (IJESC) Volume 6 Issue No.4 ISSN 2321-3361April2016.

[7] U.R.Kawade, P.A. Salunkhe, S.D. Kurhade "Fly Ash Based Geopolymer Concrete" International Research in Science, Engineering and Technology Volume 3, Special Issue 4, ISSN 2347-6710 April 2014.

[8] B. Naga Vinay, A. Venkateswara Rao "Performance of Geopolymer Concrete under Ambient Curing" International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-7, Issue-6C2, April 2019

[9] Arunangsu Patra, Arnab Sinha Roy, Arka Samanta, D.Dutta, DR.T.G.Biswas "Effect of Potassium Hydroxide As An Activator Class F & Class C Fly Ash" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, PP 46-52.

[10] R.Anuradha, V.Sreevidya, R.Venkatasubramani and B.V.Rangan "Modified Guidelines For Geopolymer Concrete Mix Design Using Indian Standard" Asian Journal of Civil Engineering (Building And Housing) Volume 13 No. 3 (2012).

[11] B.Vijaya Rangan "Fly Ash-Based Geopolymer Concrete" Proceeding of the International Workshop on Geopolymer Cement and Concrete, Allied Publishers Private Limited, Mumbai, Indian, December 2010, pp 68-106.