A PRELIMINARY STUDY ON PARTIAL REPLACEMENT OF CONCRETE BY GEOPOLYMER TREATED WITH DIFFERENT ALKALINE ACTIVATED SOLUTION

Prathyusha Ch[1], Vinay Kumar U[2], Sudheer M[3]

[1]Assistant Professor, Department of Civil Engineering, Lingayas Institute of Management & Technology, Madalavarigudem, Nunna, Vijayawada, Andhra Pradesh, India
[2,3]UG Student, Department of Civil Engineering, Lingayas Institute of Management & Technology, Madalavarigudem, Nunna, Vijayawada, Andhra Pradesh, India

---

Abstract - Concrete is the most widely used construction material in the world and Ordinary Portland Cement (OPC) is the major ingredient used in concrete. The production of cement releases large amount of carbon dioxide (CO2) to the atmosphere that significantly contributes to greenhouse gas emissions. It is estimated that one ton of CO2 is released into the atmosphere for every ton of OPC produced. This project mainly aims at the study of effect of concentration of alkaline activated solution on the properties of geo polymer concrete (GPC) using Potassium silicate (K_2O_3Si) and Potassium hydroxide (KOH) solutions as alkaline activator. The Geo-polymers are comprised of alumina-silicate materials which completely replaces the Portland cement in concrete. The alumina-silicate materials which are dissolved in alkaline activated solution i.e., Sodium Hydroxide or Potassium Hydroxide which subsequently polymerizes into molecular chains and networks to create the hardened binder which are referred as inorganic polymer cements. The main objective of this project is to investigate the compressive strengths for various concentrations of alkaline activated solution. The Mix design procedure is examined with M-20 grade of geo polymer concrete. The compressive strength and workability of the concrete are studied for various grades of the Geo-polymer concrete.

***Key Words*:** Portland Cement, Alkaline, Compressive Strength, Workability.

1.INTRODUCTION

Name Geo polymer was formed by a French Professor DAVIDOVITS in 1978 to represent a broad range of materials characterized by networks of inorganic molecules (Geo polymer Institute 2010). In this work, low-calcium fly ash-based geo-polymer is used as the binder, instead of Portland or other hydraulic cement paste, to produce concrete. The fly ash-based geo-polymer paste binds the loose course The aggregates, fine aggregates and other un-reacted materials together to form the geo-polymer concrete, with or without the presence of admixtures. The manufacture of geo-polymer concrete is carried out using the usual concrete technology methods.

Davidovits [1988] proposed that an alkaline liquid could be used to react with the silicon (Si) and the aluminum (Al) in a source material of geological origin or in by-product materials such as fly ash to produce binders. Because the chemical reaction that takes place in this case is a polymerization process, he coined the term “Geo-polymer” to represent these binders. Geo-polymer concrete is concrete which does not utilize any Portland cement in its production.

The contribution of Portland cement production worldwide to the greenhouse gas emission is estimated to be about 1.35 billion tons annually or about 7% of the total greenhouse gas emissions to the earth’s atmosphere. Cement is also among the most energy-intensive construction materials, after aluminum and steel. The trading of carbon dioxide (CO2) emissions is a critical factor for the industries, including the cement industries, as the greenhouse effect created by the emissions is considered to produce an increase in the global temperature that may result in climate changes.

2. LITERATURE SURVEY

Literature review has been related to the present work. Various considerations have been incorporated from the literature reviews which were carried out by various experts.

1] P. Chindaprasirt et.al (2011) They concentrated the union of high-quality Geopolymer utilizing fine high-Calcium fly slag. The outcomes demonstrate that the setting time of glue, abatements with an expansion in fly-fiery remains fineness. The stream quality, and drying-shrinkage attributes of mortars enhanced utilizing fine fly powder. Geopolymer mortars with high 28-day compressive quality of 86.0 MPa were acquired.

2] Partha, Prabir and Pradip [2014] researched that when the GGBS was included the scope of 0 - 20% of aggregate cover, critical increment in quality and some lessening in workability was seen in Geopolymer concrete. The expansion of GGBFS improved the setting of cement at encompassing temperature. The impact of blend factors on the improvement of elasticity was like that on the advancement of compressive quality.

3] Sunil Kumar. R, Dr V. Ramesh (2015) 18 sorts of blends of Geopolymer Concrete were set up for three diverse waters to Geopolymer solids, for two distinctive folio extents of 375 kg/m3 and 420 kg/m3 by keeping the Molarities steady (soluble base arrangement 8M), ideal Fck was chosen to cast the plain Geo polymer solid bar example and chambers. As detailed 35% GGBS (65% fly slag), in the aggregate cover content brought about the early quality advancement of geo polymer concrete under SUN DRYING which demonstrated better quality properties.

3. MATERIALS USED

3.1 FLYASH

Geo-polymer concrete can be manufactured by using the low-calcium (ASTM Class F) fly ash obtained from coal-burning power stations. Most of the fly ash available globally is low-calcium fly ash formed as a by-product of burning anthracite or bituminous coal. Although coal burning power plants are considered to be environmentally unfriendly, the extent of power generated by these plants is on the increase due to the huge reserves of good quality coal available worldwide and the low cost of power produced from these sources.

3.2 POTASSIUM HYDROXIDE

Generally, the potassium hydroxides are available in solid state by means of pellets and flakes. The cost of the potassium hydroxide is mainly varied according to the purity of the substance. Since our geo polymer concrete is homogenous material and its main process to activate the potassium silicate, so it is recommended to use the lowest cost i.e. up to 94% to 96% purity. In this investigation the sodium hydroxide pellets were used.

3.3 POTASSIUM SILICATE

Potassium silicate is also known as water glass or liquid glass, available in liquid (gel) form. In present investigation potassium silicate 2.0 (ratio between K_2O to SiO2) is used. As per the manufacture, silicates were supplied to the detergent company and textile industry as bonding agent. Same potassium silicate is used for the making of geo polymer concrete.

3.4 FINE AGGREGATES

Fine aggregates are the aggregates whose size is less than 4.75mmRiver sand and M sand compete each other for best concrete properties while strength factors are held by M sand and workability & fresh concreting properties are held by river sand, in addition the concrete with variations in coarse aggregates percentage needs structural attention to evolve a better solution in strength and appreciable fresh concrete properties. Thick binder pastes due to 60 to 70% of total aggregates in a concrete volume produce a concrete which may not have a appreciable highest strength.

3.5 COARSE AGGREGATE

The materials which are retained on IS sieve 4.75mm is termed as coarse aggregate. The crushed stone is generally used as a coarse aggregate. The nature of work decides the maximum size of the coarse aggregate. Locally available coarse aggregates having the maximum size of 20mm is considered. Here we are using 12.5mm size of aggregates. The aggregate was washed to remove dust and dirt and were dried to surface dry condition.

3.6 WATER:

From the chemical reaction, it was observed that the water comes out from the mix during the polymerization process. The role of water in the geo-polymer mix is to make workable concrete in plastic state and do not contribute towards the compressive strength in the hardened state. Similarly, the demand of water increases with increase in fineness of source material of same degree of workability. So, the minimum quantity of water required to achieve desired workability is selected on the basis of degree of workability, fineness of fly-ash and grading of fine aggregates. Water is not involved in the chemical reaction of geo polymer concrete and instead water is expelled during curing and subsequent drying. Only water can be used in preparation of alkaline activator solutions. It can be considered only for the mixing of the geo polymer concrete.

4. PARAMETERS

- Low calcium class F (ASTM CLASS F) fly ash is used.
- Solution to fly ash ratio=0.35.
- Potassium hydroxide to Potassium silicate ratio=1:2.5
- The concentrations of alkaline activator solution used are 4M, 6M, 8M, 10M, 12M, and 14M.
- For every 1M solution we have 40gms of KOH dissolves in 1000ml of water.
-

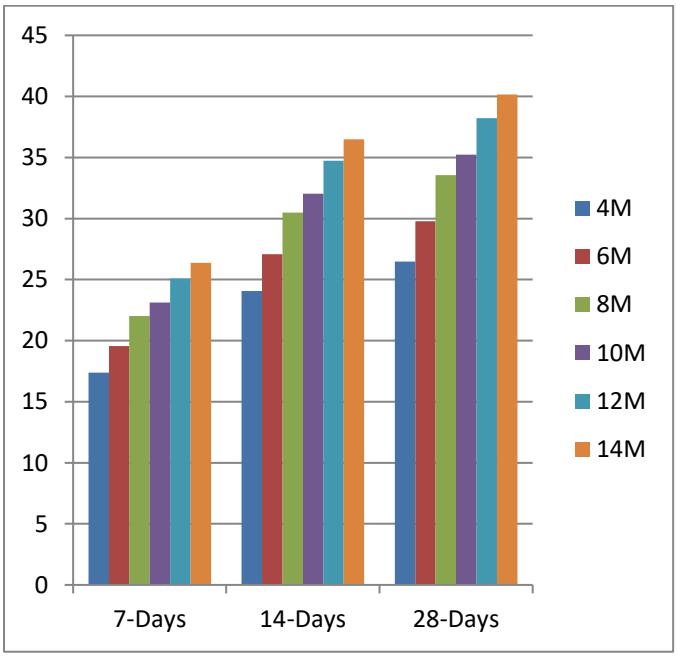
5. PREPARATION OF GEO POLYMER CONCRETE MIXES

Preparation of geo polymer concrete is similar to that of cement concrete. The fly ash, Quarry dust, coarse aggregates were mixed in dry state. Then add prepared mixture solution of potassium hydroxide and potassium silicate along with extra water based on water-to-geo polymer binder ratio and mix thoroughly for 3–4 min to give homogeneous mix.

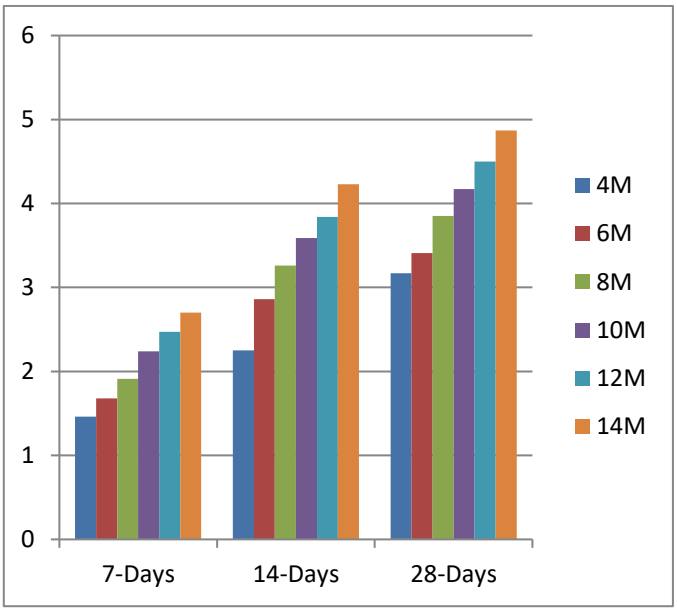
It was found that the fresh fly ash-based geo polymer concrete was viscous, Cohesive and dark in color. After making the homogeneous mix, workability of Fresh geo polymer concrete was measured by flow table apparatus as per IS 5512-1983 and IS 1727-1967. Concrete cubes of side 150 mm& cylinders of 300mm long&100 mm diameter are casted in three layers. Each layer is well compacted by tamping rod of diameter 16 mm. All cubes& cylinders were place on table vibrator and vibrated for 2 min for proper compaction of concrete. After compaction of concrete, the top surface was levelled by using trowel.

6. PROCEDURE

This Chapter presents the details of development of the process of making low-calcium (ASTM Class F) fly ash-based geo-polymer concrete. In order to develop the fly ash-based geo-polymer concrete technology, therefore, a rigorous trail-and-error process was used. The focus of the study was to identify the salient parameters that influence the mixture proportions and the properties of low-calcium fly ash-based geo-polymer concrete. As far as possible, the current practice used in the manufacture and testing of ordinary Portland cement (OPC) concrete was followed. The aim of this action was to ease the promotion of this 'new' material to the concrete construction industry. In order to simplify the development process, the compressive strength was selected as the benchmark parameter.



Graph-1 Compressive strength for various concentrations



Graph-2 Split tensile strength for various concentrations.

7. RESULTS

7.1 Tests on Geo polymer concrete

The specific gravity can be calculated by using the formula

Specific gravity (G) = W4 / [W3 – (W1-W2)]

G= 1980/2000-(2000-760) =2.61 g/cc.

7.2 Workability Test

MOLARITY/PROPERTY	4M	6M	8M	10M	12M	14M
Workability in terms of flow (%)	26.58	29.17	32.84	44.13	61.61	66.78
Degree of workability	medium	medium	medium	high	high	high
Passing ability(L-box)	0.83	0.86	0.88	0.91	0.95	0.97

Table-1 Test results of workability on geo polymer concrete

7.3 Compression test results

MOLARITY	7-days(N/mm^2)	14-days(N/mm^2)	28-days(N/mm^2)
4M	17.38	24.07	26.48
6M	19.55	27.07	29.78
8M	22.02	30.49	33.54
10M	23.13	32.02	35.23
12M	25.09	34.74	38.22
14M	26.36	36.5	40.15

Table-2 Compression test results on geo polymer concrete

8. CONCLUSIONS

- The strength of Geo polymer concrete increases with the increases of concentrations of alkaline activated solution.
- The workability flow of Geo polymer concrete increases with the increases of concentrations of alkaline activated solution.
- In the production of geo polymer binder, the materials like fly ash (waste material from thermal industries) & sodium hydroxide & sodium silicate (waste water from chemical refineries) can be utilized.
- With the use of Quarry dust, the compressive strength is increases by 30%(approx.)
- The geo polymer concrete is cheaper, eco-friendly, greater durability& having greater workability.

9. FUTURE SCOPE

- Different percentages of quarry dust shall be used and the characteristics shall be studied.
- Different Grades of geo-polymer concrete shall be used and the characteristics shall be studied.

10. REFERENCES

[1] Abdul AleemM.I1 and ArumairaP.D2 “Optimum mix for the geopolymer concrete”. Indian Journal of Science and Technology, Vol. 5 No. 3 (Mar 2012), ISSN: 0974- 6846.

[2] Bhikshma, V., Kishore, R and Raghu Pathi, C.V. (2010), Investigations on flexural behavior of high strength manufactured sand concrete, Challenges, Opportunities and Solutions in Structural Engineering and Construction Ghafoori (ed.)© 2010 Taylor & Francis Group, London, ISBN 978-0-415-56809-8.

[3] GanapatiNaidu.P1, A.S.S.N.Prasad2, S.Adiseshu3, P.V.V.Satayanarayana

[4] “A Study on Strength Properties of Geopolymer Concrete with Addition of G.G.B.S”. International Journal of Engineering Research and Development Volume 2, Issue 4 (July 2012), PP. 19-28.

[5] Joseph Davidovits. “Properties of Geopolymer cements”. Published in proceedings First International Conferences on Alkaline Cements and Concretes, Scientific Research Institute on Binders and Materials, Kiev State Technical University, Kiev, Ukraine, 1994

[6] Douglas C. Comrie, John H. Paterson & Douglas J. Ritcey, D. Code Consulting Ltd, Boulevard East, Mississauga, Ontario - Applications of geopolymer technology to waste stabilization.

[7] Concrete technology-M.S.shetty

[8] Methods of tests for aggregates for concrete-IS; 2386-1975.

[9] Sofi Yasir and Gull Iftekar, “Study of Properties of Fly Ash Based Geo-polymer Concrete” International Journal of Engineering Research, Vol. 3, Issue 1, ISSN: 2321-7758,Januaury 29 2015.

[10] Jamdade, P. K and Kawade, U. R, “Evaluate Strength of Geo-polymer Concrete by Using Oven Curing” IOSR Journal of Mechanical and Civil Engineering, Vol. 11, Issue 6, pp: 63-66, e-ISSN: 2278-1684/p-ISSN: 2320-3340, Nov-Dec 2014.

[11] C. Kamlesh. Shah, A. R. Parikh and K. J. Parmar, “Study of Strength Parameters and durability of Fly ash based Geo-polymer Concrete” Indian Journal of Research, Vol. 3, Issue 7, ISSN - 2250-1991, July 2014

[12] Jaydeep, S and B.J. Chakravarthy, “Study On Fly Ash Based Geo-polymer Concrete Using Admixtures” International Journal of Engineering Trends and Technology, Vol. 4, Issue 10, pp: 2231-5381, ISSN: 2231-5381, Oct 2013