

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 1, January 2019

Fly Ash Based Geopolymer Concrete without Cement

Prof. Vaijwade Sujit M.¹, Prof. Toshniwal Sawan S.², Prof. More Shubham A.³, Prof. Sogarwal Akash M.⁴

Lecture, Civil Engineering Department, M.G.M's Polytechnic, Aurangabad, Maharashtra, India^{1,2,3,4}

ABSTRACT: Concrete is a versatile widely used construction material. Ever since concrete has been accepted as a material for construction, researchers have been trying to improve its quality and enhance its performance. Recent changes in construction industry demand improved durability of structure. In recent years, concrete usage around the world is second only to the water. Cement not only consumes huge amount of the natural resources i.e. limestone & fossil fuels but also produces almost 0.9t of CO₂ for 1t cement clinker production generator 2.8 billion ton manmade green house gas annually. To reduce green house gas emissions, efforts are needed to develop environmentally friendly construction material. This paper represents the fly ash based Geopolymer concrete. The engineering properties of fly ash based Geopolymer concrete have been studied previously but very little work has been conducted on mix design procedure that may be suitable for this new type of concrete. Using a flow chart, the paper describes the procedure in general. A simply graphical relationship between strength of concrete in days is also presented.

KEYWORDS: Geopolymer concrete, fly ash, alkaline solutions, mix design, compressive strength, Ordinary Portland cement, Normal Concrete, etc.

I. INTRODUCTION

Geopolymer concrete is one of the building materials that have become more popular in recent years due to the fact that it is significantly more environmentally friendly than standard concrete. The term "Geopolymer" was coined by Davidovits in 1978. Geopolymer is a type of concrete that is made by reacting aluminates & silicate bearing materials with a caustic activation. Geopolymer concrete also showed good properties such as high compressive strength, low creep, good acid resistance and low shrinkage [Lodeiro et al. 2007]. The role of binder in Geopolymer concrete is replaced by fly ash which also possesses pozzolanic properties as OPC & rich with alumina & silicate. Fly ash is residual from the combustion of coal which is widely available worldwide & lead to waste management proposal. Hence fly ash based Geopolymer concrete is a good alternative to overcome the abundant of fly ash. In fly ash based Geopolymer concrete, the silica & the alumina present in the source materials are first induced by alkaline activators to form a gel known as aluminosilicate. This gel binds the loose aggregate and other unreacted materials in the mixture to form the Geopolymer concrete. This paper summarizes the properties, mix design of fly ash based Geopolymer which make it better compared to normal concrete. There are two main constituents of geopolymers, namely the source materials and the alkaline liquids. The source materials for geopolymers based on alumina-silicate should be rich in silicon (Si) and aluminium (Al). These could be natural minerals such as kaolinite, clays, etc. Alternatively, by-product materials such as fly ash, silica fume, slag, rice-husk ash, red mud, etc could be used as source materials. The choice of the source materials for making geopolymers depends on factors such as availability, cost, type of application, and specific demand of the end users. The alkaline liquids are from soluble alkali metals that are usually Sodium or Potassium based. The most common alkaline liquid used in geopolymerisation is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate. This paper is deals primarily with low-calcium fly ash based geopolymer concrete. Low-calcium fly ash is preferred as a source material than high-calcium fly ash. The presence of calcium in high amounts may interfere with the polymerization process and alter the microstructure and hence compromise some of the benefits offered by geopolymer concrete.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 1, January 2019

II. RELATED WORK

1. Cement

Portland Pozzolana cement of 53 grade (IS: 12269-1987), Specifications for 53 Grade has been used in the study. It was procured from a single source and stored as per IS: 4032 – 1977. Care has been taken to ensure that the cement of same company and same grade is used throughout the investigation. The cement thus procured was tested for physical properties in accordance with the IS: 12269 – 1987. Cement was used to prepare normal concrete, the comparison with fly ash based geopolymer concrete. ASTM C188 was followed to measure the specific gravity.

2. Flyash

Fly ash was obtained from Maharashtra, India & used in this research as the main constituents of the binding materials in geopolymer concrete. Its specific gravity was measured using the same procedure described in ASTM C188 for cement.

3. Fine Aggregate

Sand conforming to zone-II of IS: 383- 1970 having specific gravity 2.51 & fineness modulus of 2.70.

4. Coarse Aggregate

Crushed granite metal conforming to IS: 383- 1970 having specific gravity 2.70 & fineness modulus of 5.85.

5. Alkaline Liquid

The common materials used as alkaline solution in producing fly ash based geopolymer are sodium silicate & potassium hydroxide to produce the alkaline solution is 14M. According to Prof. J. Davidovits the alkaline liquids should be made prior to one day before mixing because at the time of mixing of Na_2SiO_3 with NaOH solution it generates a huge amount of heat & the polymerization takes place by reacting with one another, which will act as a binder in the geopolymer concrete. Then the materials are mixed together with fine aggregate & coarse aggregate to form concrete & curing process been done.

6. Mixing

Concrete was mixed in a tilting mixture. The weight of materials was taken with a digital weighing balance. Mixing sequence was as follows.

- Prepare requisite quantity of sodium hydroxide & sodium silicate solution 24 hours in advance.
- Mix the sodium hydroxide & sodium silicate solution.
- Mix the fly ash, fine aggregate, coarse aggregate for two minutes.
- Add alkaline solutions during mixing & mix for two minutes.
- Stop mixing & pour the concrete mix.

Concrete was placed in 150mm cube moulds in three layers & each layer was compacted by giving 25 blows with a 25mm tamping rod. The geopolymer concrete was dark in colour with shiny appearance.

7. Mix Design

In this experiment we select the grades of concrete M20 and M30. The mix design was carried out as per IS: 10262-2009. The trials have been prepared and finally we find for M25 grade was design for this experiment having the mix proportion 1:1.31:2.81 and 1:0.87:2.06. All locally available materials are used during the preparation of the mix proportion. Comparison between NC & GPC with Parameters (m^3).

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 1, January 2019

Table No. 1 Mix Proportion for Normal Concrete and Geopolymer Concrete

Parameters (kg/m ³)	M20 Grade Concrete	GPC (M20)	M30 Grade Concrete	GPC (M39)
Cement/ fly ash	380	491	190	383
Fine sand	711	425.7	696	503.2
Coarse aggregate (20 mm)	924	1012	1029	1078
Na ₂ SiO ₃	-	170	-	160
Water	160	-	145	-
Proportion	1:1:2	1:0.87:2.06	1:1.5:3	1:1.31:2.81

Following Figure shows the graphical representation of mix proportion of concrete

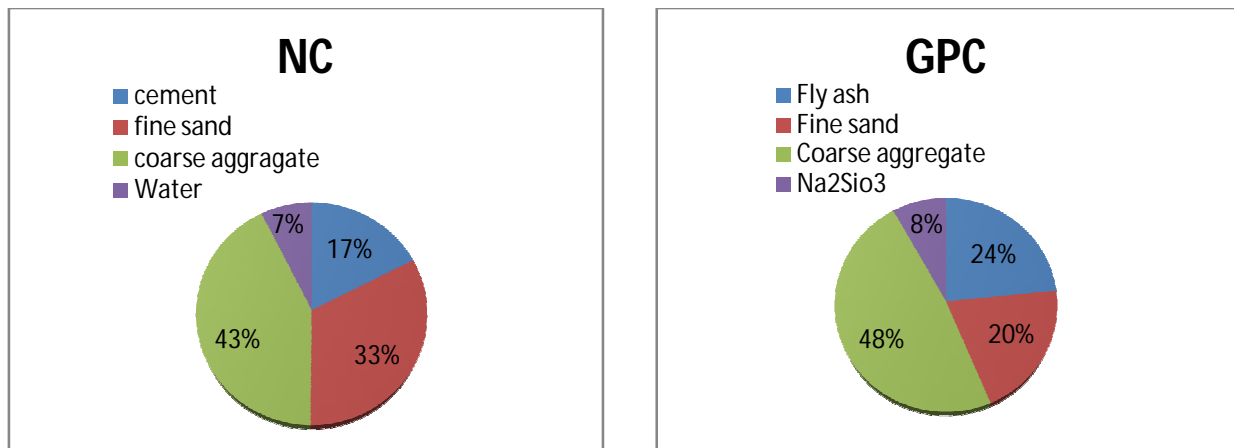


Fig. No. 1 Mix Proportion of Normal Concrete and Geopolymer Concrete

8. Compressive Strength Tests

The compressive strength tests were done by using the cubic specimen of sizes 150x150x150 mm. The moulds are conforming to the IS specification. For each test three specimens were taken and their average value is considered. The load should be applied gradually at the rate of 140 kg/cm² per minute till the specimens fails. The load at the failure divided by area of specimen gives the compressive strength of concrete.

9. Curing Process

Setting time of Geopolymer depend on many factor such as composition of alkaline solution ratio of alkaline liquid to fly ash by mass however the curing temperature is most important factor for Geopolymer as the curing temperature increases setting time of concrete decreases during curing process the Geopolymer concrete experience polymerization process due to increases of temperature polymerization become more rapid and the concrete can be 70% of its strength within 3 to 4 hour of curing.

The rate of increase of strength is rapid in initial 24 hour of curing beyond the gain of strength was moderate specimens should be cured for 24 hour only which will sufficient enough. Generally the curing which is done for Geopolymer is hot steam curing or normal hot curing in oven within a temperature of 60^oC -90^oC for 24 hour through a curing temperature 60^oC is more effective than other temperature or can be said is the optimum curing temperature.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 1, January 2019

Beyond 60⁰ C is doesn't affect the polymerization process so much the previous studies on Geopolymer concrete revealed that Geopolymer concrete did not attain any strength at room temperature or by water curing. The Geopolymer concrete harden at steam curing or hot air curing and the minimum curing period shall be 24 hours.

III. EXPERIMENTAL RESULTS

Compressive Strength and Slump Value

Table No.2 Compressive Strength and Slump Value

Grade	Slump		Compressive Strength(MPa)		Age of cube for compressive strength test (days)	
	GPC	NC	GPC	NC	GPC	NC
M20	120	220	29.23	17.94	3	7
			30.58	27.30	3	28
			29.86	17.94	5	7
			31.87	27.30	5	28
M30	90	195	35.60	23.43	3	7
			38.80	35.47	3	28
			35.82	23.43	5	7
			38.10	35.47	5	28

From above observations, we showed Graphical relation between compressive strength.3 days for GPC, 7 & 28 days for normal concrete as follow,

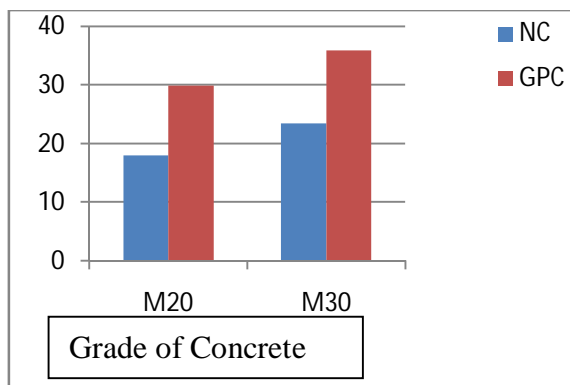


Fig No.2 Compressive strength at 3, 7 days

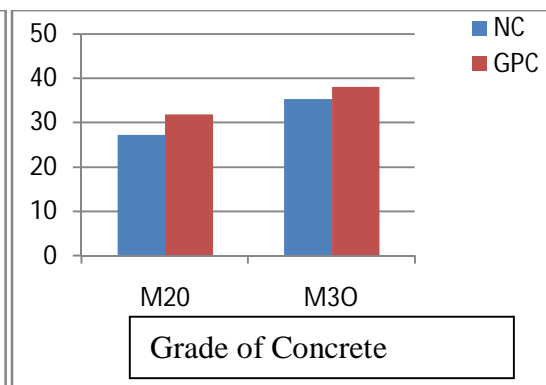


Fig. No.3 Compressive strength at 3, 28 days

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 1, January 2019

IV. CONCLUSION

From the about experiments following conclusions are observes:

1. GPC attain higher early strength than normal concrete and good corrosion resistant.
2. Higher concentration of NaOH solution results in higher strength.
3. 3 days curing period produces higher compressive strength.
4. Reduction of the concrete industry's CO₂ emission. And increased concrete industry's use of waste products.
5. Reduction of the concrete industry's use of non- renewal fuels.
6. No environmental pollution and sustainable development.
7. No increased noise & dust emission.

REFERENCES

- [1] James Aldred and John Day, (AECOM , Australia). "Is Geopolymer Concrete A Suitable Alternative To Traditional Concrete?", 37th conference on OUR World In Concrete & Structures: 29-31 August 2012, Singapore.
- [2] Djwantoro Hardjito, Steenie E. Wallah, Dody M.J. Sumajouw and Vijaya Rangan, "On The Development Of Fly Ash-Based Geopolymer Concrete" ,ACI Materials Journal/November-December 2004(467-472)
- [3] Raijiwala D.B &.Patil H.S, ". Geopolymer Concrete: A Concrete of Next Decade", Journal of engineering Research and studies/ volume. II/Issue I/January-March 2011(19-25)
- [4] Ammar Motorwala, Vineet Shah, Ravishankar Kammula, Praveena Nannapaneni & Prof. D. B. Raijiwala, "ALKALI Activated FLY-ASH Based Geopolymer Concrete", (ISSN 2250-2456, ISO 9001:2008) certified journal, volume3,Issue1,January 2013)
- [5] Karthik H. Obla., "Specifying Fly Ash For Use In Concrete", Research & Materials Engineering, NRMCA.
- [6] IS 10262-2009, "Recommended Guidelines for Concrete Mix Design".
- [7] IS 456:2000, "Plain and Reinforced Concrete- Code of Practice".
- [8] IS 383:1970, "Specification for Course and Fine Aggregates From Natural Sources For Concrete".
- [9] Shankar H. Sanni, Khadiranaikar, R.B, " Performance of geopolymer concrete under severe environmental conditions", International Journal of Civil and Structural Engineering. Volume 3.No 2,2012.
- [10] Aminul Islam Laskar and Rajan Bhattacharjee, " Effect of Plasticizer and Super plasticizer on Workability of Fly Ash Based Geopolymer Concrete" Proceedings of International Conference on Advances in Architecture and Civil Engineering(AARCV 2012), 21st- 23rd June 2012
- [11] Mr. K. MAdhan Gopal, Mr. B. Naga Kiran, " Investigation on Behavior of fly ash Based Geopolymer Concrete in Acidic Environment" International Journal of Modern Engineering Research (IJMERE) Vol.3,Issue1. Jan- Feb.2013(pp 580-586)
- [12] S. Jaydeep, B.J. Chakravarthy," Study On Fly Ash Based Geo-polymer Concrete Using Admixtures" International Journals of Engineering Trends and Technology(IJETT)- Vol.4 Issue 10- Oct 2013
- [13] M.I. Abdul Aleem and P.D. Arumaoraj," Optimum mix for the geopolymer concrete" Indian Journal of Science and Technology Vol.5 No.3 (Mar 2012) ISSN: 0974-6846
G. Saravanan, C.A Jeyasehar and S. Kandasamy, "Flyash Based Geopolymer Concrete- A state of the Art Review" Journal of Engineering Science and Technology Review 6 (1) (2013) 25-32.