International Journal of Research
Available at https://edupediapublications.org/journals
p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 04 Issue 07
June 2017

Utilization of waste materials in the development of Geopolymer Concrete: A New Innovation

Ms. Paramjeet Kaur[1], Mr. Syed Imran Shah[2]
1: Student (M.Tech), Gurukul Vidyapeeth institute of Engineering and Technology
2: Asst. Prof, Civil Engineering Department, Gurukul Vidyapeeth institute of Engineering and Technology

ABSTRACT
The production of cement increases the green house effect to a large scale, therefore harms the environment to a large extent. So there was a need to invent new materials that must be ecofriendly.Geoploymer is one of such invention. in geopolymer Fly ash or GGBS is used instead of cement & alkaline solution is used to bind all the materials.flyash is a waste materials from thermal power plant having silica & alumina content. Every year it is produced in large tonnes & dumped in open environment which pollute the atmosphere but that flyash can be used to make green concrete .This Paper is about the compressive strength of GPC, water absorption & economic analysis.

Keywords
GPC, polymerization, Waste Material, green concrete, strength

1. INTRODUCTION
The cement is used widely all over the world because of its easily availability, binding properties & Strength. The production of cement is increased many times because of its popularity increased day by day.According to a recent survey the production of cement is estimated to be more than 2.8 billion tonnes[1] and also estimated that the production of cement uses approximate 94.76 $\times 10^6$ Joules[2] The production of one ton of cement releases one ton of carbon di oxide gas in the atmosphere. As we all know carbon di oxide is responsible for green house gases which increases the warming. The carbon di oxide contributes about 65% to the green house effect. Therefore to reduce the negative effects of cement industry, new alternatives or supplementary are used.Geoploylmer is one such innovation.Geopolymer is a new technology in the history of concrete technology. It is also known as green concrete as it does not affect the environment. Geopolymer concrete can be prepared by use of waste materials like flyash, GGBS with the addition of chemicals such as sodium hydroxide (NaOH), potassium hydroxide (KOH), sodium silicate or potassium silicate. The name Geopolymer was given By Dr. Prof. J. Davidovits in 1978 and he studied the polymerization process results in a chemical reaction under alkaline condition on Si-Al minerals which results in a 3D polymeric [4] Chain.The ring structure of this chain consist of Si-O-Al-O bond.the curing of mixture of geopolymer concrete can be done at ambient temperature or by heat curing[5] .In this paper flyash is used used for making geopolymer. Normally for making high strength geopolymer concrete the class F of flyash is used.alkaline activating solution is very necessary for geopolymer concrete as it dissolves Si and Al.

2. EXPERIENTAL INVESTIGATIONS

2.1 Materials

2.1.1 Fly ash:
fly ash class F collected from RMC plant Mohali used for present Work. It was tested for chemical and physical properties per ASTM C 311

Table 1: Properties of Flyash

S.N	Particulars	Test Results
1	Fineness of Fly Ash	92.2 %
2	Soundness Expansion	3 mm
3	Specific gravity of Flyash	2.1

2.1.2 Coarse aggregates: Locally available coarse aggregates having the maximum size of 14 mm 10 mm,and 7 mm were used in the present work. The 14 mm aggregates used were first sieved through 2 0mm sieve and then through 14 mm sieve and 10mm aggregates were firstly sieved through 12.5 mm sieve 7 then through 10 mm . The 7 mm aggregates were firstly sieved through 10 mm sieve & then through 7 mm sieve they were then washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested per Indian Standard Specifications IS: 383-1970 [27]. The results of various tests conducted on coarse aggregate are given in Table 2

Table 2: Properties of Coarse Aggregate

S.No	Properties	Test Results
1	Type	Crushed
2	Maximum size	14 mm, 10 mm ,7 mm
3	Specific gravity	2.825

	(14 mm)	
4	Specific gravity (10 mm)	2.704
5	Specific gravity (7 mm)	2.654
6	Total water absorption (14 mm)	3.645%
7	Total water absorption (10 mm)	1.643%
8	Total water absorption (7 mm)	1.435%
9	Moisture content (14 mm)	0.7039%
10	Moisture content (10 mm)	0.86%
11	Moisture content (7 mm)	0.79%
12	Finness Modulus of CA	3.07

2.1.3: Fine Aggregates

The sand used for the experimental programme was locally procured and conformed to grading zone III.The sand was first sieved through 10 mm sieve to remove any particles greater than 4.75 mm, and then was washed to remove the dust. The fine aggregates were tested per Indian Standard Specifications IS: 383-1970 [27]. Properties of the fine aggregate used in the experimental work are tabulated in Table 3

Table 3: Properties of Fine Aggregate

S.N	Properties	Test Result
1.	Type	Uncrushed (natural)
2.	Specific gravity	2.65
3.	Total water absorption	1.31%
4.	Moisture content	0.158%
5.	Net water absorption	0.854%
6.	Fineness modulus	2.57
7.	Grading zone	III

2.1.4: Water:

Clean Potable water was used for making mixture & adding to chemicals

2.1.5: Super plasticizer:

Galenium based Super Plasticizer in the quantity of 2% of mass of fly ash was used to increase the workability

2.1.6 Alcofine:

The alcofine was used to increase the strength as it decrease the permeability was procured from RMC plant from Mohali.The admixure was used in different percentage such as 0,5,10 & 15 % of flyash

2.1.7: Chemicals Used:

a) Sodium Hydroxide (NaOH): It was procured from local market of Ambala Cantt in the form of Pellets with 99% purity. The mixing of water & Sodium Hydroxide is an exothermic reaction therefore suitable care should be taken. The solution was prepared one day in advance to casting so that the solution prepared cooled down.

b) Sodium Silicate: Sodium Silicate was purchased in the solution form from the market of Ambala Cantt. The sodium hydroxide & sodium silicate with addition of dosage of Super Plasticizer were mixed about one hour prior to casting.

2.2 Mix Design of Geopolymer Concrete:

The mix design used for current research was followed from the Paper of development of high strength fly ash based geopolymer concrete with alccofine by Bharat Bhushan Jindal. the mix designation and quantities of various materials for each designed concrete mix have been tabulated in given below table 4

2.3 Preparation, Casting and Curing of Geopolymer:

Cubical moulds of size 150 mmx150 mmX150mm were used to prepare the concrete specimens for the determinations of compressive strength, of fly ash concrete. All specimens were prepared in accordance with Indian Standard Specifications IS: 516-1959 [30]. All the moulds were cleaned and oiled properly. These were securely tightened to correct dimensions before casting. Care was taken that there is no gaps left from where there is any possibility of leakage out of slurry.

A careful procedure was adopted in the batching, mixing and casting operations. The sodium hydroxide is mixed with required quantity of water one day prior to the casting of cubes. After this sodium silicate & super plastizer is added to sodium hydroxide 3 hours before casting cubes. The coarse aggregates and fine aggregates were weighed first with an accuracy of 0.5 grams.

The concrete mixture was prepared by hand mixing on a watertight platform. On the watertight platform, the coarse and fine aggregates were mixed thoroughly. To this mixture, the fly ash was added. The chemicals were added to the mixture .Carefully so that no loss occurs during mixing .during this all the materials should be mixed properly so that a uniform mixed is obtained. Nine clean and oiled moulds for each category were then placed on the vibrating table respectively and filled in

Mix Designation	Fly Ash	Coarse Aggregates			Fine Aggregate	Alcofine	Sodium Hydroide	Sodium Silicates	Water
		14 mm	10 mm	7 mm					
M1	**400**	**565**	**445**	**255**	**540**	**0%**	**52.58**	**131.45**	**27.07**
M2	**400**	**565**	**445**	**255**	**540**	**5%**	**52.58**	**131.45**	**27.07**
M3	**400**	**565**	**445**	**255**	**540**	**10%**	**52.58**	**131.45**	**27.07**
M4	**400**	**565**	**445**	**255**	**540**	**15%**	**52.58**	**131.45**	**27.07**

Table 4: Mix Design for Geopolymer Concerete

three layers. Vibrations were stopped as soon as the cement slurry appeared on the top surface of the mould.The specimens were allowed to remain in the steel mould for the first 72 hours at ambient condition. After that these were demoulded with care so that no edges were broken and such cubes were placed in the room at the ambient raptureature. The ambient temperature for curing was 27 ± 20 C.

3. RESULTS AND DISCUSSIONS:

1. Workability: It is one of important property of concrete used to check the homogeneity of concrete. In the present work workability was checked by using slump test.in this 2% of superplazcier was used with other materials and slump came out to be 75mm.

2. Compressive Strength: Compressive Strength is one of important hardened property of concrete. The Compressive Strength of concrete was checked at 7 & 28 Days. Initial Strength of GPC is less than the conventional concrete.but the final Strength of GPC is somewhat Simliar or higher than the conventional concrete. The compressive strength of the GPC specimens synthesized at four different percentages of alcofine.

From the test result it was cleared that the maximum compressive strength was obtained at 15% alcofine but it was also seen that there is very little difference in the strength obtained at 10% & 15% alcofine.The tables & Figures are given below to show different values of compressive strength at 7 and 28 days with varying value of alcofine.

3. Water Absorption Test: This test was conducted to know the porous permeable void space of concrete, according to ASTM C 642-82 [18]. This test was conducted on a set of 2 cubes with varying percentage of alcofine.The cubes were kept in oven dry at 105© until the weight of cubes attain constant Value.The value of Permeable Voids in Percentage is equal to the difference in weight of of saturated surface dry specimen and weight of oven dried cubes.

The cubes removed from oven dry are weighed and wholly immersed in a water tank till the constant weight is achieved. The Difference in initial weight (Weight obtained after 30 min in water) and Final Weight (at a time when the difference between two consecutive weights was very small). It is generally observed that all concrete takes 72 hours for final absorption.

4. Economic Analysis of GPC:

The GPC concrete is also checked for its cost per unit cum volume. The production cost of Fly ash is very negliable as compare to cement .In this cost of GPC & conventional concrete were compared with same strength. From the conclusions it was found that there is small difference in cost for same strength of 1 cum volume of both concrete

Secondly advantage of using GPC is reduction in carbon di oxide emission.

Fig 1: Compressive Strength of cubes after 7 days with different %age of Alcofine

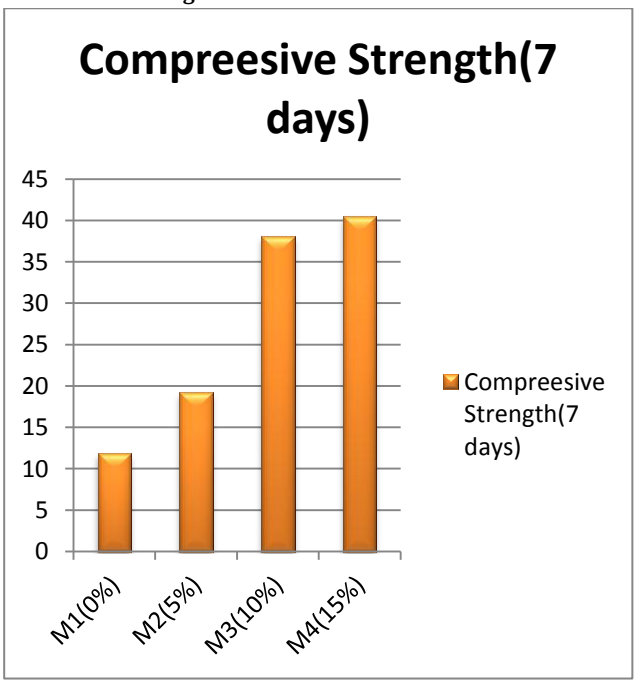
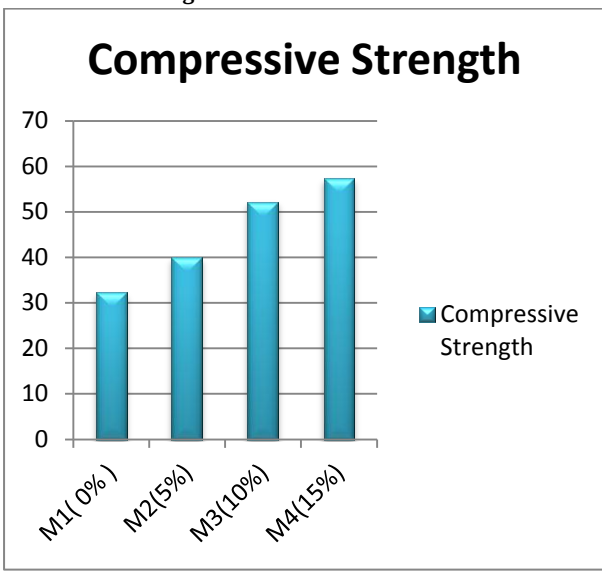


Fig 2: Compressive Strength of cubes after 28 days with different %age of Alcofine



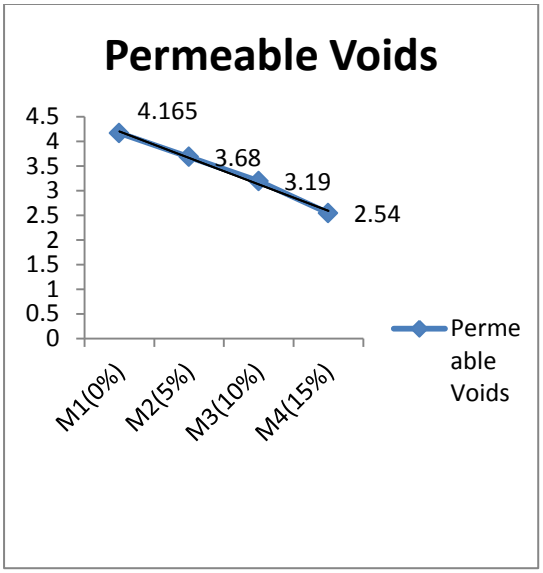


Table 5: cost analysis of 1 Cum volume of Cement Concrete

S.No.	Item Name	Quantity(Kg)	Rate	Cost
1	Fly Ash	400	1	400
2	FA	540	2.2	1188
3	CA(14 mm)	565	0.43	242.95
	10 mm	445	0.43	191.35
	7 mm	255	0.43	109.65
4	ALCOFINE	60	2.5	150
5	SODIUM HYDROXIDE	23.46	40	938.4
6	SODIUM SILICATES	131.45	20	2629
7	SUPER PLA	8	9.75	78
8	WATER	27.7	0	0
Total				5927.35

Table 6: cost analysis of 1 Cum volume of Geopolymer Concrete

S.No	Item Name	Quantity(Kg)	Rate	Cost
1	Cement	422	6	2532
2	FA	621	2.2	1366.2
3	CA(20 mm)	706	0.43	552.12
	10 mm	578		
4	Admixture	5.064	9.75	49.35
5.	Water	147	0	0

4. Conclusions:

1. Compressive Strength of GPC increases with increase in %age of Alcofine
2. Permeable Voids Decreases with increase in %age of voids
3. Water absorption also Decreases with increase in %age of voids
4. Geopolymer concrete is expensive as compare to conventional concrete
5. GPC is ecofriendly as compare to conventional concrete

References:

1. Davidovits, J. (1994). "High-Alkali Cements for 21st Century Concretes", ACI Special Publication, 144, 383-398.
2. Central Electricity Authority. (2014). "Report on Fly ash generation at Coal/Lignite Based Thermal Power Stations and Its Utilization in The Country, For The Years 2011-12 And 2012-13", Central Electricity Authority, Government of India, New Delhi.
3. Sourav Kr. Das, Amarendra Kr. Mohapatra and A.K. Rath, geo-polymer concrete–green concrete for the future—A Review. International Journal of Civil Engineering Research:ISSN 2278-3652 Volume 5, Number 1 (2014), pp. 21-28
4. Davidovits, J., 'Geopolymer chemistry and application, Institute Geopolymer, France, 2008, pp. 585.

5. Jindal Bharat Bhushan.,Yadav Aniket.,Anand Abhishak.,Badal Abhishek.,'' Development of High Strength Fly Ash based Geopolymer Concrete with Alccofine''
6. Hardjito, D., S. E. Wallah, D. M. J. Sumajouw & B. V. Rangan (2003).Introducing fly ash-based geopolymer concrete: manufacture and engineering properties. 30th Conference on our world in concrete & structures: 23 - 24 August 2005,Singapore
7. Hardjito, D., S. E. Wallah, D. M. J. Sumajouw & B. V. Rangan (2004). "On The Development of Fly Ash-Based Geopolymer Concrete." ACI Materials Journal, Vol. 101, No. 6, pp 467-472.

10 Duxson P et al. The role of inorganic polymer technology in the development of 'green concrete'. Cem Concr Res 2007;37:1590–7

11 Bakharev T. Thermal behaviour of geopolymers prepared using class F fly ash and elevated temperature curing. Cem Concrete Res 2006; 36:1134–47.

12 D, Rangan BV. Development and properties of low-calcium fly ashbased geopolymer concrete. Curtin University of Technology; 2005.

13 Lloyd NA, Rangan BV. Geopolymer concrete with fly ash. Presented at the Second International Conference on Sustainable Construction Materials and Technologies, Italy.

14 Rangan B. Design and manufacture of fly-ash based geopolymer concrete. Concr Aust 2010;34:37–43.

15 M Talha Junaid. Amar Khennane.''A mix design procedure for low calcium alkali activated fly ash-based concretes''. Construction and building materials Research Gate: MARCH 2015.

16 B. Vijaya Rangan.''Fly Ash-Based Geopolymer Concrete'' .Proceedings of the International Workshop on Geopolymer Cement and Concrete, Allied Publishers Private Limited, Mumbai, India, December 2010, pp 68-106.

17 B. Vijaya Rangan. '' Geopolymer concrete for environmental protection'' .The Indian Concrete Journal, April 2014, Vol. 88, Issue 4, pp. 41-48, 50-59.

18 B. Rajini, A.V. Narasimha Rao, '' Mechanical Properties of Geopolymer Concrete with Fly Ash and GGBS as Source Materials. International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 3, Issue 9, September 2014

19 J. Davidovits,"Geopolymers: Man-Made Geosynthesis andthe Resulting Development of Very Early High Strength Cement", J. Materials Education Vol. 16 (2&3), 1994, pp. 91-139.

20 Lloyd, N., and V. Rangan. 2009. "Geopolymer Concrete—Sustainable Cementless Concrete." ACI Special Publication SP-261, 10th ACI International Conference on Recent Advances in Concrete Technology and Sustainability Issues. American Concrete Institute, Farmington Hills, MI..

21 Sourav Kr. Das, Amarendra Kr. Mohapatra and A.K. Rath, geo-polymer concrete-green concrete for the future–A Review. International Journal of Civil Engineering Research:ISSN 2278-3652 Volume 5, Number 1 (2014), pp. 21-28.

22 S.S. Jamkar, Y.M.Ghugal and S.V.Patankar, (2013) , Effect of Fly-ash Fineness on Workability and Compressive Strength of Geo-polymer Concrete,The Indian Concrete Journal, pp:57-62.

23 Shankar H. Sanni1, R. B. Khadiranaikar, '' performance of alkaline solutions on grades of geopolymer concrete": IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308.

24 Mahaltesh, S., 'Experimental study on ratio of alkaline liquids on geopolymer concrete', , Basaveshwar Engineering College, Bagalkot.:*M.Tech Project Report*, 2011.

25 Rangan, B. V., 'Mix design and production of fly ash based geopolymer concrete', *The Indian Concrete Journal*, 82(5), 2008, pp. 7-14.

26 L.Krishnan, S.Karthikeyan, S.Nathiya, K. Suganya, '' Geopolymer concrete an eco-friendly construction material'': IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308.

27 Vijai K, Kumutha R and Vishnuram B.G, (2012). "Experimental Investigations on mechanical properties of Geopolymer Concrete composites", Asian journal of Civil Engineering (building and housing) vol. 13, no. 1 pages 89-96.

28 P.Vignesh, K.Vivek, ''An Experimental investigation on strength parameters of flyash based geopolymer concrete with ggbs'': International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 02 Issue: 02 | May-2015 www.irjet.net p-ISSN: 2395-0072

29 Neethu Susan Mathew1, S. Usha2, '' Study on strength and durability of fly ash and ggbfs based geopolymer concrete'': International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 02 Issue: 05 | Aug-2015 www.irjet.net p-ISSN: 2395-0072.

30 M Talha Junaid, Amar Khennane, Obada Kayali. '' Performance of fly ash based geopolymer concrete made using non-pelletized fly ash aggregates after exposure to high temperatures: Materials and structures · August 2014

31 M Talha Junaid, Amar Khennane, Obada Kayali, '' A Mix Design Procedure for Alkali Activated Fly Ash-based Geopolymer Concretes'': Conference paper · January 2012