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Experimental Study on Fly Ash based Geo-Polymer Concrete

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Abstract - *This paper deals with replacing of cement by fly ash. Experiments were performed on plain concrete and then it was alter with the use of fly ash. After that analysis were done to compare the result for the conventional concrete and geo polymer concrete. Compressive strength , acid resistance and water absorption tests were carried out after consequent 7, 14, 28 days respectively. In the present paper, the mechanism of activation of a fly ash (no other solid material was used)is described. This paper, report on the study of the processing of geo polymer using fly ash with geo polymerization process. The geo polymer paste samples were cured at 60°C for 1 day and keep in room temperature until the testing days. The compressive strength was done at 7 and 28 days. A concrete use around the world is second only to water. It also consumes large amount energy .Hence it is essential to find alternative to cement. Fly ash is a byproduct of coal obtained from thermal power plant. It is also rich in silica and alumina. Fly ash is used to produce a geo polymer concrete. Geopolymer concrete is totally cement free concrete. In geo polymer, fly ash act as binder and alkaline solution act as an activator. Fly ash and alkaline activator undergo geo polymerization process to produce alumino silicate gel. Alkaline solution used for present study is combination of sodium hydroxide (NaOH) and sodium silicate (Na₂Sio₃) with ratio 2.5.*

***Key Words*: Geo Polymer concrete, Fly Ash, Aggregates, Alkaline Liquid, water**.

1. INTRODUCTION

In the authors' experimental work, geo polymers is used as binder, instead of cement paste, to produce concrete. The geo polymers paste binds the loose coarse aggregates, fine aggregates and other un reacted materials together to form the geo polymers concrete. The manufacture of geo polymers concrete is carried out using the usual concrete technology methods. As in the Portland cement concrete, the aggregates occupy the largest volume, i.e. about 75-80 % by mass, in geo polymers concrete. The silicon and the aluminum in the fly ash are activated by a combination of sodium hydroxide and sodium silicate solutions to form the geo polymers paste that binds the aggregates and other un-reacted materials.

Geopolymer concrete—an innovative material that is characterized by long chains or networks of inorganic molecules—is a potential alternative to conventional Portland cement concrete for use in transportation infrastructure construction. It relies on minimally processed natural materials or industrial by products to significantly reduce its carbon footprint, while also being very resistant to many of the durability issues that can plague conventional concrete. However, the development of this material is still in its infancy, and a number of advancements are still needed. This Tech Brief briefly describes geo polymer concrete materials and explores some of their strengths, weaknesses, and potential applications.

1.1 Importance Of Current Research

Despite the fact that concrete is a extensively used construction material, it causes green house gases and create global warming. Hence in place of cement we are using Fly Ash as a binder.

2. MATERIAL

Fly Ash:- Fly Ash (Class F) collected from the thermal plant, having specific gravity2.2.

S. No.	Elemental oxides	Percentaage
1	SiO_2	53.14
2	Al_2O_3	25.88
3	Fe_2O_3	3.14
4	TiO_2	1.51
5	CaO	0.34
6	MgO	1.13
7	NaO_2	1.19
8	K_2O	1.22
9	SO_3	0.53
10	P_2O_5	1.65

Table1:- Elements of Fly Ash

Fly Ash

Fine Aggregate:- Sand Conforming to zone of IS 383:1970

Physical Properties	Test Result
Zone of Fine aggregate	Zone-II
Specific gravity	2.66
% of moisture	0.8%
Fineness modulus	2.95
Source	Narmada River
Physical Properties	Test Result
Zone of Fine aggregate	Zone-II
Specific gravity	2.66
% of moisture	0.8%
Fineness modulus	2.95
Source	Narmada River

Table 2:- Properties of sand

Sand

Coarse Aggregate:- Crushed granite metal confirming to IS: 383-1970 having:-

Physical Properties	Test Result
Specific gravity(10&20mm)	2.86
% of moisture	0.3%
Fineness modulus(10&20mm)	6.12&7.05
Source	Jabalpur

Water: Clean tap water was used for washing aggregates, and mixing and curing of concretes.

Alkaline Liquids:- The alkaline liquids are from soluble alkali metals that are usually sodium or potassium based. The most common alkaline liquid used in geo polymerisation is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate. The type of alkaline liquid plays an important role in the polymerization process. Reactions occur at a high rate when the alkaline liquid contains soluble silicate, either sodium or potassium silicate, compared to the use of only alkaline hydroxides.

3. METHODOLOGY

The objective of the present investigation is, to study the performance characteristics of the source materials 1) Study & evaluation of chemical composition & effects of NaOH& sodium silicate on fly ash. 2) Study of polymerization process in Fly ash, NaOH& sodium silicate of the composition that is geo polymers. 3) Testing of geo polymers by using universal testing machine. 4) Analysis of geo polymers testing & comparison.

4. MIX DESIGN FOR M30 GRADE

Method Based on the mix design steps discussed in preceding section, a sample mix proportioning for M30 grade of geo polymer concrete is carried out using proposed method. Following preliminary data is considered for the mix design:

1. Characteristic compressive strength of Geopolymer Concrete (fck) = 30 MPa.

2. Type of curing: Oven curing at 60 °C for 24 h and tested after 7 days 3. Workability in terms of flow: 25–50 % (Degree of workability—Medium)

4. Fly ash: Fineness in terms of specific surface: 430 m2 /kg

5. Alkaline activators (Na2SiO3 and NaOH) (a) Concentration of Sodium hydroxide in terms of molarity: 13 M (b) Concentration of Sodium silicate solution: 50.32 % solid content

6. Solution-to-fly ash ratio by mass: 0.35

7. Sodium silicate-to-sodium hydroxide ratio by mass: 1.0 8. Fine aggregate (a) Type: Natural river sand confirming to grading zone-I as per IS 383 [20], F.M. = 3.35 (b) Water absorption: 3.67 % (c) Water content: Nil

9. Coarse aggregate (a) Type: Crushed/angular (b) Maximum size: 20 mm (c) Water absorption: 0.89 % (d) Moisture content: Nil.

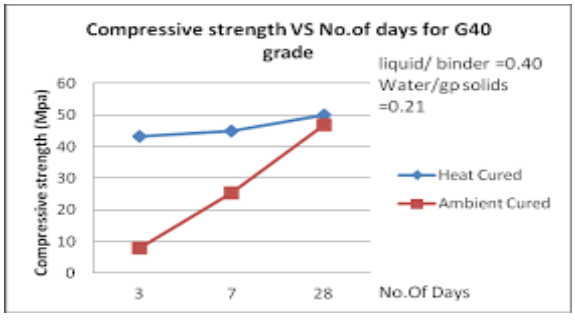
5. RESULT:-

Geopolymer concrete mix is prepared using mix proportion calculated in preceding section. It was found that the fresh fly ash-based geopolymer concrete was viscous, cohesive and dark in colour and glassy appearance. After making the homogeneous mix, workability of fresh geopolymer concrete was measured by flow table apparatus as per IS 5512-1983 and IS 1727-1967. Freshly mixed geopolymer concrete is viscous in nature and water comes out during polymerization process, methods like slump cone test is not suitable to measure workability as concrete subside for long time while in compaction factor test, concrete cannot flow freely. So, flow table test is recommended for workability measurement of Mix Design of Fly Ash Based Geopolymer Concrete

Observation	Data considered in mix design	Results obtained
Workability (flow)	25–50 %	44.15 %
% Degree of workability	Medium	Medium
Temperature/duration	60 °C/24 h	60 °C/24 h
Mass density	2,528 kg/m3	2,601.48 kg/m
Compressive strength @ 7 days after heating	38.25 MPa (target strength)	37.22 MPa

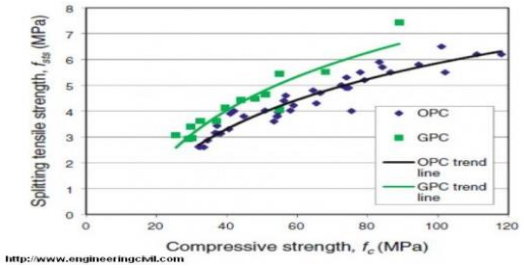
Compressive strength test:-

The compressive strength of concrete is one of the most important and useful properties of concrete. In most structural application concrete is implied primarily to resist compressive stress. In this experimental investigation, only geopolymers concrete cubes are used for testing compressive strength.



Split Tensile Strength:-

The split tensile test were conducted as per IS 5816:1999. The size of cylinder is 300mm length with 150mm diameter. The specimen were kept in water for curing for 7 days and 28 days and on removal were tested in wet condition by wiping water and grit present on the surface. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder along the vertical diameter.



Flexural Strength:-

The Flexural test were conducted as per IS 516:1959. The size of beam is 150mm*150mm*700mm. The specimen were kept in water for curing for 28 days and on removal were tested in wet condition by wiping water and grit present on the surface. The test is carried out by placing a Beam specimen horizontally such that the load shall be divided equally between the two loading rollers, and all rollers shall be mounted in such a manner that the load is applied axially and without subjecting the specimen to any torsional stressesor restraints.

6. CONCLUSION

This paper proposed the guidelines for the design of fly ash based geo polymer concrete of ordinary and standard grade on the basis of quantity and fineness of fly ash, quantity of water and grading of fine aggregate by maintaining water to-geo polymer binder ratio of 0.35, solution-to-fly ash ratio of 0.35, and sodium silicate-to-sodium hydroxide ratio of 1 with concentration of sodium hydroxide as 13 M. Heat curing was done at 60 °C for duration of 24 h and tested after 7 days after oven heating. Experimental results of M20, M25, M30, M35 and M40 grades of geo polymer concrete mixes using proposed method of mix design shows promising results of workability and compressive strength. So, these guidelines help in design of fly ash based geo polymer concrete of Ordinary and Standard Grades as mentioned in IS 456: 2000.

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REFERENCES

1. Davidovits J (1995) Global warming impact on the cement and aggregate industries. World Res Rev 6(2):263–278

2. Hardjito D, Wallah SE, Sumjouw DMJ, Rangan BV (2004) On the development of fly ash based geopolymer concrete. ACI Mater J 101:467–472

3. Mullick AK (2005) Use of fly ash in structural concrete: part I—why? Indian Conc J 79:13–22

4. Kumar V, Mathur M, Sinha SS, Dhatrak S (2005) FlyAsh: an environmental savior. Fly Ash Utilisation Programme (FAUP), TIFAC, DST, Fly Ash India, New Delhi, IV, pp 1.1–1.4

5. Malhotra VM, Ramezanianpour AA (1994) Fly Ash in concrete. Canada Centre for Mineral and Energy Technology (CANMET), Canada

6. Malhotra VM (1999) Making concrete greener with fly ash. ACI Conc Int 21(5):61–66

7. Davidovits J (1991) Geopolymers: inorganic polymeric new materials. J Therm Anal 37:1633–1656

8. Davidovits J (1994) Geopolymers: man-made geosynthesis and the resulting development of very early high strength cement. J Mater Edu 16(2, 3):91–139

9. Davidovits J (1988) Geopolymer chemistry and properties. In: Proceedings of 1st European conference on soft mineralurgy. Geopolymere, vol 88, France, pp 25–48

10. Rangan BV (2008) Mix design and production of fly ash based geopolymer concrete. Indian Concr J 82:7–15
11. Anuradha R, Sreevidya V, Venkatasubramani R, Rangan BV (2012) Modified guidelines for geopolymer concrete mix design using Indian standard. Asian J Civ Eng (Build Hous) 13 (3):353–364

12. Patankar SV, Jamkar SS, Ghugal YM (2012) Effect of sodium hydroxide on flow and strength of fly ash based geopolymer mortar. J Struct Eng 39(1):7–12

13. Jamkar SS, Ghugal YM, Patankar SV (2013) Effect of fineness of fly ash on flow and compressive strength of geopolymer concrete. Indian Concr J 87(4):57–61

14. Patankar SV, Jamkar SS, Ghugal YM (2014) Selection of suitable quantity of water, degree and duration of heat curing for geopolymer concrete production. In: Proceedings of 3rd international conference on recent trends in engineering and technology, ICRTET'2014. Supported by Elsevier

15. Patankar SV, Jamkar SS, Ghugal YM (2014) Effect of grading of fine aggregate on Flow and compressive strength of geopolymer concrete. In: UKEIRI concrete congress-innovations in concrete, pp 1163–1172

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