GEOPOLYMER CONCRETE WITH BINARY COMPOSITION IN AMBIENT CURING

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ABSTRACT

Geopolymer concrete is a type of concrete that is made by using industrial waste products such as fly ash along with an alkaline activator solution. This results in a concrete that has similar properties to traditional Portland cement concrete, but with a lower carbon footprint and higher durability. In ambient curing, the geopolymer concrete is cured at room temperature, without the need for any additional heating or curing equipment. This makes it a more cost-effective and environmentally-friendly option than traditional concrete. Binary composition refers to a geopolymer concrete mix that contains two types of waste materials as precursors, such as a combination of fly ash and slag. By using a binary composition, the properties of the resulting geopolymer concrete can be tailored to suit specific application requirements, such as strength, durability, and workability.Geopolymer concrete helps in reducing carbon footprints along with excellent engineering properties. It happens because it replaces Ordinary Portland cement which is responsible for huge carbon emission along with it also helps with the problem of handling industrial waste like Fly ash by consuming it in Geopolymer Concrete. Now a day's Geopolymer concrete becomes a popular construction material due to these positive aspects.

Most of the previous works on fly ash-based geopolymer concrete reveals that hardening is due to heat curing, which is considered as a limitation to cast in situ applications at low ambient temperatures. This study aimed to achieve geopolymer concrete suitable for curing at ambient temperature. was added in mix to enhance the early-age properties of concrete. Setting times of geopolymer concrete, workability of fresh concrete and compressive strength after curing at 25-35ºC are investigated.

Keyword - *Keywords—Geopolymerisation, OPC Free Concrete, Binder and Activator,Reduction in Carbon footprint, Utilisation of Industrial waste like Flyash.*

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1. Introduction

As Concrete is the second most consuming fluid after water in the world, It is used as a construction material because of their many benefits like easily available, more durable, comparatively cheaper etc. Among all constituents of concrete ordinary Portland cement (OPC) is the main ingredient which binds the aggregates together. However, the manufacturing of OPC requires huge energy which is generating by burning of fuels and it is responsible for almost 5% of CO_2 emission in the world environment, which is the main cause of global warming. In another estimate it was found that the production of one tone of OPC releases approximately one tone of carbon dioxide to the atmosphere Due to an increase in global population and urbanization the increasing use of concrete in construction is unavoidable in near future. This geopolymer technique leads us to the new generation concrete or binding construction material which has potential to replace OPC partially or completely.

The polymerisation process is a chemical reaction between alumina-silicate materials and alkaline solutions under elevated curing temperatures. It was found that the production of geopolymer based binding material requires approximately 60% less energy and it leads to 80% less CO2 emissions compared to the manufacture of OPC. So far, huge research work has been done on geopolymer binders and its applications worldwide to promote geopolymer as a sustainable and durable construction material for the future. Geopolymer are binders that exhibit good physical and chemical properties, and have a wide range of potential applications.

2. Test Specimen

2.1 Material Used

- Fly-Ash: The Fly ash use is a locally available It was classified as class F according to ASTM C618-12a, (SiO2 + Al2O3 + Fe2O3 = 89.15% > 70% and CaO < 10%), also having average particle size of 6.92 microns and specific gravity of 2.288.
- Activating Solution: The activating alkali solution consisted of Na2SiO3 and NaOH solutions. Both the chemicals has been used is made by Gandhi chemical company, Pune.

  The composition of Na2SiO3 is (wt.%) Na2O = 14.7, SiO2 = 29.4 and water = 55.9. The other characteristics of Na2SiO3 solution are: specific gravity = 1.53 g/cc, viscosity at 20^0 C = 400 cp and molecular weight of Sodium silicate is 122.06.

  The NaOH solution is prepared from analytical grade NaOH pellet having purity of 99.95% and Molecular weight 475.73, it can be easily soluble in water to make their solution. Although it can be easily used in elevated temperature condition because its melting point is 318^0C (lit.). The 3 M Solution of Sodium Hydroxide in made one day prior to the day of mixing by using tap water.
- Fine Aggregates: Crushed sand having Specific Gravity 2.32gm/cc and Fineness Modulus as 4.212 has been used.
- Coarse Aggregate: Crushed stone aggregate of 20 mm size, having Specific Gravity 2.59gm/cc and Fineness Modulus as 6.45 has been used.

3. Mix Proportion and Basic Investigation.

Throughout hand mixing over a tray was done. Coarse aggregate with the percent replacement of recycled aggregate were put in the tray first Exposed surface was finished with trowel to avoid uneven surface. The Standard Consistency Test has been performed and the liquid to binder ratio in find out as (0.40), According to that we use this ratio as it is for Initial and final setting time test of various binding material individually with different Sodium silicate to sodium hydroxide ratio.

Table -1: Initial Setting and Final Time (In Minutes)

Sodium silicate/Sodium Hydroxide ratio	FLYASH		MICRO SILICA	
	IST	FST	IST	FST
0.8	90	235	45	55
1.0	75	190	35	50
1.2	60	108	25	31

The Compressive test is also need to perform for investigating the strength of the binding materials individually at various sodium silicate to sodium hydroxide ratio (SS/SH) which helps us to take decision for finalizing (SS/SH) for final mix design test to obtain a best suitable mix for geopolymer concrete. We are going to use the liquid to binder ratio as (0.53) by using IS method where, ratio=p + (p/4+3) %. The mortar is prepares by using binder to IS sand ratio 1:3 and IS sand is prepared by using equal amount if Grade I, Grade II & Grade III of sand respectively. The cube of (7.07x7.07x7.07) mm has been used for this test and the results have been investigated on 7^{th}, 14^{th}, and 28^{th} day from casting. Immediately on next day of casting the casted cubes in removed from molds and kept it for ambient curing at a place of controlled temperature, the temperature is maintained in between 22^{o}C-35^{o}C.

Table -2: COMPRESSIVE STRENGTH TEST (N/MM2)

Sodium silicate/Sodium Hydroxide ratio	FLYASH			MICRO SILICA		
	7 days	14 days	28 days	7 days	14 days	28 days
0.8	1.20	16.70	27.60	2.40	4.90	6.61
1.0	3.78	23.80	41.30	6.40	9.57	14.70
1.2	3.40	27.60	37.52	7.94	8.32	13.10

This results of Setting time and Compressive strength of mortar is observed and we come to a conclusion that the (SS/SH) ratio of 1.2 gives best results all round.

4. Testing –

The final procedure to investigate the best suited mix for geopolymer concrete will be finalized according to the results we get. We are going to test three mixes M1, M2, M3. Cubes as casted of size 150 x 150 x 150mm were tested using Compression testing machine (CTM) of capacity 2000 kN, capable of giving load at the rate of 140 kg/sq.cm/min. Testing of the cubes was done at the age of 7^{th} and 28^{th} day.

The wet cubes were placed in the machine between wiped and cleaned loading surfaces and load is given approximately at the rate of 140 kg/sq.cm/min. and ultimate crushing load is noted to calculate crushing strength of concrete according to IS: 516-1959.

The measuring strength of specimen is calculated by dividing the maximum load applied to the specimen during the test by the cross section area.

5. Results –

Table - 3: Compressive Strength Test we get for M30 (N/MM2)

Sample Name	Percentage of total binder		Activator/ Admixture(Kg/m3)		Aggregate (Kg/m3)		Weight of a test cube (Kg)	Strength of a test cube (N/mm^2)	
	Fly ash	Micro Silica	NaOH 10M	Na2SiO3	*Fine*	*Coarse*		7 days	28 days
M1	80	20	80	120	1178	3354	6.64	19.86	34.76
M2	80	20	80	120	1178	3354	5.92	20.64	36.21
M3	80	20	80	120	1178	3354	5.87	20.84	28.49

Table – 4 : Compressive Strength Test Average (N/MM2)

Percentage Variation (%)	Curing Age	
	7 Days	*28 Days*
0	21.76 N/mm^2	32.43 N/mm^2

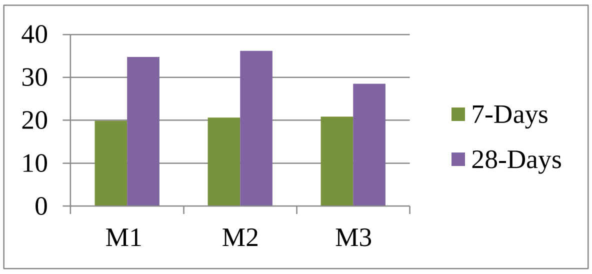

Chart -1 : Graphical Representation of Compressive Strength of Geopolymer concrete

From the results obtained, it was observed that the development of compressive strength of Geopolymer concrete is satisfactory in compare to conventional concrete. Apart from that it also exhibits better performance in workability.

The Table-1 shows the setting time of geopolymer binder where we come to know that use of micro silica reduces the setting time in opposite fly ash have very high setting time, this indicates that we can use the base material in various proportions according to our requirement. Table-3, indicates that the best test result for compressive strength is Mix Design no. 3, which consist 80% Fly ash, and 20% Micro silica, of total binder.

6. Advantages of Geopolymer

- Reduced environmental impact: By using industrial waste products as precursors, the amount of greenhouse gases emitted during the production of geopolymer concrete is significantly lower than that of traditional Portland cement concrete.
- Increased durability: Geopolymer concrete has been found to have better durability than traditional concrete, which means it can withstand harsh environmental conditions and last longer.
- Lower cost: The use of industrial waste products as precursors can significantly reduce the cost of geopolymer concrete compared to traditional concrete.
- Versatility: By using a binary composition, the properties of the geopolymer concrete can be tailored to suit specific applications, making it a versatile and customizable building material.

7. Conclusion-

From the experimental work carried out the following conclusion can be drawn:

- The geopolymer concrete gives satisfactory results to being used as an alternative of OPC concrete.
- It has been proved that we can use geopolymer concrete in ambient curing conditions.
- We can use binary or Tartary composition to obtain required results.

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