Study on Strength of Concrete Using Geopolymers

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Abstract- *OPC production is the second only to the automobile as the major generator of carbon dioxide, which polluted the atmosphere. In addition to that large amount energy was also consumed for the cement production. Hence, it is inevitable to fine an alternative material to the existing most expensive, most resource consuming Portland cement. Geopolymer concrete is an innovative construction material which shall be produced by the chemical action of inorganic molecules.*

Fly ash, a byproduct of coal obtained from the thermal power plant is plenty available worldwide. Fly ash is rich in silica and alumina reacted with alkaline solution produced alumina silicate gel that acted as the binding material for the concrete. It is an excellent alternative construction material to the existing plain cement concrete. Geopolymer concrete shall be produced without using any amount of Ordinary Portland Cement. This work briefly reviews the constituents of geopolymer concrete, its strength and potential applications.

Keywords- Geopolymer, Fly ash, , compressive strength, Concrete

I. INTRODUCTION

Concrete is the world’s most versatile most used material, which required large quantities of Portland cement. Ordinary Portland cement (OPC) production is the second only to the automobile as the major generator of carbon di oxide, which polluted the atmosphere. In addition to that large amount energy was also consumed for the cement production. Hence, it is inevitable to find an alternative material to the existing most expensive, most resource consuming Portland cement.

On the other hand, the abundant availability of fly ash worldwide creates opportunity to utilize this by-product of burning coal, as a substitute for OPC to manufacture concrete. When used as a partial replacement of OPC, in the presence of water and in ambient temperature, fly ash reacts with the calcium hydroxide during the hydration process of OPC to form the calcium silicate hydrate (C-S-H) gel. The development and application of high volume fly ash concrete, which enabled the replacement of OPC up to mass is a significant development.

The various objectives expected from this work are as follows

1. Understand what a geopolymer is through publically & privately accessible literature. The history of geopolymers, where they were first used, who pioneered their use in concrete, their significance & the comparative advantage of geopolymer concretes to ordinary concrete.
2. To investigate chemical Resistance properties of Ordinary Portland cement & Geopolymer concrete. Cast 20 Ordinary Portland cement, 20 Geopolymer concrete samples. Each type of concrete will be tested at 7, 14 & 28 days compressive strength of 3 to 4 samples will, be tested.
3. To compare the compressive strength & ordinary Portland cement concrete after exposure to the carbonation process.

II. EXPERIMENTAL WORKS

A. General

The suitability of fly ash in fly ash based geopolymer concrete as fully replacement of cement by fly ash is tested through different experimentation. In this experiment the cement is totally replaced by fly ash. Geopolymer used is mixture of sodium hydroxide and sodium silicate. Sodium hydroxide is in different molarities proportions 8M and 10M, the mix design is done as per BIS 10262:1982,

BIS 10262:2009 for M20 grade of fly ash based geopolymer concrete as per BIS 383-1970, the quantities of ingredients and the ration of sodium hydroxide to sodium silicate have been estimated and accordingly concrete cubes as per standard procedure are prepared, tested and the results are obtained and analyzed.

B. Geopolymer Materials

1. Sodium Silicate

Sodium silicate is available in liquid form. It is commercially available in the market.

2. Sodium Hydroxide

Sodium hydroxide is available in the local market in a solid state by means of pellets and flakes. The cost is varied according to the purity of the pellet substances. Sodium hydroxide pellets with 97% purity were used for preparation of geopolymer solution. Sodium hydroxide solution was prepared by dissolving sodium hydroxide pellets in pure water at the rate of various molar concentrations. It is strongly recommended that the sodium hydroxide solution must be prepared 24 hours prior to use with mixing alkaline liquid. So the prepared solution should be
used within this time.

The sodium hydroxide solution concentration can vary in different molar. The mass of NaOH solids in a solution varies in a various molar concentration of the solution. For instance, NaOH solids (in flakes form) per liter of the water, where 40 is molecular weight of NaOH. Similarly, the mass of NaOH solids per kg of the solution for other concentration was measured as 8M: 262grams, 10M: 314grams, Note that the mass of water is the major component in boththe alkaline solutions.

3. Alkaline Liquid

Generally the combination of sodium silicate and sodium hydroxide solution are chosen as the alkaline liquid stored at a room temperature. When the mining solution together the sodium silicate and sodium hydroxide solution start to react it liberates large amount of heat. So it is recommended to leave it for about 24 hours. Thus the alkaline liquid gets ready as preparation of geopolymer concrete.

CONCRETE MIX DESIGN FOR M-20 GRADE OF ORDINARY PORTLAND CEMENT CONCRETE (MIX-1) AS PER IS 10262:1982

The mix proportion for Mix-I become

Water	Cement	Fine Aggregate	Coarse Aggregate
186	372kg	592kg	1213kg
0.50	1	1.591	3.26

CONCRETE MIX DESIGN FOR M-20 GRADE OF FLY ASH BASED GEOPOLYMER CONCRETE (MIX-II, MIX-III) AS PER IS 10262:2009

Table : - Actual Quantities of Materials Required for Different Proportions

No.	Proportions	Fly ash Kg/m^3	Fine Aggregate Kg/m^3	Coarse Aggregate Kg/m^3	NaOH Solution Kg/m^3	$Na2Sio^3$ Kg/m^3
1	Mix-II	400	580.14	1354.92	64(8M)	164
2	Mix-III	400	580.14	1354.92	64(10M)	164

Test of compressive strength of concrete cubes

The concrete cubes of size 150 x 150 x 150mm 12 numbers for each proportions are prepared as per BIS 10262-2009 procedure and tested in compressive testing machine. The quantities of materials estimated for one meter cube are tabulated in table of the results of compressive strength test after 3, 7, 21 and 28 days curing. Adding of geopolymer in dry concrete is shown in photo.3 and testing of cubes are shown in photo.4

Experiment For Mix-I

Experiment with cement, sand and coarse aggregate is done. The cubes of M20 grade concrete are made as per (BIS 10262-2009) mix design of concrete. The variation in density and compressive strength of concrete are shown in Table.1

Experiment for Mix-II

Experiment with fly ash based geopolymer, sand and aggregate is done. The cubes of M20 grade concrete with 8M are made as per (BIS 10262-2009) mix design of concrete. The compressive strength of concrete are shown in Table.2

Experiment For Mix-III

Experiment with fly ash based geopolymer, sand and aggregate is done. The cubes of M20 grade concrete with 10M are made as per (BIS 10262-2009) mix design of concrete. The compressive strength of concrete are shown in Table.

RESULT- The compressive strength of ordinary Portland cement concrete is less as compare with fly ash based geopolymer concrete. It is increases with increase molarities in an alkaline solution

Table1 : - Compressive Strength of Concrete (Mix-I)

	Specimen	Compressive Strength (MPa)	Average Compressive Strength (MPa)
3 Days	Sample 1	11.11	9.92
	Sample 2	9.33	
	Sample 3	9.33	
7 Days	Sample 1	15.55	16.14
	Sample 2	15.11	
	Sample 3	17.77	
21 Days	Sample 1	20.44	21.48
	Sample 2	22.22	
	Sample 3	21.77	
28 Days	Sample 1	22.67	22.67
	Sample 2	2311	
	Sample 3	22.22	

Table 2: - Compressive Strength of Concrete (Mix-II)

	Specimen	Compressive Strength (MPa)	Average Compressive Strength (MPa)
3 Days	Sample 1	8.23	9.05
	Sample 2	9.23	
	Sample 3	9.68	
7 Days	Sample 1	12.33	12.42
	Sample 2	12.60	
	Sample 3	12.33	
21 Days	Sample 1	17.20	17.50
	Sample 2	17.21	
	Sample 3	18.10	
28 Days	Sample 1	22.80	23.38
	Sample 2	23.67	
	Sample 3	23.67	

Table 3: -Compressive Strength of Concrete for Mix-III (10M) DISCUSSION

	Specimen	Compressive Strength (MPa)	Average Compressive Strength (MPa)
3 Days	Sample 1	12.00	12.14
	Sample 2	12.21	
	Sample 3	12.20	
7 Days	Sample 1	16.32	16.85
	Sample 2	17.00	
	Sample 3	17.22	
21 Days	Sample 1	22.42	22.47
	Sample 2	22.42	
	Sample 3	22.56	
28 Days	Sample 1	26.68	26.82
	Sample 2	25.89	
	Sample 3	27.89	

III. DISCUSSION

A. Environment Impact of Cement Production

Cement is produced in 156 countries across the Globe. During 2008, the global production capacity of cement stood at around 2872 million tones with China accounting for approximately 1400 million tones and India a distant second with total production of 183 million tones. The production of Cement is highly skewed with top ten countries together accounting for close to 70% of total cement production. These countries account for close to 70% of total population. High concentration of cement production may be attributable to high capital costs and long gestation periods in cement industry. As predicted by Scientists, the worldwide requirement of cement, in the recent years, would be around 2.2 billion tones. Also, production of one tone of cement leads to the emission of 0.8 tone of CO2, the prime green house gas which mostly contributes to global warming. This underlines the need for newtechnologies to overcome the environmental issue. In this scenario, the geopolymer Technology has emerged as the viable alternative to ordinary Portland cement, which was vented by Davdovits. On the other hand, the fly ash, the byproduct from coal based thermal power stations, also poses disposable problems requiring large area for its dumping which ultimately leads to environmental hazards. In spite of various technologies developed for fly ash use in concrete, the utilization rate of fly ash in them is still quite low. This increased usage of fly ash would help to reduce disposable problems and total elimination of cement in concrete and would contribute in a minor way, cleaner environment. Davidovits invented that Geopolymers were members of the family of inorganic polymers similar to natural Zeolitic materials, when produced with low Si: Al ratio 2 would be suitable for construction industries.

As in the Portland cement concrete, the aggregates occupy the largest volume, i.e. about 75- 80% by mass, in geopolymer 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 geopolymer paste that binds the aggregates and other un-reacted materials.

B. Fly Ash Based Geopolymer Replacement

It is found by the study that it is possible touse fly ash with total replacement of cement in concrete without compromising on density and strength of concrete. This study opens up a major avenue for utilization of fly ash. The use of fly ash based geopolymer is totally replacement of ordinary Portland cement in concrete gives higher compressive strength than standard concrete.

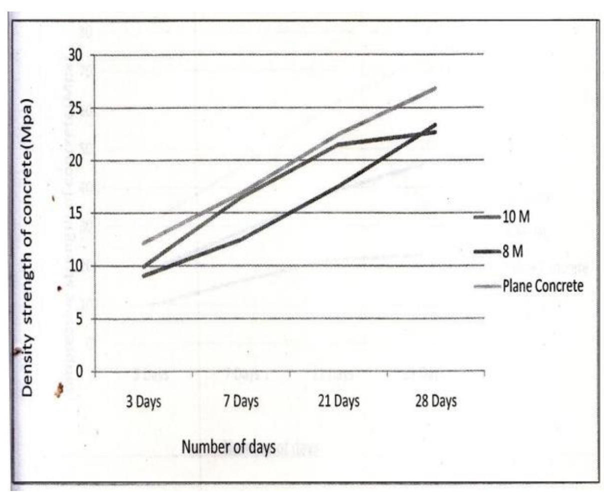

Figure : - Comparison of Compressive Strength Between 8M, 10M & Plane Concrete

IV. CONCLUSION

- Geopolymer concrete has excellent properties within both acid and salt environments comparing to Portland cement, the production of geopolymer have a relative higher strength, excellent vol. stability, better durability.
- The increase in percentage of fine aggregates and coarse aggregates increase the compressive strength upto optimum level. This may be due to high bonding between the aggregates and alkaline solution.
- As the curing temperature in the range of 60º to 90ºC increases, the compressive strength of fly ash based geopolymer concrete also increases.
- With proper design and construction process, Geopolymer concrete can be used in reinforced concrete beams and columns.
- As the cost of geopolymer concrete is less as compare to "OPC", we can use G.C for road embankment construction, college's path way, etc.
- Using geopolymer concrete we can produce more durable infrastructure capable of design life measure in hundred of years.
- It can also protect aquifers and surface bodies of fresh water via the elimination of fly ash from disposal sites.

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