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STUDY OF FLY ASH BASED GEOPOLYMER CONCRETE WITH VARYING ALKALINE ACTIVATOR RATIO

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Abstract - *Concrete is the primary materials used in civil engineering, mostly in structural industries. OPC (*Ordinary Portland Cement) *is mostly used as major binding material to produce concrete, but during preparing its emitted carbon dioxide and energy. The matter of environmental concern in view of global warming.*

In our project low calcium fly ash (FA) based Geopolymer concrete is provided. Geopolymer concrete is innovational concrete based on an inorganic aluminosilicate binder. Has contain alumio-silicate cementitious material in which combination between alkali polysilicates and geopolymeric precursor by polycondensation reaction. In this Geopolymer concrete is used instead of Portland cement, which is obtained from the reaction of fly ash and alkaline solution. This project present the details of studies carried out strength of GPC with constant molarity & alkaline liquid to fly ash ratio as 0.4, but changing ratio alkaline activator (AA) i.e. 0.5, 1.5 & 2.5.the test specimen is 150×150×150 mm cubes prepared and curing conditions. The Geopolymer concrete specimen are tested for their compressive strength at 7& 28 days.

This project aims to introduce new concrete to in construction industry, check the properties of Geopolymer concrete (compressive strength) & reduce environmental effects form CO_2 generation form OPC.

Keyword: **fly ash , molarity, sodium silicate, sodium hydroxide, coarse aggregate, fine aggregate & distilled water.**

1. INTRODUCTION

OPC is a most useable concrete material in construction industry all over the world. Due to the fast urbanization of countries required amount of OPC are increases so, demand for concrete in construction industry also increases. The production of OPC in worldwide emitted greenhouse gases is estimated to be about 7% of the total greenhouse emission to the earth atmosphere contributing greatly to the global warming(11). It is necessary to reduce or replace cement from other cementitious material such as fly ash, GGBS, rise husk ash, etc. Fly ash is made form coal burn in to the boiler of electricity generating power plant. Every year fly ash produce is estimated about 780 million tons in world but out of which only 17-20% are used. In India production are 220 million ton per year and use 35-50% in concrete and stabilization of soil(9). Hence huge amount disposed off in land as waste material.

The word Geopolymer introduced to the world by Joseph davidovits in year 1978. Geopolymer are family of carbon related polymer made from polymerization of origin material and alkaline solution. This project work fly ash use as source material, which contain silica and alumina. Geopolymerization reaction occur in between origin material and AA solution in highly alkaline medium to form three dimensional polymer series with structure of Si-O-Al-O and obtained alumina silicate gel as binder agent for Geopolymer concrete. In which couple many micro molecules into a covalently bonded chain . These small molecule known as oligomers .

This project work contain, the detailed study of Geopolymer concrete by taking constant ratio of AA to FA as 0.4 and sodium hydroxide molarity are 8M but changing ratio alkaline activator.The factors that affect GPC for compressive strength such as molarity of NaOH , fly ash to AA & AA ratio.

1.1 Geopolymer

Geopolymer are inorganic polymer material has an amorphous structure and chemical composition similar to zeolites . According to Davidovits that an alkaline solution mixed with origin material to produce binders.the origion material fly ash, GGBSand rice husk ash . In source material contain more percentage of silicon (Si) and the aluminum (Al).

Classification of Geopolymers Structure include three different inorganic polymers which depend on the ratio of Si/Al in their structures: a) Poly (sialite) (-Si-O-AL-O-) b) Poly (sialate-siloxo) (-Si-O-Al-O-Si-O-) c) Poly (sialate-disiloxo) (-Si-O-Al-O-Si-O-Si-O-).

1.2 Objectives

- To study the compressive strength property of Geopolymer concrete by using FA and varying ratio of AA solution with constant molarity.
- To mitigate the emission of green -house gases & global warming effect by low CO_2 generation as compare to ordinary Portland cement.
- To make a concrete without using cement i.e. Geopolymer concrete.
- It has Good Durability and Acid Resistance Properties.

2. MATERIAL REQUIRED FOR EXPERIMENTAL WORK

2.1 Fly Ash - Fly ash is a fine ash form in boiler of electricity generating thermal power plant using coal as fuel. It is an extremely fine ash formed by combustion of inorganic material such as coal. The ash contain below 10% CaO its low-calcium fly ash (Class F) and the ash typically containing 15% to 30% of CaO it is called high-calcium fly ash (Class C).

Table no.1 Chemical composition of fly ash:

Sr. no	Characteristics	% content (wt.)
1.	Silica	55-65
2.	Iron oxide	5-7
3.	Aluminum oxide	22-25
4.	Calcium oxide	5-7
5.	Magnesium oxide	<1
6.	Titanium oxide	<1
7.	Phosphorus	<1
8.	Sulphate	0.1
9.	Alkali oxide	<1

2.2 Aggregates

Coarse Aggregates

The material retained on 4.75 sieve are called as coarse aggregate .Size of the coarse Aggregate is 40mm, 20mm, 16mm, 12.5mm, and 10mm. methods size obviously total takes 20mm & 12 mm.

Table no.2 Properties of coarse aggregate:

Sr.no	Characteristics	result
1.	Type	Crushed
2.	Specific gravity	2.85
3.	Fineness modulus	
4.	Size	20 mm

Fine Aggregate

The material retained on 4.75 sieve are called as fine aggregate. Fineness modulus of aggregate should be in between 2.6 - 2.8.

Table no .3 properties of fine aggregate

Type	Characteristics	Result
1.	Type	Uncrushed
2.	Specific gravity	2.91
3.	Fineness modulus	2.70
4.	Grading zone	Zone II

2.3 Alkaline Activators

Sodium Hydroxide Solution (NaOH)

A pallets of sodium hydroxide of molarity 8 M was prepared in distilled water and it has 98% purity in pure form are required for used.(1)

Sodium Silicate Solution (Na_2SiO_3)

The sodium silicate solution get in the powder form has contain Na_2O-15%, SiO_2- 32.5% and H_2O- 52.5%content. Required purity up to 97%.

3.4 Distilled Water

Clean Potable water for mixing. The role of water in the Geopolymer mix is to make workable concrete in plastic state and do not contribute towards the strength in hardened state , hence need Clean Potable water for mixing.

3. Methodology

3.1 preparation of alkaline solution

We used 8 molarity of sodium hydroxide solution for study. Preparation of alkaline solution is depend on it molecular weight of NaOH &Na_2SiO_3 are 40 and 282.4 respectively.to preparing 8 M of NaOH, Take 8×40=320 gram of NaOH pallets(9). These weighed pallets are dissolved in 1 liter distilled water. Then prepare sodium silicate solution and mixed both solution. These solutions should be prepared 24 hours before use for Geopolymer concrete in experiment. In this study used 8M constant solution but take different ratio of sodium silicate to sodium hydroxide i.e. (0.5, 1.5, and 2.5).

Figure -1: Preparation of alkaline solution

3.2 Mixing, Casting & Curing of Geopolymer Concrete

Geopolymer concrete manufactured same as conventional technique used for manufacturing OPC. In this process, first mixing of aggregates and fly ash up to 3 minutes it's called dry mixing of aggregate. After get good mixing of dry material add alkaline activator solution. It will be mixed for 5 minutes up to the homogeneous paste was obtained. (6)The addition of AA solution polymerization will take place emitting large amount of heat which mean the GPC must be used for 24 hours applicable.

Figure-2: Mixing of dry aggregate

Casting of Geopolymer concrete cube of size 150 mm ×150mm ×150 mm. concrete poured in mould in 3 different layer ,each layer tamped by 25 blows by tamping rod. Then cube placed in table vibratos for three minutes for well compacting of concrete(10).top surface was leveled by using trowel.

Figure -3: Casting of GPC cube

After 24 hours of casting cube were de molded and Placed in oven curing for 24 hours in 80°c. For each ratio of sodium silicate to sodium hydroxide three cube were cast. The oven curing required for activation of Geopolymer in GPC cube. It will provided heating medium to the GPC specimen . Curing temperature and curing time affected the compressive strength of GPC(3).

Figure- 4: Oven Curing for GPC cube

3.3 Mix design of Geopolymer concrete

Table 4: mix design of Geopolymer concrete keeping fly ash to alkaline activator ratio constant 0.4 (kg/m^3).(7)

Material	Sample 1	Sample 2	Sample 3
Fly ash	394.3	394.3	394.3
Coarse aggregate	1201.2	1201.2	1201.2
Fine aggregate	648.8	648.8	648.8
NaOH Conc.	104.8(8M)	62.884(8M)	45.04(8M)
Na_2SiO_3	52.41	94.326	112.64
Mix proportion Ratio	1:1.64:3.04	1:1.64:3.04	1:1.64:3.04
Ratio of alkaline activator	0.5	1.5	2.5
Heat cured specimen @ 80°c for 24 hours			

4. Results and discussion

4.1 compressive strength

The compression test on Geopolymer concrete is carried out in accordance with IS 516-1999 standards. The test conducted on concrete cube of size 150×150×150 mm under compression testing machine. The load applied at Centre of cube, load applied gradually till the specimen fail.

Figure -5: Compression test on concrete cube

Table 5: compressive strength of specimen for 0.5 ratio

Ratio of alkaline activators	Number of Day's	Compressive strength (N/mm^2)
0.5	`7	14.9
	28	15.75

Table 6: compressive strength of specimen for 1.5 ratio

Ratio of alkaline activators	Number of Day's	Compressive strength (N/mm^2)
1.5	`7	19.4
	28	21.6

Table 7: compressive strength of specimen for 2.5 ratio

Ratio of alkaline activators	Number of Day's	Average Compressive strength (N/mm²)
2.5	`7	27.3
	28	30.2

5. CONCLUSION

- When the ratio of Na2SiO3/NaOH increased (e.g.0.5, 1.5 and 2.5) then the strength of concrete also increase and maximum strength gain for 2.5 ratio.
- The Geopolymer concrete higher compressive strength can be gain in initial 24 hours.
- The fly ash content is below 500 gram , hence rate of gain of strength is decreases because percentage of SiO_2 is less.
- The fly ash can be used to produce the Geopolymer binder phase which can be bind the aggregate to form GPC. Therefore these concrete can be considered as ecofriendly materials.
- When ratio of AA solution increases, the workability also increase.

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