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Study on Geo Polymer Concrete

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ABSTRACT
This paper presents the progress of the research on making Geopolymer concrete using the Thermal Power Plant fly ash, Hyderabad, India. The project aims at making and studying the different properties of Geopolymer concrete using this fly ash and the other ingredients locally available in Hyderabad. Potassium Hydroxide and sodium Hydroxide solution were used as alkali activators in different mix proportions. The actual compressive strength of the concrete depends on various parameters such as the ratio of the activator solution to fly ash, morality of the alkaline solution, ratio of the activator chemicals, curing temperature etc. In recent years, Concrete usage around the world is second only to water. Ordinary Portland cement (OPC) is conventionally used as the primary binder to produce concrete. The amount of the carbon dioxide released during the manufacture of OPC due to the calcinations of limestone and combustion of fossil fuel is in the order of one ton for every ton of OPC produced. In addition, the extent of energy required to produce OPC is only next to steel and aluminum. Attempts to reduce the use of Portland cement in concrete are receiving much attention due to environment-related. Fly ash-based Geopolymer concrete is a `new' material that does not need the presence of Portland cement as a binder. The role of Portland cement is replaced by low calcium fly ash. Geopolymer is an inorganic alumina- Hydroxide polymer synthesized from predominantly silicon (Si) and aluminum (Al) materials of geological origin or byproduct materials such as fly ash. The term Geopolymer was introduced to represent the mineral polymers resulting from geochemistry. The process involves a chemical reaction under highly alkaline conditions on Si-Al minerals, yielding polymeric Si-O-Al-O bonds in amorphous form.

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I. INTRODUCTION

Concrete is the world's most versatile, durable and reliable construction material. Large quantities of Portland cement are required for concrete. The consumption of Ordinary Portland Cement (OPC) causes pollution to the environment due to the emission of CO2. Geo polymer concrete was introduced to reduce environmental pollution that causes by production of Portland cement.

II. REVIEW OF LITERATURE

General

There is a wide range of research undergoing for the use of Geo-polymer Concrete. For our investigation, some important publications were reviewed to have a broad idea about Geo-polymer Concrete and they have been listed in the references at the end of the report.

III. Literature Review

Fly ash is considered to be advantageous due to its high reactivity that comes from its finer particle size than slag. The suitability of various types of fly ash to be geo polymer source material has been studied by Fernandez-Jimenez and Palomo (2003). The alkaline liquids are from soluble alkali metals that are usually sodium or potassium based. Palomo et al (1999) have reported the study of fly ash-based geo polymers.A combination of sodium hydroxide with sodium silicate was used in the study and the results showed that alkaline liquid is a main factor affecting the mechanical strength and the combination of sodium hydroxide with sodium silicate produced high compressive strength. Ammar Motorwala et al (2013) have conducted an experimental study that involves the observation of structural behaviour of fresh fly ash-based geo-polymer concrete.The main objective of this study was to find the effect of varied concentrations of alkaline solutions on the strength characteristics of the concrete. The test conducted, yielded certain important findings such as increase in the compressive strength with increase in the molarity. Curing under normal sunlight yielded strength of 16 N/mm2 and curing when done by wrapping with plastic bag showed better compressive strength as it preserves the moisture. In the rate analysis carried, fly ash-based concrete is more expensive than cement concrete and hence not economical. Geopolymer concrete is sure to play major role in construction industry.

Song et al (2005) have carried out an experimental study and has revealed many facts about the resistance of geopolymer concrete to sulphate and chloride attack. It has been found that, after being exposed to sulphuric acid solution, fly ash based geopolymer concrete was structurally inert except development of some fine cracks on the surface whereas OPC concrete shows sign of severe damage.Olivia et al (2008) have investigated on the water penetrability of low calcium fly ash geo polymer concrete. The conclusion drawn is that fly ash geo polymer concrete exhibits low water absorption and sorptivity. Low water/binder ratio and a better grading are recommended in order to reduce the capillary porosity and the overall porosity of geo polymer concrete. Anurag Mishra et al (2008) have carried out an experimental study on the effect of concentration of alkaline liquid and curing time on strength and water 15 absorption of geo polymer concrete. XiaoluGuo ,Hushing Shi , Warren A. Dick(2009) they studied the compressive strength and micro structural characteristics of a class C fly ash geopolymer (CFAG) were studied. They concluded that a high compressive strength was obtained when the class C fly ash (CFA) was activated by the mixed alkali activator (sodium hydroxide and sodium silicate solution) with the optimum modulus viz., molar ratio of SiO_2/Na_2O of 1.5. When CFA is alkali activated the sphere seems to be attacked and broken due to the dissolution of alumina-silicate in the high pH alkali solution. Utilization of this fly ash in geo-polymer materials is a resource and energy saving process and it also indirectly reduces the emission of greenhouse gas CO_2 released from cement manufacturing. This is beneficial for resource conservation and environmental protection. Smith Songpiriyakij, Teinsak Kubprasit, Chai Jaturapitakkul, Prinya Chindaprasirt (2010) they used Rice husk and bark ash as a source to partially replace.

Objective

Our aim is to have an alternative binder instead of Cement in Concrete. The reason is during the production of cement, higher amounts of Carbon dioxide is released into atmosphere and causes global warming. In this respect Geopolymer concrete is produced by replacing cement with Geopolymer binder which consists of Flyash and alkaline liquids and also fine aggregate is replaced with quarry dust because it is most economical than fine aggregate.

IV. METHODOLOGY

Mix design of G40:

- Assume density of aggregate as unit weight of concrete = 2400 kg/m3
- Mass of combined aggregate = 75-80% (assume 0.77%)

= 2400 x 0.77%

=1848 kg/m3

Now, mass of combined aggregate = 1848 kg/m3

Mass of fly ash and alkaline liquid = 2400 – 1848

=552 kg/m3

- Let us take alkaline liquid to fly ash ratio 0.4
- Now mass of fly ash = (552/1=0.4) = 394.28 kg/m3
- Mass of alkaline liquid = 552-394.28 = 157.21 kg/m3
- Let us consider the ratio of sodium hydroxide to sodium silicate as 2.5
- Now mass of sodium hydroxide solution

= (157.21)/ (1+2.5) = 45.06 kg/m3

- Mass of sodium silicate solution = 157.21 – 45.06

=112.64 kg/m3

Now calculating the total amount of mass of water and mass of solids in the sodium hydroxide and sodium silicate solution.

Sodium hydroxide NaOH:

Considering 16M concentration, where in the solution consists of 44.4% of solids (pellets or flakes) and 63.5% of water.

Mass of solids = 44.4/100 x 45.6= 20.00kg Mass of water = 45.06 – 20.00= 25.06

Now calculating the total amount of mass of water and mass of solids in the sodium hydroxide and sodium silicate solution.

Sodium hydroxide NaOH:

Considering 16M concentration, where in the solution consists of 44.4% of solids (pellets or flakes) and 63.5% of water.

Mass of solids = 44.4/100 x 45.6= 20.00kg

Mass of water = 45.06 – 20.00= 25.06

Sodium silicate Na2sio3:
The water content in the silicate solution in observed as 63.5%. So the mass of water = 63.5/100 x 112.64 = 71.52 kg.
Mass of solids = 112.64 – 71.52 = 41.11 kg

Total Mass of Water:
Mass of water in sodium hydroxide + mass of water in sodium silicate solution

= 25.60 + 71.52= 96.58 kg.

Total Mass of Solids:
Mass of solids in sodium hydroxide solution + Mass of solids in sodium silicate solution
+ mass of fly ash= 20.00 + 41.11 + 394.28 = 455.39 kg

Ratio of water to geo polymer solids ratio= 96.58/455.39 = 0.21.

Preparation of alkaline liquid:
NOTE: Molarity = moles of solute/liter of solution

In this project the compressive strength of geo-polymer concrete is examined for the mixes of varying molarities of Sodium hydroxide (8M, 10M, and 12M). The molecular weight of sodium hydroxide is 40. To prepare 8M i.e. 8 molar sodium hydroxide solution, 320g of sodium hydroxide flakes are weighed and they can be dissolved in distilled water to form 1 liter solution. For this, volumetric flask of 1 liter capacity is taken, sodium hydroxide flakes are added slowly to distilled water to prepare 1liter solution. The weights to be added to get required molarity are given in Table.3.

Table.3.2 Weights of NaOH flakes

Required Molarity	Weight in g. of Sodium hydroxide flakes
8M	320
10M	400
12M	480

The sodium silicate solution and the sodium hydroxide solution were mixed together at least one day prior to use to prepare the alkaline liquid. On the day of casting of the specimens, the alkaline liquid was mixed together with the super plasticizer and the extra water (if any) to prepare the liquid component of the mixture.

Quantities of material:
For mix 1 by fully replacement of M sand

Table (a) 3.3 Quantities of material for M sand

Materials	Cube	Cylinder	Total
Fly ash	3.99	4.16	8.16
Fine aggregate (M sand)	6.54	6.85	13.39
Coarse aggregate	12.15	12.73	24.88
Alkaline liquid =sodium hydroxide +sodium silicate	1.216	1.31	2.52
	0.456	0.477	0.93

For mix 2 by fully replacement of natural sand

Table (b)3.3 Quantities of material for natural sand

Materials	**Cube**	**Cylinder**	**Total**
Fly ash	3.99	4.16	8.16
Fine aggregate (natural sand)	6.54	6.85	13.39
Coarse aggregate	12.15	12.73	24.88
Alkaline liquid	1.216	1.31	2.52

=sodium hydroxide +sodium silicate	0.456	0.477	0.93

Coarse Aggregate:

Coarse aggregates of sizes 12mm and 20mm having following properties taken from a local supplier are used in the present study. For geopolymer concrete, the fly ash and the aggregates were first mixed together in the Pan mixer for about 3 minutes. Then the alkaline liquid mixed with super plasticizer was then added with the dry mixers in the pan mixer itself

Properties of Coarse Aggregate

Property	Coarse Aggregate	
	20mm	12mm
Fineness Modulus	8.14	8.14
Specific gravity	2.87	2.83
Bulk Density	1533.33 kg/m3	1517 kg/m3
Percentage of voids	45.24%	47.14%

V. RESULTS AND ANALYSIS

General: -

In this Chapter, the test results are presented and discussed. The test results cover the effect of age on the compressive strength and tensile strength. Test specimens were made using geo polymer concrete Mixture-1 (m sand) and Mixture-2 (natural sand). The details of these mixtures, the manufacturing process, and the test details are mention in Chapter 3. Each test result plotted in the Figures or given in the Tables is the mean value of results obtained from at least three specimens.

Effect of Age on Compressive Strength and split tensile strength:

In order to study the effect of age on compressive strength. The specimens were cured in the oven (dry curing) for 24 hours at 60oC. The test results are presented in tables.

COMPRESSIVE STRENGTH

Compressive strength

Name of the mix	Compressive strength in N/mm^2 of specimens Cured by		
	7days	14days	28days
CC	18.6	23.4	27
GP1	19.23	23.6	27.5
GP2	20.26	24.2	28.2
GP3	21	25.2	29.4

Workability Test

S.NO	Name of the Mix	Workbility in mm
1	**cc**	**65**
2	**Gp1**	**75**
3	**Gp1**	**82**
4	**Gp1**	**92**

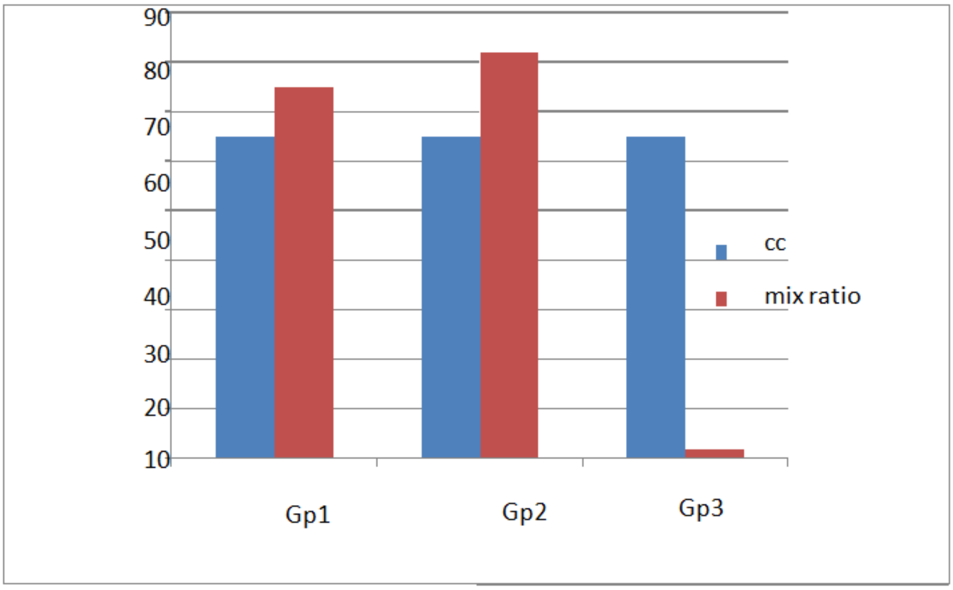

Figure 6.3 Workability Test of specimen

VI. Conclusion:

Based on the experimental work reported in this study, the following conclusions are drawn Geo polymer concrete is a greater corrosion resistance. By using manufacture sand, high compressive and tensile strength are gained than the natural sand. Reducing the problem of Co2 and greenhouse gases which are affecting the global warming. Higher concentration (in terms of molar) of sodium hydroxide solution results in higher compressive strength of fly ash based on geo-polymer concrete.Longer curing time, in the range of 4 to 96 hours (4 days), produces higher compressive strength of fly ash &quarry dust based geo-polymer concrete. However, the increase in strength beyond 24 hours is not significant.The fresh fly ash-based geo-polymer concrete is easily handled up to 120 minutes without any sign of setting and without any degradation in the compressive strength.The mix GP3 gives higher compressive strength, as it has high molarity of NaOH. we Observe that the compressive strength is increased with the increase in the molarity of the sodium hydroxide.After three days of curing the increase the compressive strength is not sufficient.The geo-polyemer concrete shall be effeviely used for the beam coloumn junction of the reinforced concrete structure.Geo-polymer concrete shall also be used in the Infrastructure works.In addition to that fly ash shall be effectively used and hence no landfills are required to dump the fly ash

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