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RESEARCH PAPER

GEOPOLYMER CONCRETE BY USING FLY ASH IN CONSTRUCTION

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Geopolymer, Alkali, Fly Ash, Class F, compressive Strength.

ABSTRACT

The *alkali activation of waste materials is a chemical process that allows the user to transform glassy structures into very compact well-cemented composites. Nowadays, the knowledge concerning the mechanisms controlling the alkali activation process is considerably advanced; however, there are still many things to investigate. In the present paper, the mechanism of activation of a fly ash (no other solid material was used) with highly alkaline solutions is described. These solutions, made with NaOH, Na2Sio3.This paper, report on the study of the processing of geopolymer using fly ash and alkaline activator with geopolymerization process. The factors that influence the early age compressive strength such as molarities of sodium hydroxide (NaOH) have been studied. Sodium hydroxide and sodium silicate solution were used as an alkaline activator. These studies comprises the comparison of the ratios of Na2Si03&NaOH at the values 0.39&2.51.The geopolymer 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. The result showed that the geopolymer paste with NaOH concentration, compressive strength increase with molarities increases.*

1. INTRODUCTION

The most commonly used structural material for all types of construction is concrete to enhance the strength properties and serviceability requirements by using supplementary materials in concrete. Such supplementary materials are blast furnace slag, fly ash, silica fume, steel fibers, glass fibers, rice husk, crushed stone dust etc. Every 1 ton of concrete leads to CO2 emissions which vary between 0.05 to 0.13 tons. About 95% of all CO2 emissions from a cubic yard of concrete are from cement manufacturing. It is important to reduce CO2 emissions through the greater use of substitute to ordinary Portland cement (OPC) such as fly ash, clay and others geo-based material. This project should be study on the processing of geopolymer using fly ash and alkaline activator with geopolymerization process. The factors that influence the early age compressive strength such as molarities of sodium hydroxide (NaOH) need to be studied. Sodium hydroxide and sodium silicate solution were used as an alkaline activator. These studies comprise the comparison of the ratios of Na2Si03&NaOH at the values 0.39&2.51.

As far as India is concerned, the first ever study on use of fly ash in concrete was carried out in 1955 by CBRI, Roorkee(1), in the form of a review of American and Australian research work on Fly ash. Later, Fly ash was used in small proportions in mass concreting for dams and other hydraulic. Ali Allah Verdi &Frantisek Skvara[2000]2, investigated the response of harden paste of a geopolymer cement to acid attack & compared to that of ordinary Portland cement. These cement was produced by activating a mixture of fly ash & blast furnace slag using a proportioned solution of NaOH& Na2SiO3. A.Buchwald, M.Hohmann&Ch.Kaps[2000]3, investigation focuses the influence of the clay composition on the geopolymer performance. Clays with different kind & amount of the clay mineral as well as side mineral were investigating.

The famous report on sustainable cement industry published by Batelle Institute: titled Climate Change, is available on the Internet at the following address: This report confirms the studies carried out by Prof. Joseph Davidovits since [1990]4, on CO2 emissions during Portland cement manufacture (in the LIBRARY the paper on Global Warming). Batelle's report recommends the development of geopolymer cement. John Zachar&Tarun R. Naik[1990]5, use fly ash & foundry sand & slag as a replacement for cement and fine coarse aggregates in concrete. Davidovits [1988]6 proposed that an alkaline liquid could be used to react with the silicon (Si) and the aluminum (Al) in a source material of geological origin or in by-product materials such as fly ash and rice husk ash to produce binders. Because the chemical reaction that takes place in this case is a polymerization process, he coined the term Geopolymer to represent these binders. Geopolymer concrete is concrete which does not utilize any Portland cement in its production. Geopolymer concrete is being studied extensively and shows promise as a substitute to Portland cement concrete. Research is shifting from the chemistry domain to engineering applications and commercial production of geopolymer concrete.

2. METHODOLOGY & EXPERIMANTAL PROGRAM:

2.1. Objective:

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 geopolymer.
3. Testing of geopolymer by using universal testing machine.
4. Analysis of geopolymer testing & comparison.

2.2. Material Used

1. Fine aggregate (fineness modulus 2.6 — 2.8).
2. Sodium silicate solutions (8M, 10M, 12M and 14M)
3. Low calcium class F type fly ash
4. Sodium hydroxide (98% purity in pure form)
5. Distilled Water.

2.3. Chemical Composition of Fly Ash:

Description	Fly Ash (% wt)
Silica	55-65
iron oxide	5-7
aluminum oxide	22-25
calcium oxide	5-7
magnesium oxide	<1
titanium oxide	<1
Phosphorous	<1
alkali oxide	<1

2.4. Physical Properties of Fly Ash:

Physical properties	Properties of fly ash used	Properties of fly ash according to IS 1320-1981
Specific gravity	2.51	-
Initial setting time	120 minutes	-
Final setting time	280 minutes	-

Fineness specific surface in m2/ kg min	320	340
Lime reactivity Avg compressive strength	4.00	6.200

In the research work, low calcium, class F dry fly ash obtained from **Raichur**is used as base material to make the geopolymers. Sodium silicate (Na_2SiO_3) mixed with sodium hydroxide (NaOH) as an alkaline activator has been used in this study, NaOH in pellet form with 97% purity & Na_2SiO_3 consist of Na_2O=9.4%, SiO_2=30.1% &H_2O=60.5%, with weight ratio SiO_2/Na_2O=3.20-3.30), By varying the ratio of Na_2SiO_3&NaOH i.e. 0.39. & 2.51. Oven dry curing temperature i.e., 600 for time in 24 hours is kept constant.

3. Compressive Strength Test (IS: 516 -1959

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 geopolymer concrete cubes are used for testing compressive strength. The load at which the control specimen ultimately fail is noted, compressive strength is calculated by dividing load by area of specimen .The figure 5.12 shows the apparatus for compressive strength testing.

$f_c = P/A$

Where f_c = cube compressive strength in

p = cube compressive load causing failure in n

A = cross sectional area of cube in mm^2

The compressive strength for mix designations 8 m to 14 m are shown in tables at 7 days and at 28 days. it is observed that as the molarity and Na_2SiO_3 / NaOH ratio is increased the compressive strength increases. Result for compressive strength will be for 7 days & 28 days for oven drying & ambient temperature.

Compressive Strength Test Results at 7 Days For Cube 150mm X 150mm X 150mm

Table 3.1 : compressive strength test results at 7 days

Size	specimen	compressive strength N/mm2	avg.compressive strength N/mm2
8m	sample 1	30.3	30.33
	sample 2	33.0	
	sample 3	28.0	
10m	sample 1	34.0	36.8
	sample 2	37.0	
	sample 3	39.44	
12m	sample 1	39.0	41.06
	sample 2	43.2	
	sample 3	44.0	
14m	sample 1	44.0	42.83

	sample 2	46.0	
	sample 3	38.5	

$\frac{Na_2SiO_3}{NaOH}$ = 2.51 (od)

Where od =Oven Drying

Compressive strength test results at 28 days For cube 150mm x 150mm x 150mm

Table 3.2 : compressive strength test results at 28 days

Size	specimen	compressive strength N/mm2	avg.compressive strength N/mm2
8m	sample 1	32	32.79
	sample 2	36.5	
	sample 3	30	
10m	sample 1	37	37.72
	sample 2	37.5	
	sample 3	38.0	
12m	sample 1	45	43.5
	sample 2	41.5	
	sample 3	44	
14m	sample 1	47	47.43
	sample 2	50.5	
	sample 3	44.8	

$\frac{Na_2SiO_3}{NaOH}$ = 2.51 (od)

Od = Oven drying

fig.casting of specimen **fig. setup for compressive strength**

Compressive Strength Test Results at 7 Days For Cube 150mm X 150mm X 150mm Using Fly Ash

Table 3.3 : compressive strength test results at 7 days

Size	specimen	compressive strength N/mm2	avg.compressivestrength N/mm2
8m	sample 1	13.0	15.83
	sample 2	18.0	
	sample 3	16.5	
10m	sample 1	14.9	16.78
	sample 2	17.0	
	sample 3	17.1	
12m	sample 1	19.11	17.23
	sample 2	15.19	
	sample 3	17.2	
14m	sample 1	19.3	17.32
	sample 2	15.31	
	sample 3	17.29	

$\frac{Na_2SiO_3}{NaOH}$ = 0.39 (at)

Compressive Strength Test Results at 28 Days For Cube 150mm X 150mm X 150mm Using Fly Ash

Table 3.4 : compressive strength test results at 28 days

Size	specimen	compressive strength N/mm2	avg.compressive strength N/mm2
8m	sample 1	14	16.16
	sample 2	17.2	
	sample 3	17.3	

10m	sample 1	18	18.92
	sample 2	19.2	
	sample 3	20.2	
12m	sample 1	23.3	20.47
	sample 2	17.39	
	sample 3	21	
14m	sample 1	24.3	21.57
	sample 2	18.5	
	sample 3	21.6	

Na2SiO3= 0.39 (at)

NaOH

Where at = ambient temperature

4. CONCLUSION

The construction industry is in demand of ecofriendly & greener materials which are durable. As compared to the existing concrete materials, fly ash is advantageous but its uses as tested against strength & durability needs to be confirmed.The present project work emphasis on the research & development activity in construction materials using fly ash with geopolymers.

The project work revels with preparation of test samples of fly ash with geopolymers of different composition in the ratio of 0.39 & 2.51.The samples are prepared with the different molarities such as 8,10,12,14. Tests for compressive strength, split tensile strength, flexural strength, rebound hammer test, acid resistant test are carried out on samples as above for ambient temperature(A.T) & oven drying (O.D) for 7 & 28 days, as per prevailing standards for respective properties. The details of the results are summarized as under.

Compressive Strength Test:

1. For ratio Na2SiO3/ NaOH=2.51, As higher concentration in terms of molar of solutions, results in higher compressive strength of fly ash based geopolymer concrete.

2. For ratio Na2SiO3/ NaOH= 0.39, It is observed that, when quantity of sodium silicate & sodium hydroxide is reversed by mass, it is observed that compressive strength increases as increase in molarity. For both cases that is 1 & 2 compressive strength is more for oven drying as compare to specimen left in ambient temperature.

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