INVESTIGATION OF ALKALINE ACTIVATORS FOR FLY-ASH BASED GEO-POLYMER CONCRETE

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ABSTRACT

Geopolymer concrete technology has the potential to reduce globally the carbon emission and lead to sustainable development and growth of the concrete industry. This study represents "Effects of alkali activators on fly ash based concretes". The main objective of this study is to investigate different alkali activators for Geopolymer concrete and their effect on strength of fly ash based concrete. The Geopolymer concrete is the mixture of coarse aggregate, sand, fly ash and alkaline solution of Sodium hydroxide (NaOH) or Potassium hydroxide (K2SiO3) or Calcium hydroxide and sodium silicate (Na2SiO3) or Potassium silicate (K2Si) 3) or calcium silicate .This study presents the experimental investigation were total nine different trial combination of alkaline activators are used having concrete grade M30 with 8M molarity at 80^0 oven curing. From those, three combinations is selected for further studies as KOH + Na2SiO3, NaOH+K2SiO3 and KOH + Na2SiO3for different molarity for temperature 90^0. The compressive strength of Geopolymer concrete were carried out during this study and it was observed that, how different alkaline activators effect the strength of Geopolymer concrete. Also it is found that KOH+Na2SiO3 combination having maximum strength than other two combinations... Also it is found that KOH + Na2SiO3 and KOH + Na2SiO3is suitable for concrete work.

Keyword: - *Geopolymer concrete1, Fly ash2, Sodium hydroxide3, Sodium silicat4e, Potassium hydroxide5, Potassium silicate6, Calcium hydroxide7, Calcium silicat8e, molarity 9.*

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1. INTRODUCTION

Geopolymer concrete technology has the potential to reduce globally the carbon emission and lead to a sustainable development and growth of the concrete industry. The demand for Portland cement is increasing day by day and hence, efforts are being made in the construction industry to address this by utilizing supplementary materials and developing alternative binders in concrete; the application of geo-polymer technology is one such alternative. 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 (CS- H) Gel. Geopolymer is synthesized by mixing aluminosilicate-reactive material with strong alkaline solutions, such as sodium hydroxide (NaOH), potassium hydroxide (KOH), sodium silicate or potassium silicate. The mixture can be cured at room temperature or temperature cured. Fly ash is the most common source material for making geopolymer. Normally, good high-strength geopolymer can be made from class F fly ash. Alkaline activating solution is important for dissolving of Si and Al atoms to form geopolymer precursors and finally alumino-silicate material. The most commonly used alkaline activators are NaOH and KOH.

1.1 Geo-Polymers

Geo- polymers are members of the family of inorganic polymers. The chemical composition of the geo-Polymer material is similar to natural zeolitic materials but the microstructure is amorphous instead of crystalline Palomo, Xu and Van Deventer. The polymerization process involves a substantially fast chemical reaction under alkaline condition on Si-Al minerals that results in a three-dimensional polymeric chain and ring structure consisting of -Si-O-Al-O bonds. Unlike ordinary Portland cements, geo-polymers do not form calcium silicate-hydrates (C-S-H) for matrix formation and strength; it utilize the poly-condensation of silica and alumina and a high alkali content to attain structural strength. Therefore, geo-polymers are sometimes referred to as alkali activated alumino silicate binders.

2. MATERIALS

2.1 Fly-ash

In the present experimental work, low calcium, Class F (American Society for Testing and Materials 2001) dry fly ash obtained from the silos of Thermal Power Station, Nasik was used as the base material. Fly ash (Pozzocrete 63) is a high efficiency class F pozzolanic material confirming to BS 3892, obtained by selection and processing of power station fly ashes resulting from the combustion of pulverized coal. Pozzocrete 63 is subjected to strict quality control.

2.2 Alkaline Liquids:

A combination of sodium silicate/potassium silicate /calcium silicate solution and sodium hydroxide /potassium hydroxide/ calcium hydroxide solution was chosen as the alkaline liquid. The sodium hydroxide (NaOH) and potassium Hydroxide (KOH) solids were a commercial grade in form of pellets with 97% purity and 96% purity respectively whether calcium hydroxide (CaOH2) is available in white powder form.

The potassium hydroxide (KOH) solution was prepared by dissolving either the flakes or the pellets in water. The mass of KOH solids in a solution varied depending on the concentration of the solution expressed in terms of molar, M. in this experimental work, KOH solution with a concentration of 8M consisted of 8x56.11 = 448.88 grams of KOH solids (in pellet form) per liter of the solution, where 56.11 is the molecular weight of KOH. Similar procedure is follows for sodium hydroxide and calcium hydroxide depending upon their molecular weight.

2.3 Aggregates:

Generally, locally available coarse aggregates with combination of 20 mm (70%) and 10 mm (30%) are used in the present work. Also, natural available river sand is used as a fine aggregate.

3. METHODOLOGY

The laboratory investigation has been carried out to investigate different alkaline activators for geo-polymer concrete and their effect on it. Also study of various such as temperature and molar concentration of alkaline activator on compressive strength of geo polymer concrete. No standard mix design procedure is available for geo-polymer concrete using fly-ash and alkaline liquid. So, previous research suggested procedure of mix design is followed and percentage of materials is taken on the basis of author's previous work. The grade chosen for the investigation is M30 with 8M morality for trail mix and then it varies for different molarities as 10M, 12M and 14M for further work for temperature 90^0.

Table -1: Trial Mix For Cross Combination Activators

Trial mix	Mass of fly ash Kg/m3	Coarse aggregate Kg/m3	Fine aggregate (Kg/m3)	Alkaline solution	Water in ml
KOH+ Na_2SiO_3	4.7	15.9	8.55	1.65	720
KOH+ K_2SiO_3	4.7	15.9	8.55	1.65	850
KOH+ Ca_2SiO_3	4.7	15.9	8.55	1.65	1520
NaOH+ Na_2SiO_3	4.7	15.9	8.55	1.65	900
NaOH+ K_2SiO_3	4.7	15.9	8.55	1.65	1080
NaOH+ Ca_2SiO_3	4.7	15.9	8.55	1.65	700
$CaOH_2$+ Na_2SiO_3	4.7	15.9	8.55	1.65	2000
$CaOH_2$+ Ca_2SiO_3	4.7	15.9	8.55	1.65	1450
$CaOH_2$+ K_2SiO_3	4.7	15.9	8.55	1.65	1400

4. EXPERIMENTATION AND TESTS

The compressive strength tests on hardened fly ash-based Geopolymer concrete were performed on Universal compressive testing machine. 150x150x150 mm concrete cubes were tested for every mix. A test result is the average of at least three standard-cured strength specimens made from the same concrete sample and tested at the same age.

5. RESULTS AND DISCUSSION

5.1 Cube Compressive Strength Test:

To perform this test, we prepared 150x150x150 mm cube of M30 grade of concrete and cured for 3, 7 and 28 days for each trial mixes. After trial mix results ,we select three combination of alkaline solution for further experimental work for different molarities as 10M, 12m and 14M with temperature 90^0 for every combination at 24 hours oven curing. The following test results observed as,

Table -2: Compressive Strength of GPC of trial mix at 80^0 C

Trial mix	Average Compressive strength of concrete for 8M(N/mm^2)		
	3days	7 days	28days
KOH+ Na_2SiO_3	29.58	34.33	37.50
KOH+ K_2SiO_3	10.13	10.90	11.65
KOH+ Ca_2SiO_3	9.11	9.83	10.30
NaOH+ Na_2SiO_3	23.33	31.47	32.66

NaOH+ K_2SiO_3	14	17.33	18.9
NaOH+ Ca_2SiO_3	22.13	28.67	30.98
$CaOH_2$+ Na_2SiO_3	14.44	15.67	18.77
$CaOH_2$+ Ca_2SiO_3	12.35	12.70	13.67
$CaOH_2$+ K_2SiO_3	15,42	19.08	21.28

Table -3: Compressive Strength of GPC of ratio silicate/hydroxide=1 at 90^0 C for 10M

Content	Average Compressive strength of concrete for 10M (N/mm^2)	
	7days	28days
KOH+ Na_2SiO_3	33.46	44.2
NaOH+ Na_2SiO_3	31.02	41.76
NaOH+ K_2SiO_3	25.15	33.15

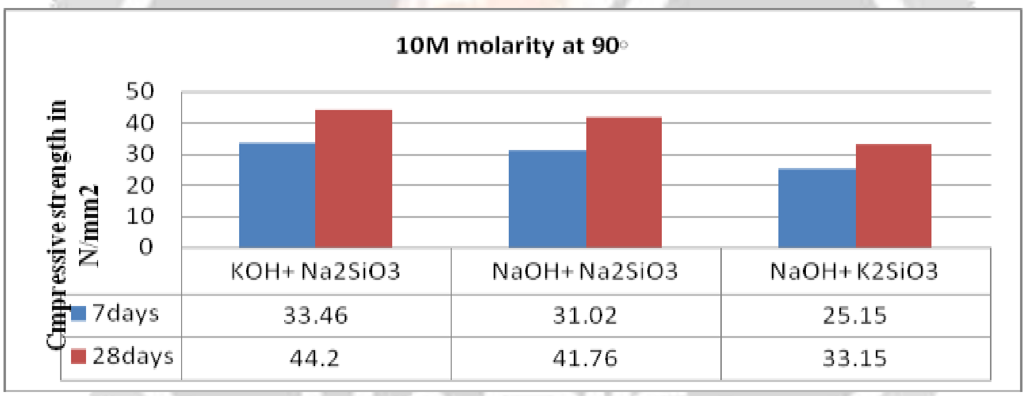

Chart -1: 1Comparison of Compressive Strength of different activators combinations for 10M at 90^0C

Table -4: Compressive Strength of GPC of ratio silicate/hydroxide=1 at 90^0 C for 12M

Content	Average Compressive strength of concrete for 12M (N/mm^2)	
	7days	28days
KOH+ Na_2SiO_3	23.22	29.04
NaOH+ Na_2SiO_3	28.31	35.95
NaOH+ K_2SiO_3	25.73	31.14

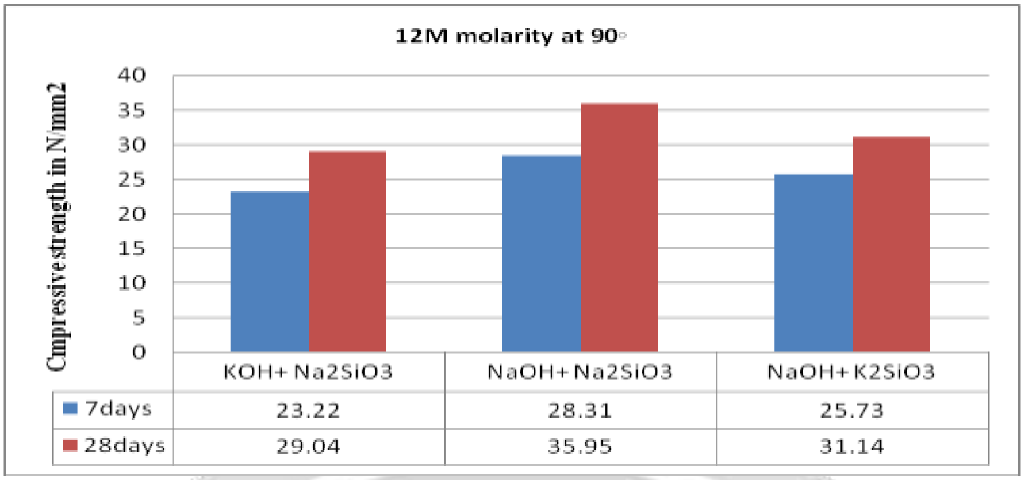

Chart -2: 1Comparison of Compressive Strength of different activators combinations for 12M at 90^0C

Table -5: Compressive Strength of GPC of ratio silicate/hydroxide=1 at 90^0 C for 14M

Content	Average Compressive strength of concrete for 14M (N/mm^2)	
	7days	28days
KOH+ Na_2SiO_3	22.49	27.78
NaOH+ Na_2SiO_3	26.08	39.48
NaOH+ K_2SiO_3	21.12	30.07

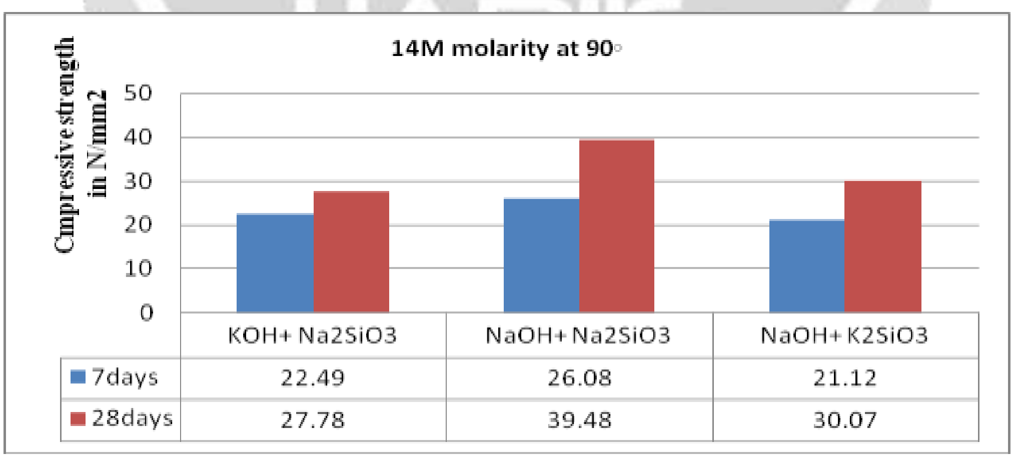

Chart -3: 1Comparison of Compressive Strength of different activators combinations for 14M at 90^0C

6. CONCLUSIONS

The compressive strength of Geopolymer containing K-based activator is slightly higher than the Na based activators. The compressive strength of Geopolymer containing K-based activator is slightly higher than the Na based activators. The failure and crack patterns observed for Geopolymer concrete specimen were similar to those in Portland cement concrete. KOH+Na_2SiO_3 and NaOH+Na_2SiO_3.Has excellent compressive strength and is suitable for structural applications.

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