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Geo-Polymer Concrete using Metakaolin , Fly-Ash and their Comparision

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***Abstract*— Portland cement is under critical review due to high amount of carbon dioxide(co_2) released into atmosphere.However it is necessary to search for alternative low emission binding agent for concrete to reduce the environmental impact caused by manufacturing of cement.Geo-polymer is also known as inorganic polymer is one such material that uses the by-product materials such as metakaolin,flyash etc., instead of cement and these are activated by alkaline liquids such as sodium silicate and sodium hydroxide to prodece the binder.This project covers the material,the mixture proportion,the manufacturing process and properties etc.Compressive strength for various molarities were determined .Also suggestions for further exploration were given.**

Keywords*— Geopolymer concrete,metakaolin,flyash,sodium hydroxide,sodium silicate.

I. INTRODUCTION

The use of alkali materials and aluminosilicates to form a concrete is broadly refered to as Geo-polymer technology and is coined by French researcher Davidovits in 1978.Geo-polymers were first trailed in some concrete applications by Glikhovsky and Co-workers in the soviet union post worldwar-2.In gro-polymers,the polumerisation process involves a chemical reaction under highly aalkaline conditions on Al-Si minerals yielding polymeric Si-o-Al-o bonds as proposed by Davidovits.The chemical composition of geopolymer is similar to Zeolite,but shows an amorphus microstructure.The structural model of geo-polymer material is under investigation.Hence the exact mechanism by which geopolymer setting and hardning occues is not yet clear.

Metakaolin is one of the by-product used in the geo-polymer concrete.Metakaolin compraises of 55.556% of sio_2, 1.612% Tio_2, 44.788% Al_2O_3, 0.485% Fe_2O_3, 0.004% MnO, 0.125% MgO, 0.054% CaO, 0.204% Na_2O, 0.155% K_2O ,0.062% P_2O_5.

Fly ash is one of the residues generated in the combustion of coal. Fly ash is generally captured from the chimneys of power generation facilities.Low calcium Flyash has been sucessfully used to manufacture geopolymer concrete.This is easily available in the market or in the thermal power plants.In flyash the silicon and Aliminium oxides constitute of about 80% by mass with Si-o-Al ratio of about 2.The Iron oxides usually ranges from 10% - 20% by mass.The calcium oxide content was less than 5% by mass.Flyash also consists of magnesium and toxic heavy metals like lead, arsenic, cobalt, and copper.

The alkaline liquids such as sodium hydroxide and sodium silicate were generally used as binders.sodium silicate solution is sticky in nature and this helps to bind the mixture.Sodium hydroxide solution is prepared by disolving the hydroxide flakes in distilled water.

II. EXPERIMENTAL PROGRAMME

A. Preperation of Alkaline Solution

The alkaline solutions used are Sodium hydroxide(NaoH) and sodium silicate.Sodium silicate solution is directly available in the market.Sodium hydroxide flakes are available and to make hydroxide solution first the beakers are to be cleaned and the the flakes are to be weighed according to the required molarities.Now for obtaining 2M(2 molarity) solution first sodium hydroxide flakes of 80 gm are taken in a beaker and and then distilled water is added slowly for dissolving the flakes.And then 1 liter solution is prepared.While flakes are dissolved heat is evolved.In the same way solution is prepared for 4M,6M and 8M respectively.

Molarity=moles of solute/litre of solution.
2M=2 molarity
=2 x molecular weight
=2 x40
=80 gm of flakes to be dissolved in 1 lit of distilled water.

Required Molarity	Weight in grams of sodium Hydroxide Flakes
2M	80
4M	160
6M	240
8M	320

B. *Mix design*

Fly-ash based concrete

The mix design in the case of geopolymer concrete is based on conventional concrete with some modifications.In case of normal concrete for the required strength material properties can be found using code.But in case of geopolymer concrete

there is no mis design procedure and by means of trail and error method optimized mixes is being prepared.several trail mixes are prepared with fly ash based on the mix given by B.V.Rangan.

Assume the density of geopolymer concrete =2500 kg/m^3
Assume the volume of combined aggregate occupied =65% of mass of concrete=65 x 2500 =1625 kg/m^3
Mass of Coarse aggregate + Fine aggregate = 1625 kg/m^3
Coarse aggregate =65 % of 1625 = 1056.25 kg/m^3
Fine aggregate =35 % of 1625 =568.75 kg/m^3
Mass of Alkaline liquids and flyash =2500 – 1625 =875 kg/m^3
Assume mass of flyash =28% of 2500 = 700 kg/m^3
Alkaline liquid / flyash = 175/700 = 0.25
The ratio of sodium silicate to sodium hydroxide solution by mass =1.5
Mass of sodium hydroxide solution = 65 kg/m^3
Mass of sodium silicate solution =110 kg/m^3
Mass of super plasticizer = 0.7% of flyash = 0.7 x 700=5 kg/m^3

Fly Ash (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)		Sodium Silicate solution (kg/m^3)	Sodium Hydroxide Solution (kg/m^3)	Super-Plasticizer (kg/m^3)
		20mm	12mm			
700	600	325	700	110	65(2M)	5
700	600	325	700	110	65(4M)	5
700	600	325	700	110	65(6M)	5
700	600	325	700	110	65(8M)	5

Metakaolin based concrete

The mix proportion followed as in case of flyash based concrete is exactly followed here also i.e, mix proportion is same as flyash based concrete.

Fly Ash (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)		Sodium Silicate solution (kg/m^3)	Sodium Hydroxide Solution (kg/m^3)	Super-Plasticizer (kg/m^3)
		20mm	12mm			
700	600	325	700	110	65(2M)	5
700	600	325	700	110	65(4M)	5
700	600	325	700	110	65(6M)	5
700	600	325	700	110	65(8M)	5

C. Casting Procedure

Generally the fine aggregate,coarse aggregate and fly ash are weighed to the required quantities and then they are mixed ni dry condition foe 2-3 minuites and then the alkaline solutions prepared(combination of sodium hydroxide and sodium silicate) are to be taken to required quantity in addition to the superplasticizer and this solution is added to the dry mix.This mixing is done for 5-7 minuites in the mixer for proper bonding of all the materials.After the mixing is done the mix is filled in the cube moulds of size 100mm x 100mm x 100mm in 3 layers with equal compacting an the these cubes are kept on a vibrating table so that no voids are formed.This is the process for both Flyash based concrete and also Metakaolin based concrete for different molarities.

D. Curing Procedure

The casted cubes are kept in oven for 12 hours at 60^0 temperature and then the moulds are removed and the cubes are cured at the room temperature by free air for 3 days,7 days and 28 days and then they are tested.

III. RESULTS

The following are the test results of both fly ash based concrete and metakaolin based concrete.

A. Based on Metakaolin

2Molarity

Weight	Strength		
	3days	7days	28days
2.43	300	310	300
2.48	310	310	320
2.52	310	315	320
Average	306.66	311.66	313.66

4Molarity

Weight	Strength		
	3days	7days	28days
2.49	400	410	415
2.52	410	420	410
2.55	410	400	410
Average	406.66	410	411.66

6Molarity

Weight	Strength		
	3days	7days	28days
2.56	500	520	530
2.58	510	510	515
2.57	530	530	525
Average	513.33	520	523.33

8Molarity

Weight	Strength		
	3days	7days	28days
2.58	560	565	570
2.49	555	550	560
2.52	560	570	570
Average	558.33	561.66	566.66

B. Based on Fly-Ash

2 Molarity

Weight	Strength		
	3days	7days	28days
2.36	220	225	240
2.39	215	225	225
2.35	220	230	230
Average	218.33	226.66	231.66

4 Molarity

Weight	Strength		
	3days	7days	28days
2.42	300	315	315
2.45	310	310	320
2.39	300	315	310
Average	303.33	313.33	315

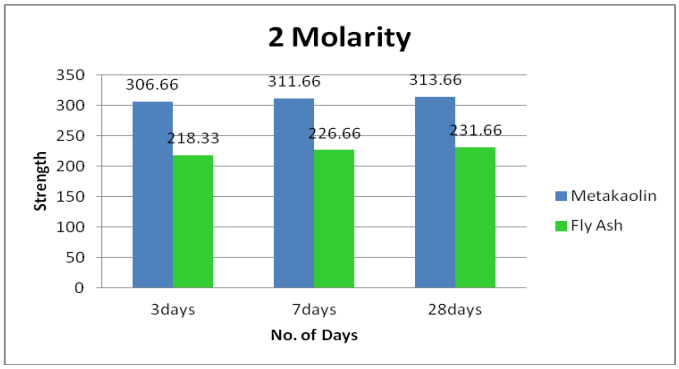
6 Molarity

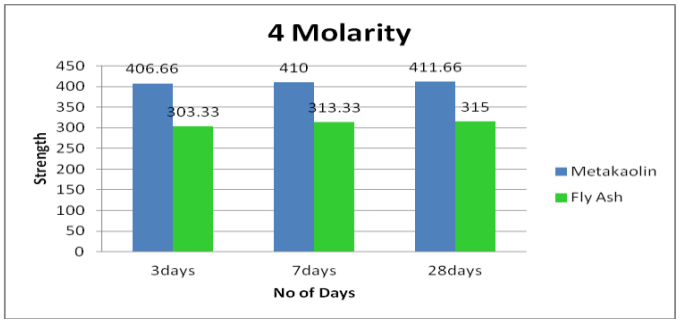
Weight	Strength		
	3days	7days	28days
2.52	450	460	470
2.46	445	450	450
2.48	460	455	465
Average	451.66	455	461.66

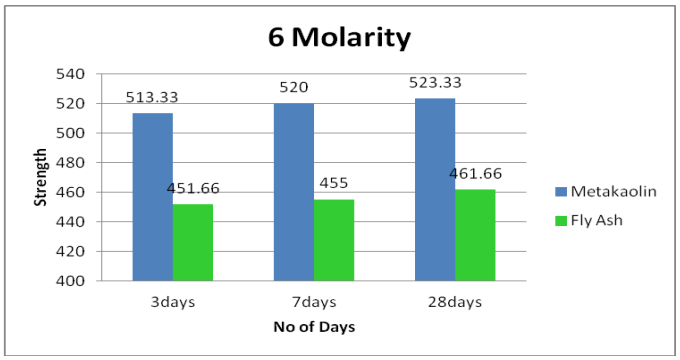
8Molarity

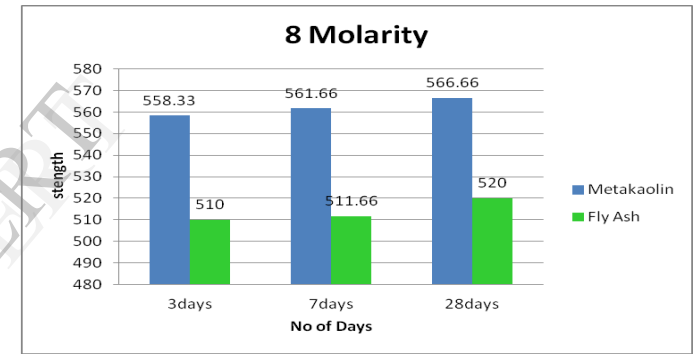
Weight	Strength		
	3days	7days	28days
2.56	520	500	520
2.53	510	520	510
2.49	500	515	530
Average	510	511.66	520

IV. COMPARISION









V. CONCLUSION:

From the observations it is clear that when the molarity increased, the compressive strength is increasing.Compared to flyash based concrete the compressive strengts of metakaolin based concrete are high,but the cost of metakaolin based concrete is more.Further exploration can be done by using other by-products.

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