Effect of Coarse Aggregate And Binder Ratio on Lime Added Fly Ash Based Geopolymer Concrete

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Abstract- *Geopolymer concrete results from the reaction of a source material which is rich in silica and alumina with alkaline liquid. A summary of the extensive studies conducted on fly ash-based geopolymer concrete is presented. Test data are used to identify the effects of salient factors that influence the properties of the geopolymer concrete and to propose a simple method for the design of geopolymer concrete mixtures. Geopolymer concrete 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.*

Geopolymer concrete (GPC) is an emerging construction material that uses a by-product material such as fly ash as a complete substitute for cement. Geopolymer concrete is eco-friendly which is used as the alternate for the Portland cement. It results from the reaction of fly ash and alkaline liquid. Alkaline solution results from sodium silicate and sodium hydroxide

Keywords- Geopolymer concrete, Lime, alkaline liquid, Compressive strength etc.

I. INTRODUCTION

General

The production of Portland cement is an energy-intensive process that releases a very large amount of greenhouse gas into the atmosphere. Therefore, efforts have been made to promote the use of pozzolans to partially replace Portland cement in concrete production. Other efforts seek to totally replace Portland cement with other forms of cementitious materials such as geopolymers. A geopolymer or alkali-activated cement is an inorganic, alumino-silicate–based material. The strengths of geopolymer mortar and concrete are of the same order as those made with normal Portland cement. The texture and appearance are similar. Furthermore, it is known that geopolymers possess good mechanical properties as well as fire and acid resistance.

The global use of concrete is second only to water. Concrete is one of the most widely used construction materials; it is usually associated with Portland cement as the main component for making concrete. As the demand for concrete as a construction material increases, so also the demand for Portland cement. It is estimated that the production of cement will increase from about from 1.5 billion tons in 1995 to 2.2 billion tons in 2010 (Malhotra, 1999).On the other hand, the climate change due to global warming has become a major concern. The global warming is caused by the emission of greenhouse gases, such as carbon dioxide (CO2), to the atmosphere by human activities. Among the greenhouse gases, CO2 contributes about 65% of global warming (McCaughey, 2002). The cement industry is held responsible for some of the CO2 emissions, because the production of one ton of Portland cement emits approximately one ton of CO2 into the atmosphere (Davidovits, 1994; McCaffery, 2002). Several efforts are in progress to supplement the use of Portland cement in concrete in order to address the global warming issues. These include the utilization of supplementary cementing materials such as fly ash, silica fume, granulated blast furnace slag, rice-husk ash and metakaolin, and the development of alternative binders to Portland cement. In this respect, the Geopolymer technology shows considerable promise for application in concrete industry as an alternative binder to the Portland cement (Duxson et al, 2007). In terms of global warming, the Geopolymer technology could significantly reduce the CO2 emission to the atmosphere caused by the cement industries as shown by the detailed analyses of Gartner (2004).

As per IS3812 (Part II): 2013, fly Ash is defined as ‘pulverized fuel ash extracted from flue gases by any suitable process such as by cyclone separator or electro-static precipitator’. It is also the byproduct of thermal power plants which facing the problems of its disposal. Government of India has taken initiative through ‘Fly Ash Utilization Program me’ to increase utilization of fly ash in concrete, brick, agriculture etc. It is expected that such program will help to meet the reduction of CO_2 emission.

II. OBJECTIVES OF WORK

A. Effect of addition of lime into fly ash in Geopolymer concrete.

B. To study characteristics of fly ash of different regions for thermal power plant
C. Effect fineness of fly ash on geopolymer concrete
D. To use GPC mix on site with natural quiring.

III. SCOPE OF WORK

Geopolymer concrete is a new invention in the world of concrete in which cement is totally replaced by industrial waste which contributes towards the global worming by reducing use of cement and utilization of by products like fly ash. It helps to reduce the utilization of ordinary Portland cement. Scope of present work is to use the optimum ratio of the materials which will enhance the different parameters of the concrete.

But the major problem with geopolymer concrete is it required heat quiring for gaining strength. So basically, geopolymer concrete requires oven quiring or membrane quiring which is not possible on site. By adding lime into geopolymer concrete will helps to sort out above said problem.

IV. MATERIALS UTILIZED

A. Fly Ash:

In the present experimental work, low calcium, Class F (American Society for Testing and Materials 2001) dry fly ash obtained from the dirk India put limited, 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.

Table 1. General Information

Presentation	: Finely divided dry powder
Color	: Light grey
Bulk Weight	: Approx. 0.90 metric ton per cubic meter
Specific density	: Approx. 2.30 metric ton per cubic meter
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Size	:90% < 45 micron
Particle shape	: Spherical

B. Alkaline Liquid

A combination of sodium silicate solution and sodium hydroxide solution was chosen as the alkaline liquid. Sodium-based solutions were chosen because they were cheaper than Potassium-based solutions. The sodium hydroxide solids were either technical grade in flakes form (3 mm), with a specific gravity of 2.130, 97% purity. The sodium hydroxide (NaOH) solution will be prepared by dissolving either the flakes or the pellets in water. The mass of NaOH solids in a solution varied depending on the concentration of the solution expressed in terms of molar, M. For instance, NaOH solution with a concentration of 8M consisted of 8x40 = 320 grams of NaOH solids (in flake or pellet form) per liter of the solution, where 40 is the molecular weight of NaOH. The mass of NaOH solids was measured as 262 grams per kg of NaOH solution of 8M concentration.
Note that the mass of NaOH solids was only a fraction of the mass of the NaOH solution, and water is the major component.

Table 2: Chemical composition of sodium hydroxide

Chemical component	Percentage (%)
Sodium hydroxide (min.)	97
Carbonate	2
Chloride	0.01
Sulphate	0.05
Potassium	0.1
Silicate	0.05
Zinc	0.02

C. Fine Aggregate: (Natural Sand):

Locally available natural river sand is used confirming to IS 383-1970. Properties of aggregate are as shown in table.

D. Coarse Aggregate:

The aggregate of size 20mm were used confirming to IS 383-1970.Properties of aggregate are as shown in table.

Table 3. Properties of aggregate

Properties	Coarse Aggregate	Fine Aggregate
Type	Crushed angular	Spherical (River sand)
Maximum Size	20mm	4.75 mm
Specific Gravity	2.70	2.63
Material finer than 75 microns	Nil	1.25 %
Water Absorption	0.63%	1.63%
Moisture Content	Nil	Nil

V. EXPERIMENTAL WORK AND MIX DESIGN

The Fly-ash based geopolymer concrete is design for characteristic strength M30 grade where cement is totally replaced by low calcium class F (P60) Fly-ash. The alkali activators ratio i.e. sodium silicate to sodium hydroxide solution ratio by mass is maintained constant as 2.5 and the solution to fly ash ratio is 0.35. After one day casting cubes and cylinder were remolded and exposed in atmosphere for 24 hours of normal curing. The experimental work evaluation on type of lime used and its effect on compressive and tensile strength of Geopolymer concrete for 5%, 10%, 15%, 20% and 25% of lime addition, whereas lime percentage is by weight to that of fly ash. Initially 10% lime are used in M30 grade of GPC and three set of 150 X 150 X 150 mm cubes are casted for each type of lime i.e. Quick lime, Hydrated lime and Slaked lime. Table no 1 provided quantities of various materials for the above said mix.

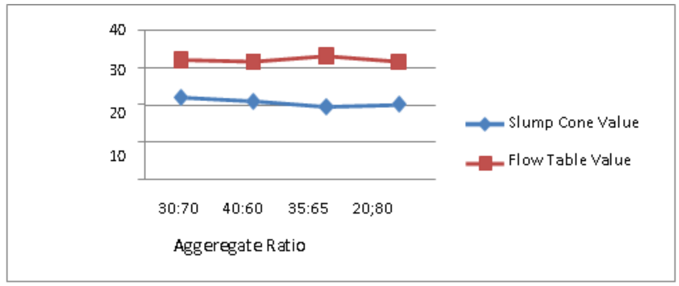
Table 4: Quantity of Materials

	W/G PB	Fly Ash (Kg)	NaOH (Gram)	Na2SiO3	Aggregate		Lime (Kg)	Total Quantity of Water (Kg)
					Fine (Kg)	Course (Kg)		
Cubes	0.35	4.79	840	40	7.66	14.7	0.479	0.690

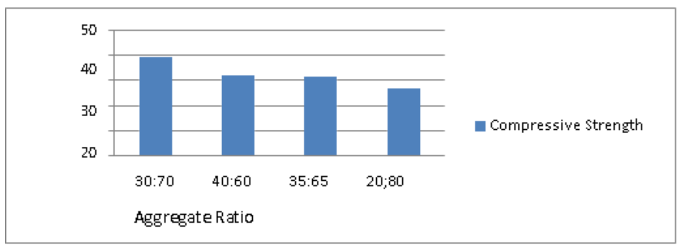
VI. RESULT AND DISCUSSION

Table 5: Lime Addition Effect on Coarse Aggregate Ratio: -

Cube No	Aggr Ratio	Lime Addition	Mole	Slump Value (CM)	Flow Table Test (CM)	Curing Temperature	Curing Time (Hrs.)	Rest period (Day)	Compressive Load (KN)	Compressive Strength (N/mm²)	Average Compressive Strength (N/mm²)
61									872	38.75	
62	30:70	10%	13	22	32+32/2 =32	34°C	24	7	836	37.15	39.18
63									937	41.64	
64									711	31.6	
65	40:60	10%	13	21	32+31/2 =31.5	34°C	24	7	634	28.18	32.10
66									680	30.22	
67									698	31.02	
68	35:65	10%	13	19.5	36+30/2 =33	34°C	24	7	730.3	32.46	31.49
69									696.9	30.98	
70									605	26.9	
71	20:80	10%	13	20	30+33/2 =31.5	34°C	24	7	599.7	26.7	26.56
72									587	26.08	



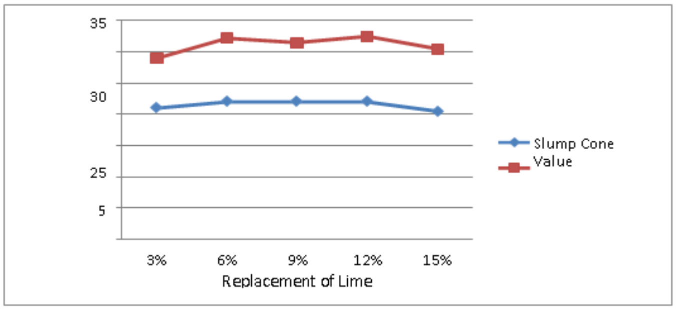
Graph No 1: Aggregate Ratio Vs Slump & Flow Table Value



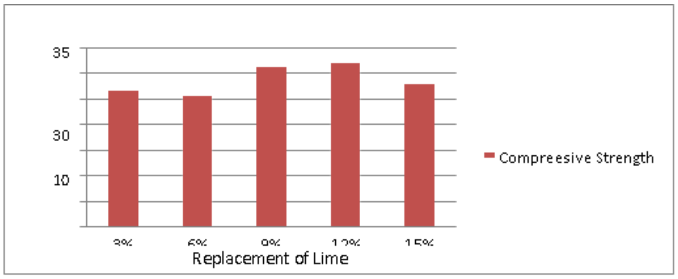
Graph No 2: Aggregate Ratio Vs Comp. Strength

Table No. 6: Replacement of Lime Percentage: -

Cube No	Lime Replace	Lime Addition	Mole	Slump Value (CM)	Flow Table Test (CM)	Curing Temperature	Curing Time (Hrs.)	Rest period (Day)	Compressive Load (KN)	Compressive Strength (N/mm²)	Average Compressive Strength (N/mm²)
73									600	26.66	
74	03%	10%	13	21	28+30/2 =29	35°C	24	7	591	26.26	26.63
75									595.8	26.98	
76									598	26.58	
77	06%	10%	13	22	32+32.4/2 =32.2	35°C	24	7	611	27.15	25.49
78									512	22.75	
79									872	38.75	
80	09%	10%	13	22	30+33/2 =31.5	35°C	24	7	604	26.84	31.06
81									621	27.60	
82									721.8	32.08	
83	12%	10%	13	22	32+33/2 =32.5	35°C	24	7	686	30.50	31.94
84									748	33.24	
85									650.3	28.90	
86	15%	10%	13	20.5	31+30/2 =30.5	35°C	24	7	596	26.50	27.86
87									634	28.18	



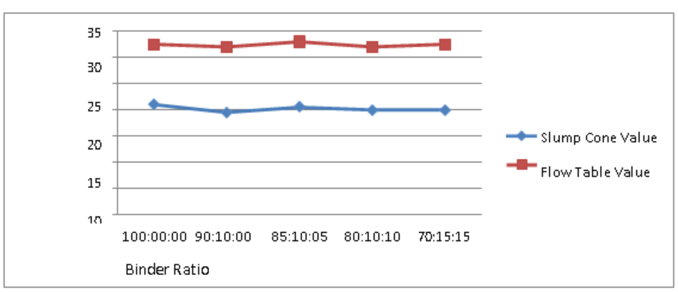
Graph No 3: Replacement of Lime Vs Slump & Flow Table Value.



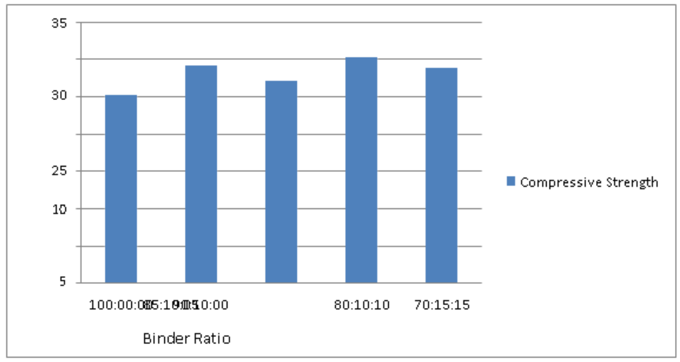
Graph No 4: Replacement of Lime Vs Comp. Strength

Table No 7: Lime Replacement Effect on Binder Ratio:-

Cube No	Binder Ratio	Lime Addition	Mo-le	Slump Value (CM)	Flow Table Test (CM)	Curing Temp-rature	Curing Time (Hrs.)	Rest period (Day)	Compre-ssive Load (KN)	Compre-ssive Strength (N/mm²)	Average Compre-ssive Strength (N/mm²)
88	100:0:0	10%	13	21	32+33/2 =32.5	34ºC	24	7	571	25.37	25.16
89									541.8	24.08	
90									586	26.04	
91	90:10:0	10%	13	19.5	36+28/2 =32	34ºC	24	7	650	28.88	29.11
92									678	30.13	
93									637.2	28.32	
94	85:10:5	10%	13	20.5	38+32/2 =33	34ºC	24	7	634	28.18	27.13
95									619.2	27.52	
96									578	25.69	
97	80:10:10	10%	13	20	32+32/2 =32	34ºC	24	7	689.2	30.63	30.31
98									676	30.04	
99									681	30.26	
100	70:15:15	10%	13	20	32+33/2 =32.50	34ºC	24	7	660	29.30	28.91
101									634.8	28.21	
102									658	29.24	



Graph No 5: Binder Ratio Vs Slump & Flow Value



Graph No 6: Binder Ratio Vs Comp. Strength

VII. CONCLUSIONS

1. Max result for compressive test with aggr ratio 30:70. The strength goes on decreasing with aggr ratio40:60, 35:65, 20:80 respectively.
2. Aggr ratio does not show considerable effect on slump and flow test result.
3. Replacement of lime with cement shows good binding property and compressive strength goes on increasing with increasing percentage of replacement of cement to lime.
4. Slump and flow test result goes on increasing with increasing percentage of cement replacement to lime.

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