Effect of Water to Geopolymer Binder Ratio and Curing Methods on Fly Ash based Concrete

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Abstract— The experiments were conducted on fly ash based geopolymer concrete by varying water to geopolymer binder ratio 0.25, 0.30, 0.35, 0.40. Total four mixes were prepared with alkaline activators (NaOH solution concentration of 13M and Na2SiO3 solution) for natural curing and artificial curing. Flexural strength test is conducted on each of the four mixes. The results of investigation indicate that there is increase in strength with increase in temperature. Also it was seen that water to cementitious material ratio of 0.30 the results were promising. Hence geopolymer concrete has a greater potential for utilization in construction industry as it is environmental friendly and also facilitate the use of fly ash, which is a waste product from thermal power plant.

Key words: Geopolymer, Fly Ash, Temperature, Curing, Alkaline Activator

I. INTRODUCTION

Geopolymer is produced by a polymeric reaction of alkaline liquid with source material of geological origin or byproduct material such as fly ash [1, 4]. In terms of reducing global warming, geopolymer technology could reduce approximately 80% of CO_2 emission to the atmosphere caused by cement and aggregate industry [5]. Compared with Ordinary Portland Cement concrete, geopolymer show many advantages. Geopolymer show substantially superior resistance to fire and acid attack and much less shrinkage than OPC concrete. Geopolymer concrete can obtain 70% of the final compressive strength in the first four hours of setting [2]. The tensile strength of geopolymer concrete falls within the range predicted for OPC based concrete. Also, the flexural strengths are generally higher than the standard model line for OPC based concrete [5]. This favorable behavior can be attributed to the type of matrix formation in geopolymer concrete. It has been reported that the stress strain relationship of fly ash based geopolymer concrete is almost similar to that of ordinary Portland cement concrete [1].

II. LITERATURE SURVEY

Davidovits (1988; 1994) [5] 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.

Davidovits, Djwantoro Hardjito, A. Palomo and A. Fernandez-Jimenez, N.P. Rajamane, Barbosa, and Zhang Yunsheng and Sun Wei studded the geopolymer concrete using fly ash and or Metakaoline as source material and activated by sodium hydroxide and sodium silicate solutions. Most of the past research on the behavior of geo-polymetric material was based on binder paste or mortar using small size samples.

Joseph Davidovits in developed amorphous to semi-crystalline three dimensional silico-aluminate materials in 1979 called as geopolymer. These are the mineral polymers resulting from geochemistry or geosynthetic. Geopolymerization is a geosynthesis that allows the products to exhibit the most ideal properties of rock- forming elements, i.e., hardness, chemical stability, etc. The author designated the geopolymers as poly (sialates) which is an abbreviation for poly (silico-oxo-aluminate) or (-Si-O-AI-O-) n in which n is the degree of polymerization. Developed for industrial applications are either crystalline or non-crystalline.

Joseph Davidovits found that the naturally occurring alumina- sialates, such as kaolinite, are transformed into three-dimensional tecto-alumina- sialates at low temperature. This basic innovation, the low-temperature transformation from kaolinite into hydrosodalite, demonstrated the tremendous potential of this new mineral reaction. The thermosetting method is very similar that used for the polycondensation of organic resins. The process yields nano-composites that are actually man-made rocks. This geosynthesis is manifest in nature itself in great abundance. At least 55% of the volume of the Earth's crust is composed of siloxo-sialates and sialates, with pure silica or quartz at only 12%.

The author also reported that the chemical CO2 emission from cement manufacturing is 8 times higher than emissions resulting from metallurgical activities. Since the 1970 decade, due to the exponential uses of concrete, cement production has increased at a much higher speed than atmospheric CO2 concentration. Geopolymetric cementitious systems would reduce CO2 emission caused by cement and concrete industries by 80% to 90%.

III. EXPERIMENTAL WORK

We have tested Geopolymer concrete for following Test.

- Flexural Strength test
- Workability Test.

Water/Cementitious ratio	0.25	0.3	0.35	0.4
Coarse aggregates:				
20 mm	19.5	19.5	19.5	19.5
12.5mm	10.5	10.5	10.5	10.5
Fine sand	15	15	15	15
Fly ash(P-63)	10	10	10	10
NaOH solution	1.75	1.75	1.75	1.75
Na_2SiO_3 solution	1.75	1.75	1.75	1.75
Extra water	1.45	1.5	2.1	2.68

Table 1: Geopolymer Concrete Mixture Proportions for 4 Beams (All Values Are In Kg)

IV. Results and Discussions

A. *For Flexural Strength*

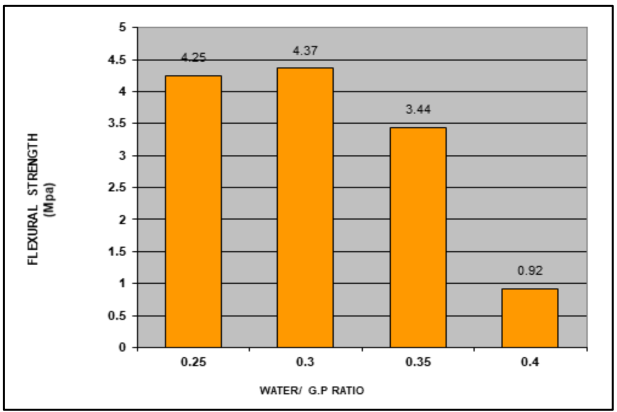

Fig. 1: Effect of various Water/Binder ratios on flexural strength. (Natural Curing).

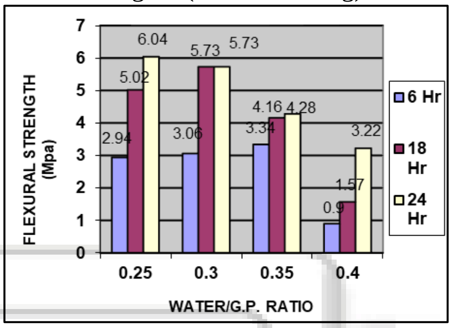

Fig. 2: Effect of various Water/Binder ratio & temperature on flexural strength. (Oven Curing).

B. *For Workability Test*

Sr. No.	Workability Tests	Water/ Geopolymer binder ratio			
		0.25	0.3	0.4	0.4
1	Slump (mm)	6	105	155	190
2	Flow Table (%)	30.7	43	54	80.7
3	Compaction Factor	0.9	0.9	0.9	0.92

Table 2: Workability for geopolymer Concrete for Various W/G.P. Ratios

C. *Cost Comparison*

Items	C.C.C. Kg.	Rate Rs./ Kg.	Cost Rs.	G.P.C. Kg.	Rate Rs. /kg.	Cost Rs.
Cement	454.54	6	2727	----	----	----
Fly ash	----	----	----	384.01	0.4	154
Sand	681.81	----	----	681.81	----	----
C.A. (20mm)	886.36	----	----	886.36	----	----
C.A. (12.5 mm)	886.36	----	----	477.26	----	----
Na_2SiO_3	----	----	----	80	10	800
NaOH	----	----	----	42.95	27	1160
Water	136..32	----	----	47.614	----	---
		Total Rs.	2727		Total Rs.	2114

Table 3: Cost Comparison between Cement Concrete and Geopolymer Concrete for 1 M3

V. Conclusion

Geopolymer concrete is more environmental & ecofriendly in upcoming future and has the potential to replace ordinary cement concrete in many applications such as precast units, green technology and self-compaction technique, as it gives 20 to 30 % more flexural strength than cement concrete also shows good workability.

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