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EFFECT ON FLEXURAL STRENGTH OF GEOPOLYMER CONCRETE BY USING FLY ASH AND ALKALINE SOLUTION AS A 100% REPLACEMENT OF CEMENT

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Abstract: With the passing of times, the emission of Carbon from different aspects are on a verge of rise, as the time passes by the rate goes on increasing, production of cement also adds up in the emission of carbon, Replacing Cement 100% by Fly Ash is a step taken to decrease the carbon emission from concrete, By replacing Geo-polymers in concrete in place of cement by using waste materials as binders, & implementing various curing techniques to provide strength to our units.

Keywords: Geopolymer, Fly ash, Alkaline Solution, Flexural Strength, Replacing Cement, Reduce Carbon emission in atmosphere

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INTRODUCTION

Geopolymers are new materials for fire and heat-resistant coatings and adhesives, medicinal applications, high-temperature ceramics, new binders for fire-resistant fiber composites, toxic and radioactive waste encapsulation and new cements for concrete[1].

The properties and uses of geopolymers are being explored in many scientific and industrial disciplines: modern inorganic chemistry, physical chemistry, colloid chemistry, mineralogy, geology, and in other types of engineering process technologies.

Geopolymers are part of polymer science, chemistry and technology that forms one of the major areas of materials science. Polymers are either organic material, i.e. carbon-based, or inorganic polymer, for example silicon-based.

The organic polymers comprise the classes of natural polymers (rubber, cellulose), synthetic organic polymers (textile fibers, plastics, films, elastomers, etc.) and natural biopolymers (biology, medicine, pharmacy) [2]. Raw materials used in the synthesis of silicon-based polymers are mainly rock-forming minerals of geological origin [3].

MATERIALS

This includes materials and their specifications the tests performed on geopolymer concrete as per relevant standards and details of making and testing of geopolymer concrete. On the basis of literature review and trails experimental program was derived. It specifies the materials (such as fly ash), mixture proportion, parameters such as ratio of alkaline solution to source material, methods of curing, tests to be performed, period of testing. The materials used for making fly ash-based geopolymer concrete specimens are fly ash as the source material, aggregates, alkaline solution, and water.

Alkaline solution:-

The alkaline liquid used was a combination of sodium silicate solution and sodium hydroxide solution. The sodium silicate solution (Na_2O = 13.7%, SiO_2 = 29.4%, and water = 55.9% by mass) was purchased from a local supplier in bulk. The sodium hydroxide (NaOH) in flakes or pellets from with 97%-98% purity was also purchased from a local supplier in bulk. The NaOH solids were dissolved in water to make the solution.

Table -1: Chemical Properties of Fly Ash

Chemical composition weight %	Fly Ash
SiO_2	53.79
Al_2O_3	32.97
Fe_2O_3	5.51
CaO	1.84
MgO	0.92
Na_2O	0.37
K_2O	1.76
TiO_2	2.10
SO_3	0.46
P_2O_5	0.15

Table -2: Sieve analysis of Fine Aggregate

Sieve	Retain	Retain	Cumulative	Passing
	Gm	%	%	%
10 mm	0	0	-	10
4.75 mm	6	3	3	97
2.36 mm	38	19	21	79
1.18 mm	54	27	48	52
600	31	15.5	63.5	36.5
300	43	21.5	85	15
150	10	5	90	10
Pan	20	10	100	0

Table -3: Sieve analysis of Coarse Aggregate

COARSE AGGREGATE 10 MM				
Sieve	Retain	Retain	Cumulative	Passing
	Gm	%	%	%
12.5	16	0.8	0.8	99.2
10	212	10.6	11.4	88.6
4.75	1445	72.25	83.65	16.35
2.36	308	15.4	99.05	0.95

Silica Fume:-

Silica fume is a by product of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable. Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete production. Placing, finishing, and curing silica-fume concrete require special attention on the part of the concrete contractor.

MIX DESIGN

Table -4: Mix Design for One Beam

Materials	Weight in kg
Fly Ash	2.51
Fine Aggregate (sand)	2.76
Coarse Aggregate (10mm)	1.86
Coarse Aggregate (20mm)	1.86
Silica Fume	0.93
Alkaline Solution	
NaOH Flakes	0.21
Water	0.26
Na_2siO_3	1.19

Table -5: Different Proportion for Test

M30	G1	G2	G3	G4	G5	G6	G7	G8
FLY ASH	2.51	2.51	2.51	2.51	3.69	3.69	3.69	3.69
F.A	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76
C.A. (10mm)	1.86	2.232	1.488	3.72	1.86	2.232	1.488	3.72
C.A.(20mm)	1.86	1.488	2.232	-	1.86	1.488	2.232	-
SILICA FUME	0.93	0.93	0.93	0.93	0.21	0.21	0.21	0.21
NaOH	0.21	0.21	0.21	0.21	0.26	0.26	0.26	0.26
WATER	0.26	0.26	0.26	0.26	1.19	1.19	1.19	1.19
Na_2SiO_3	1.19	1.19	1.19	1.19				

EXPERIMENTAL PROGRAM

Geopolymer Concrete Beams having grade M30 were made by fly Ash as a 100% replacement of cement and Alkaline Solution. Moulds with dimensions of 500 mm X 100mm X 100 mm. After casting, all moulds were cured by 5 different methods natural, Self, Oven cured, by Adding Accelerometer as an admixture and cured by silica fume. Mix proportion of geopolymer concrete as per table – 6.

Table – 6 Flexural test results of 28th and 56th days

TYPE	28th Days			56th Days			f_{ck}(N/mm²)	Eqn (as per IS:456-2000)
	P(kN)	M(kN.m)	f_{cr}(N/mm²)	P(kN)	M(kN.m)	F_{cr}(N/mm²)		
G1	10.67	0.71	4.36	11.33	0.75	4.53	30	3.83
G2	10	0.65	4.21	10.67	0.73	4.36	30	3.83
G3	10.33	0.69	4.23	11.33	0.75	4.53	30	3.83
G4	11	0.74	4.45	11.67	0.79	4.87	30	3.83
G5	11.33	0.75	4.53	12.33	0.82	4.93	30	3.83
G6	12.33	0.83	5.39	13.33	0.88	5.33	30	3.83
G7	15.67	1.04	6.26	17	1.13	6.79	30	3.83
G8	13.33	0.79	5.67	15.67	1.04	6.26	30	3.83

Fig – 1 Mixing of Geopolymer Concrete

Fig – 2 Beam after Flexural Test

CONCLUSION

- The maximum Flexural strength 15.67 and 17 respectively for 28th and 56th day for G7 (Having maximum C.A. content and minimum Silica fume).

- Increasing the Silica Fume content in Geopolymer Concrete will decrease the Flexural strength of Geopolymer Concrete.
- The maximum Flexural Strength gain from the Oven Curing of 24 hours.
- Also Increasing the C.A./F.A. ratio increase the Flexural Strength.

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