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Effect of Alkali Activators on Strength Characteristics of GPC

Mohammed Asim Ahmed¹, Mohammed Faisaluddin², Nadeem Pasha³, Md Mansoor Ahmed⁴

P.G. Student, Department of Civil Engineering, K.B.N College of Engineering, Kalaburagi, Karnataka, India¹

Assistant Professor, Department of Civil Engineering, K.B.N College of Engg, Kalaburagi, Karnataka, India²

Assistant Professor, Department of Civil Engineering, K.B.N College of Engg, Kalaburagi, Karnataka, India³

Assistant Professor, Department of Civil Engineering, K.B.N College of Engg, Kalaburagi, Karnataka, India⁴

ABSTRACT: Geopolymer concrete technology has the prospective to reduce worldwide carbon emission and lead to a sustainable development and growth of a concrete industry. This study represents “Effects of Alkali Activators on Strength Characteristics of GPC” This study presents the demonstration of total six different trial composition of alkaline activators were used with concrete grade M40. From those three combinations is selected for studies as Binder ratio=0.4 at different molarities(10M,12M,14M) Remaining 3 combinations is selected for studies as Binder ratio=2.5 at different molarities(10M,12M,14M). 1 set of M40 grade OPC is made for comparison with GPCs. Compression strength test results Split Tensile strength test results and Flexural strength test results were compared at 7 days and 28days. Geopolymer concrete with Binder ratio=2.5 and Molarity of NaOH =14M was obtained as the optimum dosage of Alkaline liquid for Compression strength test, Split Tensile strength test and Flexural strength test. Geopolymer concrete with Binder ratio=0.4 and Molarity of NaOH =10M was obtained as the least compressive strength test value, least Split Tensile strength test value and least Flexural strength test value.

KEYWORDS: Geopolymer concrete, alkaline solution, Molarity, Binder Ratio.

I. INTRODUCTION

The emission of CO₂ during the production of OPC is tremendous. The Geopolymer technology is an alternative to application in concrete industry. Geopolymers have increasing interest world wide as an alternative to OPC for concrete due to limited reserve of limestones, limited manufacturing growth of cement and increasing carbon taxes. Geopolymers have high early compressive strength low drying shrinkage good fire resistance and superior durability in aggressive environment compared to Portland cement concrete.

The term GPC was coined by the Davidovits in 1979. Geopolymer concrete was introduced to reduce the amount of CO₂ emits in the Environment during manufacturing of cement. Geopolymer technology reduces carbon dioxide emission in to the atmosphere by 80%. The structural model of the Geopolymer materials is still under investigation. Many efforts has been done to reduce the use of Portland cement. The Geo polymer concrete is a inorganic polymer composite, which are environmentally friendly construction. Following materials were used to produce Geopolymer concrete.

- 1) Fly ash
- 2) Fine aggregates (in the form of river sand)
- 3) Coarse aggregates (in the form of crushed stone)

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- 4) AAS – a mixture of SiO_2 and NaOH, beside distilled water.
- 5) Super plasticizer (Masterpel 777)

II. RELATED WORK

Yasir Sofi and Iftekar Gull (2015) proposed to concentrate the properties of fly ash based Geopolymer concrete. M20 review GPC can be framed by choosing nominal mix of 1:1.5:3 (fly ash: fine aggregates: coarse aggregates) by fluctuating alkaline fluid to fly ash remains proportion from 0.3 to 0.45. The compressive strength tensile strength and flexural strength tests were directed on Geopolymer concrete and parameters that influence it are dissected and demonstrated tentatively. The durability properties like permeability and acid attack are additionally considered. From the test outcomes it was reasoned that Geopolymer concrete has good compressive strength and offers good durability characteristics. With the expansion of alkaline liquid to fly ash proportion strength reductions and alkaline liquid to fly ash proportion under 0.3 is very stiff.

P. K. Jamdade and U. R. Kawade (2014) concentrated the strength of Geopolymer concrete by utilizing oven curing. In this review Geopolymer concrete is set up by blending sodium silicate and sodium hydroxide with handled fly ash. The concrete is cured at various condition and distinctive temperatures i.e 60°C , 90°C and 120°C in order to expand the strength of concrete. It was watched that higher curing temperature brought about bigger compressive strength of Geopolymer concrete despite the fact that an expansion in the curing temperature past 60°C did not build the compressive strength generously. Additionally longer curing time enhanced the polymerization procedure bringing about higher compressive strength of Geopolymer concrete.

S. Jaydeep and B. J. Chakravarthy(2013) arranged an ideal blend for Geopolymer concrete utilizing admixtures. concrete shapes of size $150 \times 150 \times 150\text{mm}$ were set up to discover compressive strength at 7 and 28 days. Comes about demonstrated that the expansion of sodium silicate solution to the sodium hydroxide solution as a alkaline activator upgraded the response between the source material and solution. Oven cured specimen gives the higher compressive strength when contrasted with direct daylight curing. It was additionally watched that Geopolymer concrete is more invaluable practical and eco friendly technique when contrasted and regular concrete

Aminul Islam Laskar and Rajan Bhattacharjee(2012) explored the variety of workability of fly ash based Geopolymer concrete with the variety of lignin based plasticizer and poly carboxylic ether based superplasticizer. It has been watched that there exists a basic estimation of molar quality of sodium hydroxide past which super plasticizer and plasticizer have unfriendly impact on workability of fly ash based Geopolymer concrete. There is an expansion in slump below the critical molar strength of sodium hydroxide. Lignin based original plasticizer demonstrates better execution regarding workability over third era super plasticizer underneath the basic estimation of molar quality. It was additionally watched that there is a decent relationship between the rheological parameters and slump for fly ash based Geopolymer concrete joining plasticizer and super plasticizer.

Monita and Hamid R. Nikraz(2011) concentrated the strength characteristics water absorption and water porousness of low calcium fly ash based Geopolymer concrete. Blends with varieties of water/binder proportion aggregate/binder proportion aggregate grading and alkaline/fly ash ratio were examined. Comes about demonstrated that a decent quality concrete was gotten by diminishing the water/binder proportion and aggregate/binder proportion and the water retention of low calcium fly ash remains Geopolymer was enhanced by diminishing the water/binder proportion expanding the fly ash substance and utilizing an a well graded aggregate. No huge change was seen in water porousness coefficient for the Geopolymer with various parameters.

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III. PROPOSED METHODOLOGY AND DISCUSSION

PREPARATION OF ALKALINE SOLUTION

For preparation of Alkaline solution, $14 \times 40 = 560$ g of NaOH fillets is dissolved in 1 litre of water to prepare the sodium hydroxide solution of 14M. After 20 to 30 minutes sodium silicate 2.5kg is added. This solution is prepared one day prior to use. SiO_2 to NaOH ratio is fixed to 2.5.

3.1 DRY MIXING

Manually mixing is done in a pan. Fly ash, FA and CA is mixed in a pan.



Figure:1 Dry Mixing

3.2 WET MIXING

After dry mixing, the alkaline liquid which is prepared one day prior is added to the mix. Super plasticizer is added to the required amount. Extra water is added for better workability.



Figure:2 Wet Mixing

3.3 SPECIMEN CASTING

The fresh fly ash-GGBS based GPC was very cohesive. The amount of extra water plays a very vital role in the workability of concrete. Some standard process of mixing is studied.

1. Mix NaOH solution and SiO_2 solutions one day prior of casting.
2. First mix dry materials in the pan mix it for 180 seconds after that add liquid to the mixture and mix for 240

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second's.



Figure3: Casting of Specimens

3.4 AMBIENT CURING

When the room temperature was higher than the 30°C, the concrete didn't get hardening at least for 20hrs. Handling time of concrete is most vital parameter for fly ash based geopolymer concrete.

3.5 MIX DESIGN

Mix design is done based on the literature available as there is no code provision of mix design for geopolymer concrete.

1. SiO₂ to NaOH solutions ratio is fixed to 2.5 and 0.4.
2. Molarities of NaOH solution is 10M, 12M, and 14M.
3. Liquid to binder ratio is fixed to 0.5.
4. Coarse and Fine aggregate is close to 75% of the entire mixture by mass
5. Super plasticizer is on the range of 0% to 2.5% of binders.
6. Extra water when needed.

3.6 MIX PROPORTION

The initial density of GPC was assumed as 2400 kg/m³, the mass of combine aggregates(fine aggregate and coarse aggregate) is 75% of initial density of GPC. 4.75mm fine aggregate were taken as 35% of combine weight of

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aggregates and coarse aggregate were taken as 65% of combine weight of aggregates. Fineness modulus is 5 and the remaining mass is of both alkaline solution and binders (fly ash) assuming sodium hydroxide to sodium silicate ratio is 2.5 and 0.4. The mix is for M40 grade of concrete.

TABLE 1.MIX PROPORTION IN KG/M³

Grade of GPC	Na ₂ SiO ₃ /NaOH	Molarity	Flyash (kg/m ³)	FA (kg/m ³)	CA (kg/m ³)		Alkaline solution (kg/m ³)	Extra Water (kg/m ³)	SP (kg/m ³)
					12 mm	19 mm			
M 40	2.5	10M	428.57	580	380	880	94.60	57.02	10.71
		12M	428.57	580	380	880	92.73	59.451	10.71
		14M	428.57	580	380	880	91.02	61.67	10.71
M 40	0.4	10M	428.57	580	380	880	111.28	35.34	10.71
		12M	428.57	580	380	880	106.63	41.66	10.71
		14M	428.57	580	380	880	102.35	46.95	10.71

TABLE.2 DRY & WET VOLUME QUANTITY OF MATERIALS REQUIRED FOR 3 CUBES 3 CYLINDERS 3 PRISMS SPECIMENS.

Specimen type	Flyash (kg)	Fine aggregate(kg)	Course Aggregate(kg)	Water(ltr)
Cubes	7.449	10.053	21.897	2.535
Cylinder	11.691	15.782	34.371	3.974
Prism	11	14.891	32.427	3.749

Specimen type	Flyash (kg)	Fine aggregate(kg)	Course Aggregate(kg)	Water(ltr)
Cubes	4.965	6.702	14.598	1.689
Cylinder	7.794	10.521	22.914	2.649
Prism	7.353	9.927	21.618	2.499

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FRESH GEO-POLYMER CONCRETE(GPC)

The fresh geo-polymer concrete can be handled up to 80 minutes with slump up to 200mm.

DESIGNATION OF CONCRETE SPECIMENS WITH MEANINGS

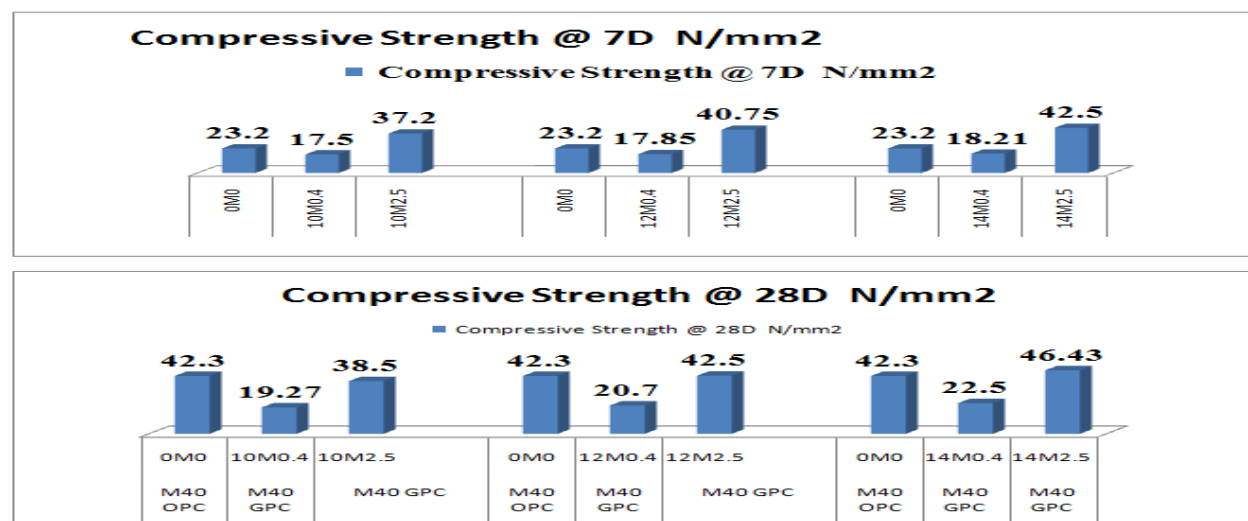
Designation of Concrete	Meaning	Designation on Specimen(lab)
0M0	Conventional Concrete	M
10M2.5	GPC with NaOH (10 Molarity) & Binder Ratio of 2.5	M1
12M2.5	GPC with NaOH (12 Molarity) & Binder Ratio of 2.5	M2
14M2.5	GPC with NaOH (14 Molarity) & Binder Ratio of 2.5	M3
10M0.4	GPC with NaOH (10 Molarity) & Binder Ratio of 2.5	M4
12M0.4	GPC with NaOH (12 Molarity) & Binder Ratio of 2.5	M5
14M0.4	GPC with NaOH (14 Molarity) & Binder Ratio of 2.5	M6

IV. EXPERIMENTAL INVESTIGATION AND RESULTS

COMPRESSIVE STRENGTH (IS 516-1959)

150 x 150 x 150mm size cube were tested for cube compression testing at 7th day and 28th day. Concrete cubes of OPC and GPC of 10M, 12M and 14M were cast. The Geopolymer concrete cubes were cured at ambient temperature.

GRAPH.1 VARIATION OF COMPRESSIVE STRENGTH WITH MOLARITIES AND AGES



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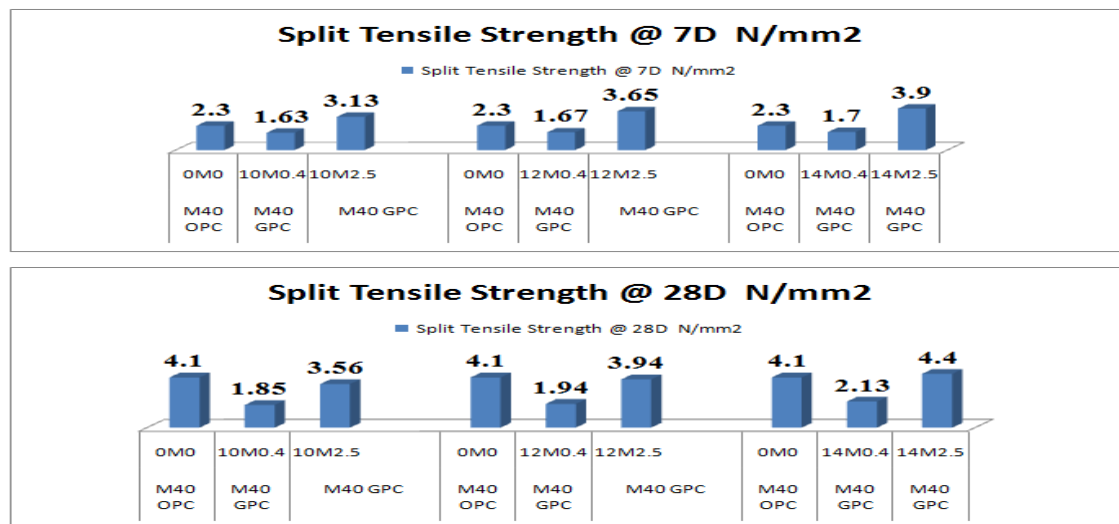
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SPLIT TENSILE STRENGTH (IS 5816-1970)

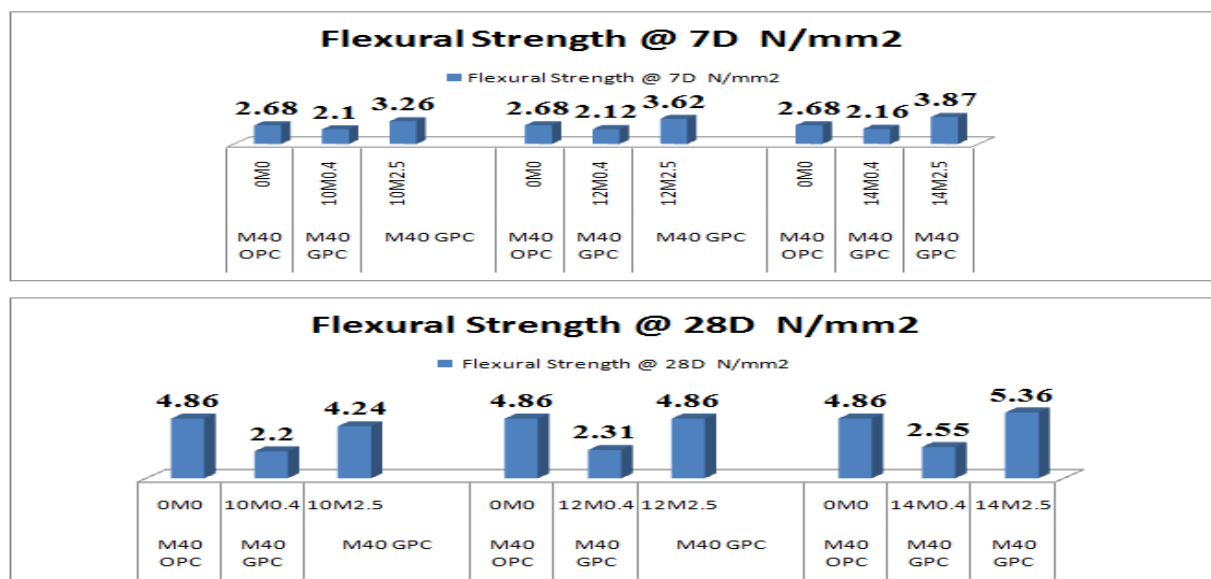
Geopolymer concrete cylinder of 8M, 12M and 16M were casted. The cylinders were cured at ambient temperature.

GRAPH 2 VARIATION OF SPLIT TENSILE STRENGTH WITH MOLARITIES



FLEXURAL STRENGTH (IS 516-1959)

GRAPH .3 VARIATION OF FLEXURAL STRENGTH WITH MOLARITIES



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V. CONCLUSION

1. To develop geopolymer concrete mix lots of trial and error has to be carried out, after various trials Geopolymer concrete 428.57 kg/m^3 of Fly ash, 1260 kg/m^3 of Coarse Aggregate, 580 kg/m^3 of Fine Aggregate, 91.02 kg/m^3 of Alkaline Solution and 61.67 kg/m^3 of extra Water with 10.71 kg/m^3 of Super plasticizer is used to prepare GPC of 14 Molarity and Binder ratio of 2.5 is found to be ideal.
2. As the molarities increases cohesiveness increases.
3. As the liquid to binder ratio increases setting time of concrete decreases.
4. As the liquid to binder ratio decreases, requirement of extra water increases.
5. Main point of Observation is the Quantity of NaOH & Na_2SiO_3 Solid varies as the molarity and Binder Ratios varies (Optimum dosage of NaOH Flakes is M14 Molarity and Least with M10 Molarity)-refer GPC Mix Design.
6. Geopolymer concrete with Binder ratio=2.5 and Molarity of NaOH =14M was obtained as the optimum dosage of Alkaline liquid for Compressive strength test (46.43 N/mm^2), Split Tensile strength test (4.4 N/mm^2) and Flexural strength test (5.36 N/mm^2) at 28 Days.
7. Geopolymer concrete with Binder ratio=0.4 and Molarity of NaOH =10M was obtained as the least compressive strength test value (19.27 N/mm^2), least Split Tensile strength test value (1.85 N/mm^2) and least Flexural strength test value (2.2 N/mm^2) at 28 Days.

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