Technium Vol. 2, Issue 3 pp.128-133 (2020)
ISSN: 2668-778X
www.techniumscience.com

Dominance of Material Composition on Mechanical Properties of Normal & High Strength Grade Binary Blended Geopolymer Concrete

Addepalli Mallinadh Kashyap[1], Tanimki Chandra Sekhar Rao[2],N.V.Ramana Rao[3]

[1]Ph.D Scholar, Department of Civil Engineering, JNT University,Hyderabad, India
[2]Professor,Department of Civil Engineering, Bapatla Engineering College, Bapatla, India
[3]Director, National Institute of Technology, Warangal, India
mallinadhkashyap@gmail.com

Abstract. The utilisation of pozzolanic materials as the replacement to conventional cement material have the potentiality to mitigate the pollution caused by the émission of carbon based green house gases which are a main source for global warming problem. For every production of 1 ton of cement it was approximated that the emission of carbon based green house gases are about 1 ton. Keeping this in view, a new material called Geopolymer which was first coined by Davidovits has gained a lot of interest by the researchers. In this study, different molarity variations of NaOH in the order of 4M, 6M, 8M, 10M, 12M and 14M and also the blending of mineral admixtures like Fly Ash and Ground Granulated Blast Furnace Slag with percentages (50%+50%) and the mechanical properties of normal M30 and high strength grade M70 binary blended Geopolymer concrete were studied after 28 days of ambient curing and were reported. The test results revealed that the effect of molar concentration of NaOH at 12 M is effective and the optimum replacement of mineral composition of source materials is (50%+50%) fly ash and ground granulated blast furnace slag.

Keywords. pozzolanic materials, molarity, fly ash, ground granulated blast furnace slag

1.INTRODUCTION

Cement concrete is the most used material in the construction. The concrete material is generally produced by the combination of Ordinary Portland Cement as the material binder, fine and coarse aggregates and water. Due to the emission of green house gases in the production of cement, a new material called Geo polymer which was coined by Davidovits in the year 1991 [1] has proven to be an effective material for the replacement of cement concrete in the regard of green house emissions into the atmosphere during the production of cement. Mohammed Al-majidi et al.,(2016) [2] investigated and concluded that the inclusion of silica fume in the fly ash based Geo polymer concrete impacts the setting time, workability and the strength criteria. Supriya Kulkarni (2018) [3] reported that Geo polymer with fly ash based shown better properties than the normal cement content in terms of mechanical properties, durability aspects and elevated temperatures. Amer Hassan (2018) [4] concluded that the use of fly ash based Geo polymer concrete is proved to be an environmental eco friendly material than ordinary Portland cement concrete in precast elements. Also he concluded that the replacement of 40% and 60% ground granulated blast furnace slag to fly ash reported high mechanical properties in oven curing. Shaswat Kumar Das et al., (2019) [5] reported the environmental issues by means of various

data collection and surveys related to green house emissions and the sustainability of supplementary cementitious materials in the use of Geo polymer concrete were presented. The strength properties of geopolymer are greatly influenced by the concentration and molarity of the alkaline activator i.e., Sodium Hydroxide (NaOH). With the increase in the concentration of the molarity of NaOH, the strength of the geo polymer concrete also increases significantly up to a specific level. This study also concluded the same. The compressive strength properties were identified by the compressive strength test at the age of 1,3,7,14 and 28 days of curing.

2.EXPERIMENTAL INVESTIGATION

Class F Fly ash is procured from Vijayawada Thermal Power Station and Ground Granulated Blast Furnace Slag (GGBS) is procured from Vizag Steel Plant were used as source materials to prepare the geo polymer concrete. These source materials are rich in calcium oxide and silicon contents which accelerates the pozzolanic activity. The sodium silicate to sodium hydroxide ratio adopted in the present study is 2.5.

2.1. Mix design and proportion

Mix design for the Geo polymer concrete was done on par with the normal concrete design.M30 grade concrete was designed as per IS:10262-2009 and M70 grade concrete was designed as per ACI:211-4R-1998 and the mix proportions were furnished in Table:1.

Table: 1 Mix Design of M30 normal grade & M70 grade High strength grade Geo polymer Concrete

S.No	Constituents	M30 grade Quantity(kg/m^3)	M70 grade Quantity(kg/m^3)
1.	Binder content(GGBS+Fly ash)	360	410.70
2.	Fine aggregate	798	770.00
3.	Coarse aggregate	882	1155.00
4.	Sodium Silicate solution	70.8	117.30
5.	Sodium Hydroxide solution	28.3	47.00
6.	Admixture (1.5%)	6.075	6.2
7.	Extra water (10%)	40.5	41.07

The experimental investigation was divided into two phases. In the first phase of study, Cube specimens of size 150 mm x 150 mm x 150 mm were casted for varying molarities of 4M , 6M,8M,10M,12M, and 14M and the compressive strength property was studied after 1,3,7,14,& 28 days of ambient curing and after obtaining the optimum molarity value for (50%+50%) of fly ash and ground granulated blast furnace slag and the cylinder specimens of sizes 150 mm x 300 mm and prism specimens of 500 mm x 100 mm x 100 mm were casted to know the mechanical properties of the normal and high strength grade geopolymer concrete. Ambient curing was done to the casted Geopolymer Concrete specimens.

2.1. Testing of specimens

The compressive strength test was carried out by using Compression Testing Machine of capacity 2000 kN Capacity and the split tensile test was also carried on C.T.M and the flexural strength was carried out on the Universal Testing Machine.

3. RESULTS AND DISCUSSIONS

3.1. Strength development of normal grade and high strength grade geo polymer concretes.

Table 2 and Figure 1 presents the strength gain of normal grade geo polymer concrete of grade M30 with the change in molarity content of sodium hydroxide for different days of ambient curing.

Table 2. Compressive strength of M30 grade geo polymer concrete cured in ambient condition

Technium Vol. 2, Issue 3 pp.128-133 (2020)
ISSN: 2668-778X
www.techniumscience.com

Mix Designation	Morality of NaOH	Compressive Strength (MPa) after different test ages in ambient curing condition					
		1 day	3 days	7 days	14 days	21days	28 days
GPC – I	4	2.00	8.88	16.00	24.88	32.88	35.11
GPC – II	6	2.22	10.22	16.88	25.77	33.77	36.44
GPC –III	8	3.11	10.66	17.77	26.22	34.22	37.33
GPC –IV	10	4.00	11.55	19.11	26.66	35.11	38.22
GPC – V	12	4.81	12.00	19.55	27.11	35.11	39.00
GPC - VI	14	3.55	11.11	18.22	26.22	34.66	37.77

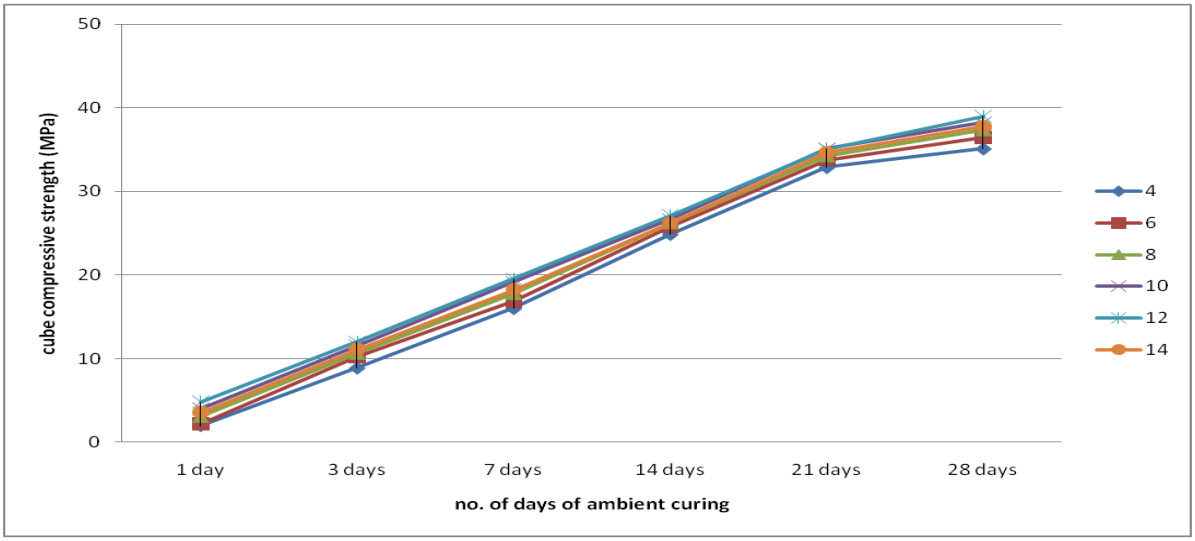

Fig. 1 Variations in compressive strength of M30 grade geopolymer Concrete with various alkali concentration for different days of ambient curing

From the above graph, it can be concluded that with the increase in alkali concentration, the compressive strength of geo polymer concrete specimens was increased. All the specimens exhibit a high compressive strength at alkali concentration of 12 Molar. Further increase in concentration of alkali content decreased the strength of geopolymer concrete.

Table 3 and Figure 2 presents the strength gain of high strength grade geo polymer concrete of grade M70 with the change in molarity content of sodium hydroxide for different days of ambient curing.

Table 2. Compressive strength of M70 grade high strength concrete cured in ambient condition

Mix Designation	Morality of NaOH	Compressive Strength (MPa) after different test ages in ambient curing condition					
		1 day	3 days	7 days	14 days	21days	28days
GPC – VII	4	8.00	37.77	52.88	59.11	68.00	74.22
GPC – VIII	6	8.88	39.11	53.77	60.00	69.77	75.11
GPC –IX	8	9.77	40.44	54.66	61.33	71.77	76.00
GPC –X	10	11.11	41.33	55.55	63.11	72.88	77.33
GPC – XI	12	12.00	43.80	56.60	65.00	74.66	78.22
GPC - XII	14	10.66	40.00	54.22	62.66	71.55	75.55

Technium Vol. 2, Issue 3 pp.128-133 (2020)
ISSN: 2668-778X
www.techniumscience.com

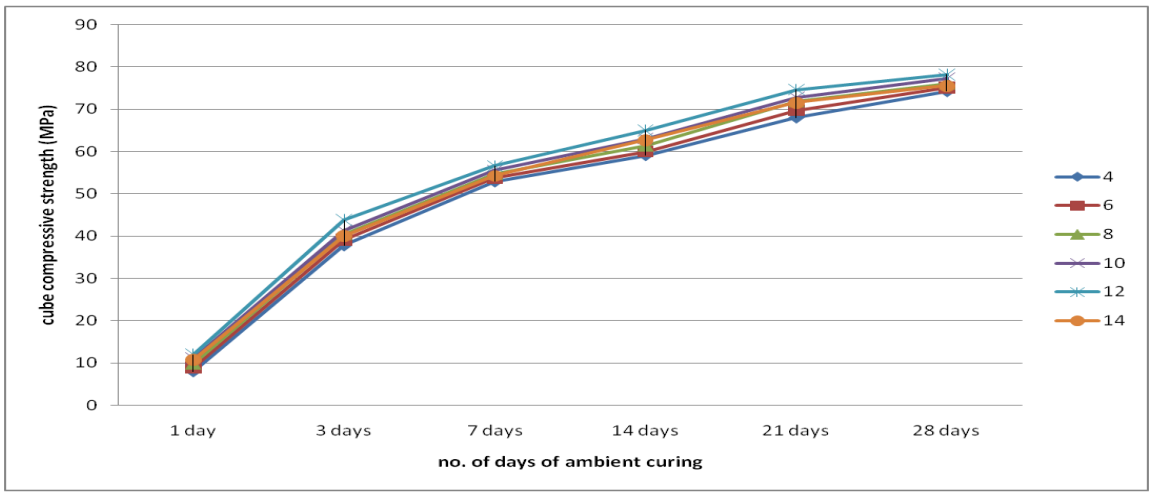

Fig. 2 Variations in compressive strength of M70 grade high strength geo polymer Concrete with various alkali concentration for different days of ambient curing

From the above graph, it can be concluded that with the increase in alkali concentration, the compressive strength of geo polymer concrete specimens was increased. All the specimens exhibit a high compressive strength at alkali concentration of 12 Molar. Further increase in concentration of alkali content decreased the strength of geopolymer concrete.

3.2 Mechanical properties of M30 and M70 grade Geo polymer Concrete

Table 3 : Mechanical Properties of M30 and M70 grade GPC after 28 days of ambient curing

Grade of Concrete	Molarity Concentration of NaOH	Compressive Strength (MPa)	Split tensile strength(MPa)	Flexural Strength (MPa)
M30	12 M	39.00	4.82	5.83
M70	12 M	78.22	5.00	5.90

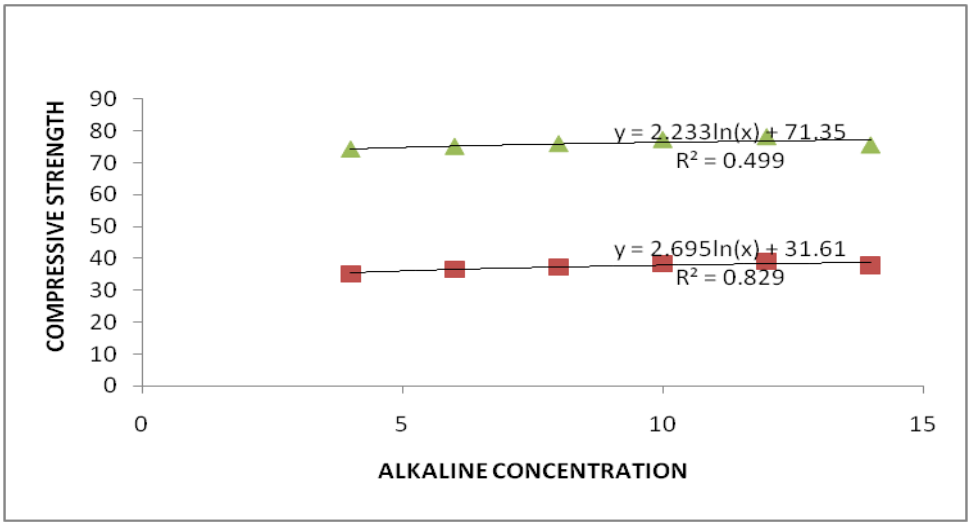

Fig.3 Relationship between alkaline concentration and compressive strength of M30 and M70 grade geo polymer concrete after 28 days of ambient curing

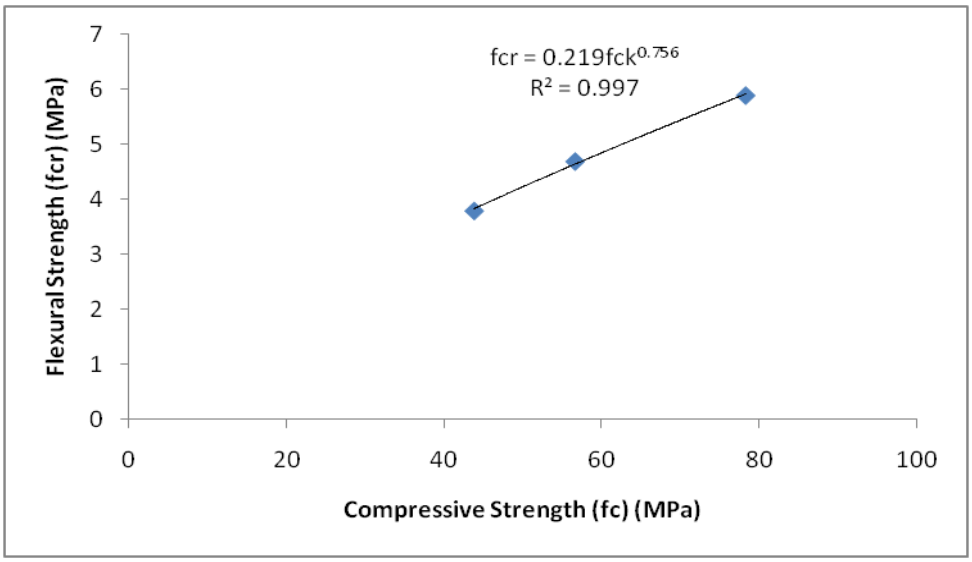

Fig.4 Relationship between compressive strength and flexural strength of geo polymer concrete after 28 days of ambient curing

From the experimental study, the following equations were drawn

Relationship between alkaline concentration and compressive strength of M30 grade concrete may be expressed as

$y=2.695\ln(x)+31.61$; $R^2= 0.829$ -------- (1)

Relationship between alkaline concentration and compressive strength of M70 grade concrete may be expressed as

$y=2.233\ln(x)+71.35$; $R^2= 0.499$ ----------(2)

Relationship between compressive strength and flexural strength of geo polymer concrete

$f_{cr}=0.219(f_{ck})^{0.756}$; $R^2 = 0.997$ --------(3)

4.Conclusion

The effect of NaOH molarity on strength development of binary blended geopolymer normal and high strength grade concretes were studied experimentally from 1 to 28 days age. The primary conclusions were drawn based on this study are:

(1) The alkaline concentration of Sodium Hydroxide significantly affected the compressive strength development of binary blended geopolymer concrete.
(2) The optimum molarity content of Sodium Hydroxide content was found to be 12 M in both the cases of normal and high strength grade concretes throughout all ages of ambient curing.
(3) The increase in molarity concentration after 12 M of Sodium Hydroxide significantly affected the compressive strength of normal and high strength grade geopolymer concrete.
(4) The experimental relationships were significantly correleated with the theoretical relationships and good agreement was achieved between them.

5.References

[1] Davidovits, J., (1991), Geopolymers: Inorganic Polymeric New Materials, J. Thermal Analysis, 37, 1633–1656.
[2] Mohammed Al-majidi (2016)," Experimental Investigaion of the Effect of Silica Fume on Geopolymer Mortar Cured under Ambient Temperature", Conference: Rheological Measurement of Building Materials 2016. At Regensburg-Germany, Volume: Proceedings of the 25th Conferences and Laboratory Workshops, 2nd and 3rd March,2016.
[3] Supriya Kulkarni (2018), "Study on Geopolymer Concrete", International Research Journal of Engineering and Technology, Volume: 05 Issue: 12 | Dec 2018.
[4] Amer Hassan (2018) **,** **"**Experimental Study of Fly Ash Based Geopolymer Concrete", International Journal of Advanced Earth Science and Engineering 2018, Volume 7, Issue 1, pp. 635-648..
[5] Shaswat Kumar Das (2019)" An Overview of Current Research Trends in Geopolymer Concrete", International Research Journal of Engineering and Technology, Volume:05, Issue:11.
[6] Antonius1 and Iswandi Imran (2012), Experimental study of low, medium and high strength concrete subjected to concentric compression, ITB J. Eng. Sci., 44(3), 252-269, 2012.
[7] Hardjito D, Wallah S E, Sumajouw D M J and Rangan B V, On the development and properties of low calcium fly ash geopolymer concrete, ACI materials journal 101(6) , 467-472.
[8] Dattreya J.K, Rajamane N.P ,Sabhitha D, Ambily P.S and Nataraja M.C, Flexural behaviour of reinforced geopolymer concrete beams, International journal of civil and structural engineering., 2(1), 138-159,2011.