6th International Conference on Multidisciplinary Research (ICMR-2019)
Osmania University Campus, Hyderabad (India)
30th-31st May 2019 www.conferenceworld.in ISBN : 978-93-87793-89-7

Effect of Binder Index on Modulus of Rupture of Fly ash based Geopolymer concrete.

Hathiram Gugulothu [1] B. Sesha Sreenivas [2] D. Rama Seshu [3]

[1]Research Scholar (Reg.No15016HD0704), Kakatiya Univ., Warangal, India,

[2] Professor and Principal, University College of Engg, Kothagudem, Kakatiya Univ., India.

[3] Professor of Civil Engineering, National Institute of Technology, Warangal, India.

Corresponding Author: Hathi Ram Gugulothu [1],

ABSTRACT: *This research work aims at finding the effect of Binder Index[1] on Modulus of Rupture of Fly ash based Geopolymer concrete. The Unit weight of Geopolymer concrete (GPC) is taken as 2400 Kg/m^3. Different Fly ash to Ground granulated blast furnace slag (GGBS) combinations (80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80) are used with 8M as alkaline molar activator. Alkaline liquid content to fly ash ratio is taken as 0.36 and fine aggregate to total aggregate ratio is taken as 32%. The ratio of sodium silicate solution to sodium hydroxide solution is taken as 2.5[(2,3)]. Three identical specimens for each variation were cast and tested after 7 days and 28 days ambient curing. Variation of Modulus of rupture with Binder index is presented and discussed.*

Key words*: *Geopolymer Concrete (GPC), Fly Ash (FA), Ground Granulated Blast Furnace Slag (GGBS), Modulus of Rupture (fcr), Binder Index (B_i), 7 days (7D), 28 days (28D), Ambient temperature.

1. INTRODUCTION

After water concrete is the second usage material around the world. The main binder used for concrete production is Ordinary Portland Cement (OPC). In addition to the energy (calcination of limestone and combustion of fossil fuel), required to produce OPC the environmental issues related are at high rate[4]. The availability of fly ash worldwide creates opportunity to utilise this by-product of burning coal, as a substitute for OPC to manufacture concrete. When added with GGBS the heat curing can be avoided to some extent.

In 1978, Davidovits proposed that binders could be produced by a polymeric reaction of alkaline liquids with the silicon and the aluminium in source materials of geological origin or by-product materials such as fly ash and rice husk ash[5]. He termed these binders as geopolymers. Palomo et al suggested that pozzolans such as blast furnace slag might be activated using alkaline liquids to form a binder and hence totally replace the use of OPC in concrete. In this scheme, the main contents to be activated are silicon and calcium in the blast furnace slag. The main binder produced is a C-S-H gel, as the result of the hydration process.

ISBN : 978-93-87793-89-7

This research article aims at finding the effect of Binder Index on Modulus of Rupture of Fly ash based GPC.

2. EXPERIMENTAL INVESTIGATION: The experimental program consisted of determination of the Modulus of rupture strength of GPC by casting and testing Prisms of size 100 mm X 100 mm X 500 mm. Seven different FA to GGBS proportions (80:20, 70:30, 60:40, 50:50, 40:60, 30:70 and 20:80) are used. Alkaline Liquid Content/FA ratio is taken as 0.36 and Fine Aggregate / Total. Aggregate ratio is taken as 32%. 8 molar solution is used throughout the experimental investigation. Three identical specimens for each variation were cast and tested for 7 days and 28 days ambient curing.

2.1 MATERIALS: Fly ash is obtained from Kothagudem Thermal Power Station, Bhadradri Kothagudem Dist, Telangana, India. GGBS is obtained from Blue way exports supplier, from Vijayawada, Andhra Pradesh, India. Specific gravity of FA and GGBS are 2.17 and 2.90 respectively. Chemical composition details of FA and GGBS are shown in Table 1. Natural river sand confirming to grading zone II of IS 383:1970 was used. Specific gravity and fineness modulus of Sand used were 2.32 and 2.81 respectively. Coarse aggregate of maximum size 20 mm from local source was used. 8 molarity of sodium hydroxide solution used. The sodium hydroxide pellets used for preparation of NaOH solution is given in table 2. The NaOH solution thus prepared is mixed with Na_2SiO_3 solution. The ratio of sodium silicate solution to sodium hydroxide solution is fixed as 2.5. The mixture was stored for 24 hours at room temperature before casting. Super Plasticizer Conplast Sp-430 is used to obtain the desired workability.

Table 1. Chemical Composition of Fly Ash and GGBS percentage by mass.

Material	SiO_2	Al_2O_3	Fe_2O_3	SO_3	CaO	MgO	Na_2O	LOI
Fly ash	60.12	26.63	4.22	0.32	4.1	1.21	0.2	0.85
GGBS	34.16	20.1	0.81	0.88	32.8	7.69	nd	.

Table 2. Materials used for NaOH solution preparation.

	8 moles/L
Sodium hydroxide pellets, (grams)	262
Potable Water (grams)	738

2.2 MIX PROPORTIONS: The Geo Polymer Concrete mix proportions are shown in table 3.

Table 3. Geo Polymer Concrete mix proportions.

ISBN : 978-93-87793-89-7

FA:GGBS	Geo Polymer Concrete mix proportions (Kg/m^3)							
	Coarse Aggregate	Fine Aggregate	Fly Ash	GGBS	NaOH Solution	Sodium Silicate	Super Plasticizer(2% of the Binder)	Extra water (7.5% of the Binder)
80:20	1100	517.45	460.16	115.04	59.10	148.25	11.50	43.15
70:30	1100	517.45	402.64	172.56	59.10	148.25	11.50	43.15
60:40	1100	517.45	345.12	230.08	59.10	148.25	11.50	43.15
50:50	1100	517.45	287.6	287.6	59.10	148.25	11.50	43.15
40:60	1100	517.45	230.08	345.12	59.10	148.25	11.50	43.15
30:70	1100	517.45	172.56	402.64	59.10	148.25	11.50	43.15
20:80	1100	517.45	115.04	460.16	59.10	148.25	11.50	43.15

2.3 CASTING OF GEO POLYMER CONCRETE SPECIMENS: The solids constituents of the GPC, i.e. the aggregates and the fly ash were dry mixed for about three minutes. The liquid part of the mixtures, i.e. the alkaline solution, added water and the super plasticiser were premixed then added to the solids. The wet mixing usually continued for another four minutes. The fresh GPC was dark in colour and shiny in appearance. The mixtures were usually very cohesive. The workability of the fresh concrete was measured by means of the conventional slump test. Compaction of fresh concrete in the moulds was done by applying 25 manual strokes per layer in three equal layers, followed by compaction on a vibration table for ten seconds. The moulds were demoulded after 24 hours and kept for ambient curing.

The GPC prisms were tested under two-point loading for modulus of rupture with Universal Testing Machine of capacity 1000KN. The load was increased gradually at constant rate until failure. The maximum loads applied on various specimens were recorded as per IS 516-1956[6]. Three identical specimens with each variation were cast and tested after 7 days and 28 days of ambient curing. A total of 42 prisms using different FA to GGBS ratios, 8 Molar alkaline activator were cast and tested after 7days and 28 days of ambient curing .The test results are given in table 4.The '**Binder Index (B_i)** has been used to study the combined effect of GGBS to (GGBS+fly ash ratio) and molarity[8].

Binder Index = Molarity x [GGBS / (GGBS + Fly Ash)] .....equation (1)

ISBN : 978-93-87793-89-7

3. 0 RESULTS AND DISCUSSIONS

Table 4. Modulus of Rupture values for GPC

S.No	FA: GGBS	[GGBS / (GGBS + Fly Ash)]	Molarity	Binder Index	Modulus of Rupture (Mpa)		
					7D	28D	(7D/28D)
1	80:20	0.2	8 Molarity	1.6	1.80	2.39	0.75
2	70:30	0.3		2.4	2.13	3.10	0.69
3	60:40	0.4		3.2	3.12	5.00	0.62
4	50:50	0.5		4	3.90	5.89	0.66
5	40:60	0.6		4.8	4.70	6.90	0.68
6	30:70	0.7		5.6	5.20	7.12	0.73
7	20:80	0.8		6.4	6.78	8.45	0.80

The variation of Modulus of rupture with Binder index is shown in below.

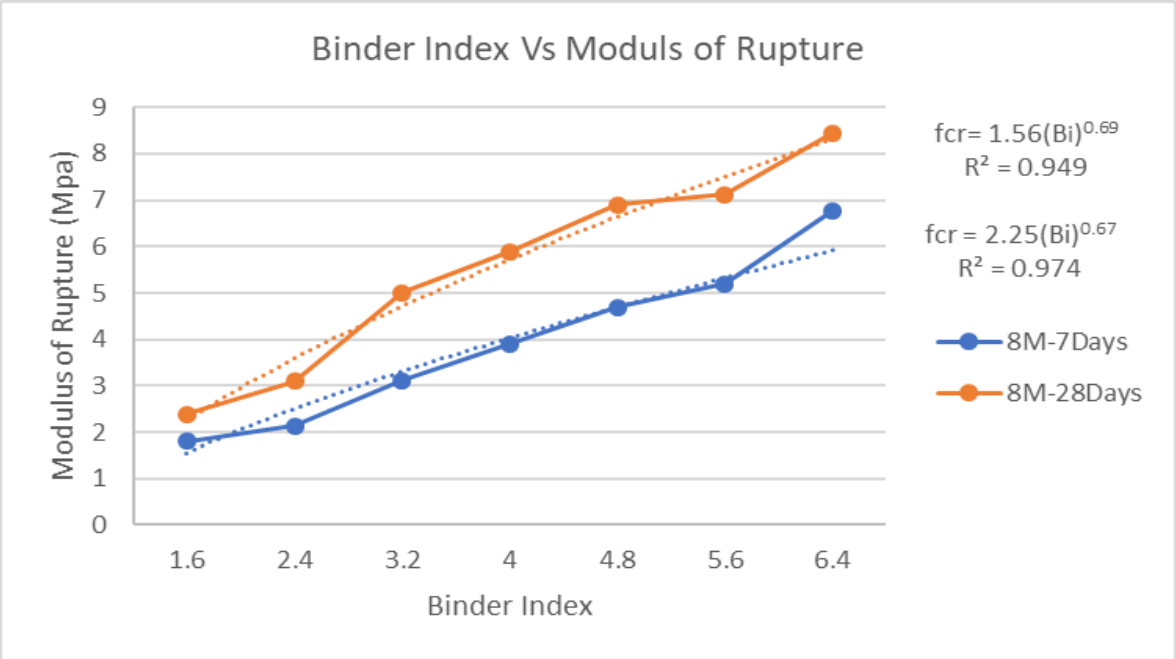

Fig 1. Variation of Modulus of rupture with Binder Index

ISBN : 978-93-87793-89-7

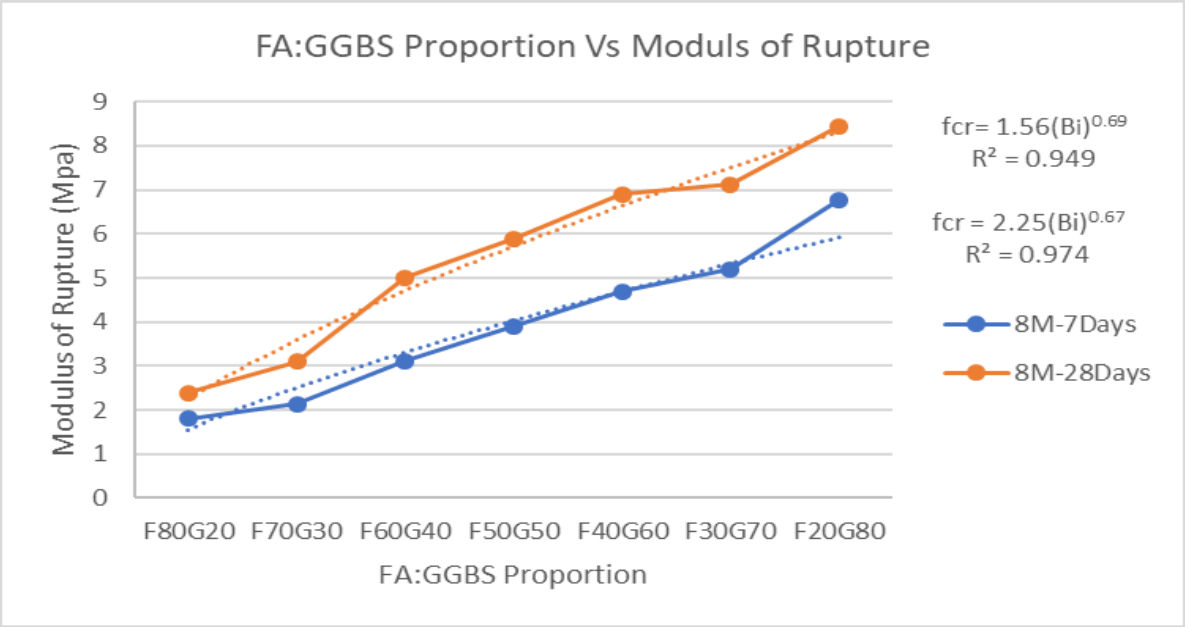

Fig 2. Variation of Modulus of rupture with FA: GGBS Proportion

From fig 1, it is clear that the 7D and 28D modulus of rupture increased with increase in Binder index values.

From fig 2, it is clear that 7D and 28D the modulus of rupture increased with increase in GGBS proportion in the mix.

From Table 3, it is clear that for constant molarity of alkaline activator(8M) the modulus of rupture both for 7D and 28D increased with increase in GGBS proportion in the mix.

The following best fit equations give the relation between Modulus of rupture of GPC at 7 days and 28 days of ambient curing with binder index (Bi) along with the correlation coefficient (R^2).

$fcr_{-7D} = 1.56\,(B_i)^{0.69}$, $R^2 = 0.949$…..equation (2)

$fcr_{-28D} = 2.25\,(B_i)^{0.67}$, $R^2 = 0.974$…..equation (3)

4.0 CONCLUSIONS

Based on the experimental results reported in this investigation, the following conclusions are drawn

1. The Modulus of rupture of Geopolymer concrete increased with increase in GGBS proportion in the mix.

ISBN : 978-93-87793-89-7

2. The rate of gain in strength of Geopolymer concrete is very fast at 7 days curing period and the rate gets reduces with age.
3. The Strength of Geopolymer Concrete increased with increase in Binder index value.
4. Fly ash and GGBS combination can be used for the production of GPC without the need of heat curing.
5. The binder index which combines the effect of GGBS, fly ash and molarity can be used for prediction of Modulus of rupture of GPC.

REFERENCES

1. D.Rama Seshu, R.Shankaraiah, B.Sesha Sreenivas, (2017), A study on the effect of Binder index on compressive strength of Geopolymer concrete, CWB -3/2017. Pages 211-215.
2. B.V. Rangan , Mix design and production of fly ash based geopolymer concrete, Indian concrete journal, 82, 7 (2008).
3. R. Anuradha, et al , Modified Guide lines for Geopolymer concrete mix design using Indian standard, Asian journal of Civil Engineering (Building and Housing), Vol.13 No.3(2012
4. Malhotra, V.M. (1999). “Making Concrete Greener “with Fly ash. Concrete International.21 (5), 61-66.
5. J. Davidovits, Synthetic mineral polymer compound of the silico aluminates family and preparation process.US patent 4472199, 1978.
6. IS516-1956, Indian standard methods of Test for Strength of Concrete.