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EXPERIMBENTAL EVALUATION OF THE COMPRESSIVE STRENGTH OF FIBER REINFORCED GEOPOLYMER CONCRETE (FRGPC)

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ABSTRACT

The experimental program consisted of determination of the compressive strength of the Fiber Reinforced Geo polymer Concrete (FRGPC) by casting and testing cubes of size 100 mm. Two different fibers namely Rigid and soft fibers are used. Two different Ground Granulated Blast Furnace Slag (GGBS), to Fly Ash (FA) ratios (60:40, 40:60) are used. Three different alkaline molar activators 8, 10 and 12 are used. Rigid fibers of volume fractions 0.2, 0.4, 0.6 and 0.8 (R2, R4, R6 and R8), are used for making the Rigid fiber reinforced Geo polymer concrete (RFRGPC). Soft fibers of volume fractions 0.2, 0.4, 0.6 & 0.8 (S2, S4, S6 and S8), are used for making the Soft fiber reinforced Geo polymer concrete (SFRGPC). For making combined fiber reinforced Geo polymer concrete (CFRGPC), combined fiber combinations R0S10, R2S8, R4S6, R6S4, R8S2 and R10S0 are used. Three identical specimens for each variation were cast and tested for 7 days and 28 days ambient curing. Two Parameters called 'Binder Index and Modified Binder Index 'is introduced to quantify the effects of molarity, GGBS to fly ash ratio and fiber effect on compressive strength of Fiber Reinforced Geo Polymer Concrete is presented.

Keywords: Fiber reinforced Geo polymer concrete, Fly ash, GGBS, Alkaline solution, Rigid fibers, soft fibers, Compressive strength, ambient temperature

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1. INTRODUCTION

The global warming is caused by the emission of greenhouse gases like carbon dioxide (CO_2), to the atmosphere. The cement industry contributes about 65% of global warming by emitting carbon dioxide to the atmosphere [1]. Several researches are in progress to invent the alternative material for cement. These include the utilization of supplementary cementing materials such as fly ash, silica fume, granulated blast furnace slag, rice-husk ash and metakaolin, and the development of alternative binders to Portland cement. In terms of global warming, the Geopolymer technology could significantly reduce the CO_2 emission to the atmosphere caused by the cement industries [2]. In India, one of the major sources of material for power generation is coal and it's by product- fly ash- is an environmental threat to the environment, if not disposed off properly. Statistics shows that, during the year 2016 -2017, production of fly ash in India was 169.6 Million tons [3].Two types of materials are required to make a Geopolymer. One is the source Material containing alumina, silica and other is an alkali that activates the polymerization reaction. Davidovits proposed that an alkaline liquid could be used to react with the silicon (Si) and the aluminium (Al) in a source material of geological origin or in by product materials such as fly ash, blast furnace slag, 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 [4]. For the preparation of the alkali solution a single alkali type or a mixture of different alkalis can be used. The most commonly used alkali for the manufacture of Geopolymer is a mixture of the solutions of NaOH and Na_2SiO_3 [5]. Prudon, cited by Torgal carried out investigation on the formation of alkali activated cement (binder) in 1940.The investigator used blast furnace slag as alumina silicate material and sodium hydroxide as alkali [6]. Since then, alkali activation studies were carried out in different countries but it picked up momentum only in the 1990's.Keeping in view of the past research work done on GPC, the present experimental investigation is aimed at studying the effect of fibers on compressive strength of GPC. The compressive strength of Geo Polymer Concrete (GPC) is studied by adding the fibers (Steel and Polypropylene) in different volume proportions. When the Steel and Polypropylene fibers are added to GPC individually and combined, the modified GPC is named as Rigid Fiber Reinforced Geo Polymer Concrete (RFRGPC), Soft Fiber Reinforced Geo Polymer Concrete (SFRGPC) and Combined Fiber Reinforced Geo Polymer Concrete (CFRGPC) respectively. Two Parameters called '**Binder Index and Modified Binder Index** 'is introduced to quantify the effects of molarity, GGBS to fly ash ratio and fiber effect on compressive strength of Fiber Reinforced GPC is presented.

2. EXPERIMENTAL PROGRAM

The experimental program consisted of determination of the strength of the FRGPC by casting and testing cubes of size 100 mm. Two different Ground Granulated Blast Furnace Slag (GGBS), to Fly Ash (FA) ratios (60:40, 40:60) are used. Three different alkaline molar activators 8, 10 and 12 are used. Rigid fibers of volume fractions 0.2, 0.4, 0.6 and 0.8 (R2, R4, R6 and R8), are used for making the RFRGPC. Soft fibers of volume fractions 0.2, 0.4, 0.6 & 0.8 (S2, S4, S6 and S8), are used for making the SFRGPC. For making CFRGPC, combined fiber combinations R0S10, R2S8, R4S6, R6S4, R8S2 and R10S0 are used. 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 12 mm from local source was used. Hooked end steel fibers of aspect ratio 60 with tensile Strength 1100 Mpa, is used. Polypropylene fiber (Recron 3S) of length 12 mm and diameter 20 microns with tensile Strength 490.3 Mpa is used. The molarities of sodium hydroxide solution used are 8, 10 and 12.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[9, 10]. 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 FA 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	10 moles/L	12 moles/L
Sodium hydroxide pellets , (grams)	262	314	361
Potable Water (grams)	738	686	639

2.2. Mix proportions

The GPC fiber mix proportions are shown in table 3 and 4.

Table 3. GPC mix proportion.

FA:GGBS	Molarity(M)	FRGPC Composition (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)
60:40	8	1100	517.45	345.10	230.10	59.10	148.25	11.50	43.15
60:40	10	1100	517.45	345.10	230.10	59.10	148.25	11.50	43.15
60:40	12	1100	517.45	345.10	230.10	59.10	148.25	11.50	43.15
40:60	8	1100	517.45	230.10	345.10	59.10	148.25	11.50	43.15
40:60	10	1100	517.45	230.10	345.10	59.10	148.25	11.50	43.15
40:60	12	1100	517.45	230.10	345.10	59.10	148.25	11.50	43.15

Table 4. Fiber mix proportion

Rigid fiber			**Soft fiber**			**Combined fiber**				
***fiber designation**	**volume fraction (%)**	**Weight (Kg/m³)**	**#fiber designation**	**volume fraction (%)**	**Weight (Kg/m³)**	**@fiber designation.**	**Rigid fiber volume fraction (%)**	**Soft Fiber volume fraction (%)**	**Rigid fiber weight (Kg/m³)**	**Soft fiber weight (Kg/m³)**
R0	--	--	S1	1	9.50	R0S10	0	1	0	9.5
R2	0.20	15.7	S2	0.20	1.9	R2S8	0.20	0.80	15.7	7.6
R4	0.40	31.4	S4	0.40	3.8	R4S6	0.40	0.60	31.4	5.7
R6	0.60	47.1	S6	0.60	5.7	R6S4	0.60	0.40	47.1	3.8
R8	0.80	62.8	S8	0.80	7.6	R8S2	0.80	0.20	62.8	1.9
R10	1	78.5	S0	--	--	R10S0	1	0	78.5	0

*1st letter indicates the rigid fiber designation (R), 2nd letter indicates the volume fraction percentage for rigid fiber (0, 0.2, 0.4, 0.6, 0.8 and 1).

#1st letter indicates the Soft fiber designation (S), 2nd letter indicates the volume fraction percentage for Soft fiber (1, 0.2, 0.4, 0.6, 0.8, and 0).

@1st letter indicates the Rigid fiber designation (R) , 2nd letter indicates the volume fraction percentage for Rigid fiber (0,0.2,0.4,0.6,0.8,and 1), 3rd letter indicates the Soft fiber designation (S) and 4th letter indicates the volume fraction percentage for Soft fiber (1,0.8,0.6,0.4,0.2 and 0).

2.3. Casting of FRGPC specimens

The solids constituents of the FRGPC, i.e. the aggregates and the fly ash, fibers 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 FRGPC concrete 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 cube 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 cubes were demoulded after 24 hours and kept for ambient curing.

3. COMPRESSIVE STRENGTH

The compressive strength tests on hardened FRGPC were performed on a 1000 kN capacity universal testing machine in accordance to the relevant Indian Standard code IS 516[7]. Three 100 mm x 100 mm x 100 mm, Fiber Reinforced Geo Polymer Concrete (FRGPC) cubes were tested for every compressive strength test. The results given in the various Figures and Tables are the mean of these values. Binder index is taken as the product of Molarity of alkaline activator and binders ratio, as given below.

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

Table 5. Compressive strength values of RFRGPC.

A:GGBS	Molarity (M)	Binder Index (B_i)	Compressive strength values of RFRGPC (f_{ckr}) (Mpa)											
			R2			R4			R6			R8		
			7D	28D	7D to 28 D ratio	7D	28D	7D to 28 D ratio	7D	28D	7D to 28 D ratio	7D	28D	7D to 28 D ratio
60:40	8	3.2	36	42.1	0.86	39	46.8	0.83	42	49.5	0.85	46.1	55.1	0.84
60:40	10	4	40	51.1	0.78	40.9	53.5	0.76	45.9	56	0.82	59	65	0.77
60:40	12	4.8	43	54.1	0.79	44.1	61	0.72	48.2	65	0.81	62	75	0.75
40:60	8	4.8	38.2	45	0.85	40	48.3	0.81	43.5	52.6	0.83	48	57	0.84
40:60	10	6	41.2	53.4	0.77	42	57	0.74	46.8	59	0.81	61	73	0.74
40:60	12	7.2	44.8	57	0.79	45.9	63.4	0.72	49	68.1	0.72	70	80	0.77

Table 6. Compressive strength values of SFRGPC

FA:GGBS	Molarity (M)	Binder Index (Bi)	Compressive strength values of SFRGPC (f_{cks}) (Mpa)											
			S2			S4			S6			S8		
			7D	28D	7D to 28 D ratio	7D	28D	7D to 28 D ratio	7D	28D	7D to 28 D ratio	7D	28D	7D to 28 D ratio
60:40	8	3.2	32.1	39	0.82	34.2	42.7	0.80	36.5	48.1	0.76	45.2	53.8	0.84
60:40	10	4	37	48.5	0.76	39	52.1	0.75	42.3	53	0.80	48.2	61	0.79
60:40	12	4.8	41	52	0.79	42.9	59	0.73	45.4	61	0.80	54.1	66	0.82
40:60	8	4.8	35	43	0.81	36.2	47	0.77	41.9	49.5	0.85	47	55.4	0.85
40:60	10	6	39.5	51.3	0.77	41.5	54.9	0.76	44.2	57	0.81	51.8	62.3	0.83
40:60	12	7.2	43.5	55.3	0.79	45.9	61	0.75	47	63.7	0.74	58.2	71	0.82

Table 7. Compressive strength values of CFRGPC

FA:GGBS	Molarity(M)	Binder Index	Compressive strength values of CFRGPC (f_{ckc}) (Mpa)											
			R0S10		R2S8		R4S6		R6S4		R8S2		R10S0	
			7D	28D	7D	28D	7D	28D	7D	28D	7D	28D	7D	28D
60:40	8	3.2	38.1	42	39.5	47.4	42	50.4	43.5	51.3	47.2	54.9	51.9	62.3
60:40	10	4	40.1	48.2	42.1	51.4	45.3	55.7	46.5	57.5	51.9	69.9	58.2	76.5
60:40	12	4.8	42.5	52.2	45	56	48.7	63.8	51.8	65	61.2	79.5	67.1	88.5
40:60	8	4.8	39	45	40.1	49	43	52	44.8	55.9	49.3	61.2	55.3	69.3
40:60	10	6	41	50.1	43.5	54.4	46.5	59.9	48.9	64.5	58.4	74.2	63.8	86.2
40:60	12	7.2	43.5	53.9	45.5	59.8	49	65	52.5	71.2	63.1	83.1	68	91.1

Table 8. 7D to 28D ratio of Compressive strength values of CFRGPC.

FA:GGBS	Molarity (M)	Binder Index	The ratio of 7D to 28 D Compressive strength values of CFRGPC					
			R0S1	R2S8	R4S6	R6S4	R8S2	R1S0
			7D to 28 D ratio	7D to 28 D ratio	7D to 28 D ratio	7D to 28 D ratio	7D to 28 D ratio	7D to 28 D ratio
60:40	8	3.2	0.91	0.83	0.83	0.85	0.86	0.83
60:40	10	4	0.83	0.82	0.81	0.81	0.74	0.76
60:40	12	4.8	0.81	0.80	0.76	0.85	0.77	0.76
40:60	8	4.8	0.87	0.82	0.83	0.80	0.81	0.80
40:60	10	6	0.82	0.80	0.78	0.83	0.79	0.74
40:60	12	7.2	0.81	0.76	0.75	0.74	0.76	0.75

The variation of compressive strength with Rigid fibers is shown in fig 1 to fig 4.

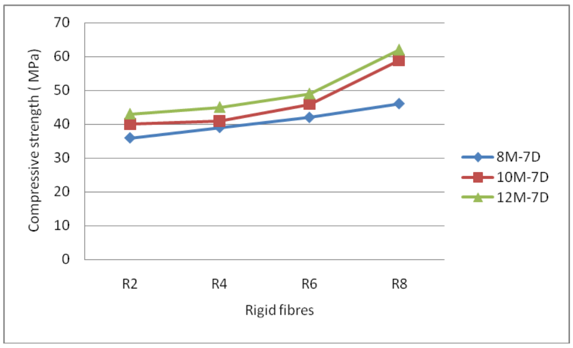

Fig 1.Rigid fiber effect on f_{ck} (FRGPC)(FA: GGBS = 60:40)

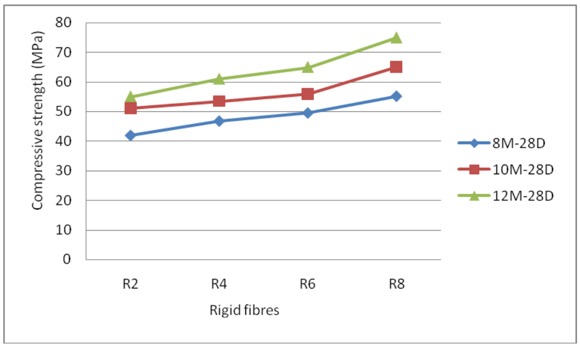

Fig 2. Rigid fiber effect on f_{ck} (FRGPC) (FA: GGBS = 60:40)

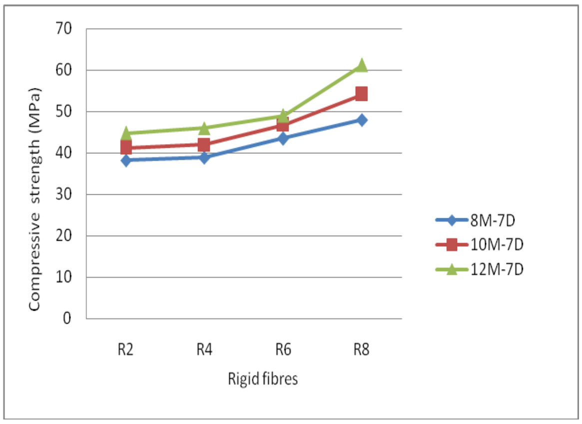

Fig 3. Rigid fiber effect on f_{ck} (RFRGPC) (FA: GGBS = 40:60)

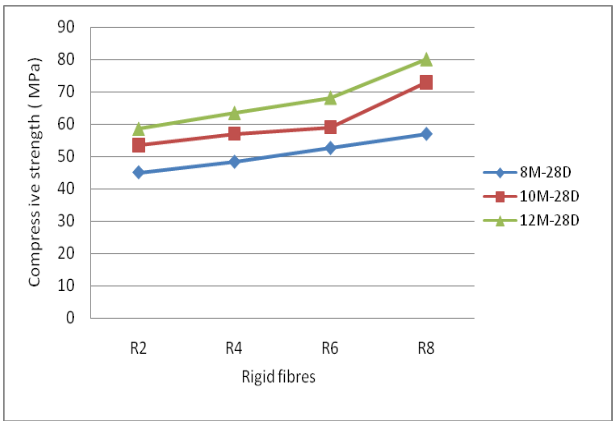

Fig 4. Rigid fiber effect on f_{ck} (RFRGPC) (FA: GGBS = 40:60)

From fig1 to fig 4, the 7 days and 28 days compressive strength of Rigid Fiber Reinforced GPC is increased with increase in volume fraction of rigid fibers, for any chosen molarity of alkaline activator solution considered. For any volume fraction of the rigid fibers considered with constant Fly ash, GGBS proportion the compressive strength of the Rigid Fiber reinforced GPC is increased with increase in the molarity of the alkaline solution.

The variation of compressive strength with Soft fibers is shown in fig 5 to fig 8.

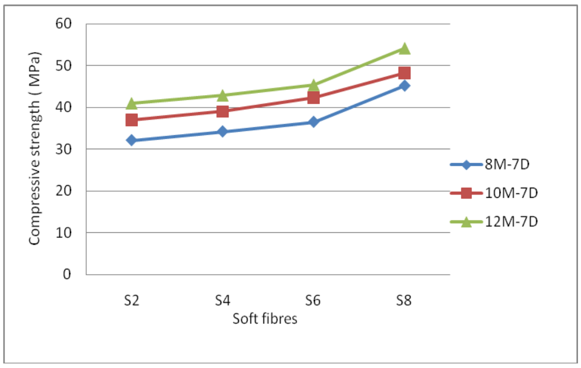

Fig 5. Soft fiber effect on f_{ck} (SFRGPC) (FA: GGBS = 60:40)

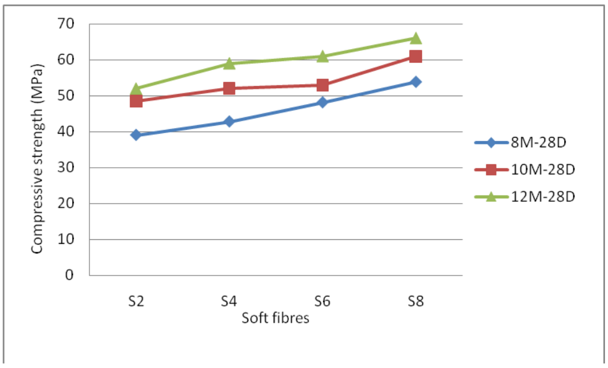

Fig 6. Soft fiber effect on f_{ck} (SFRGPC) (FA: GGBS = 60:40)

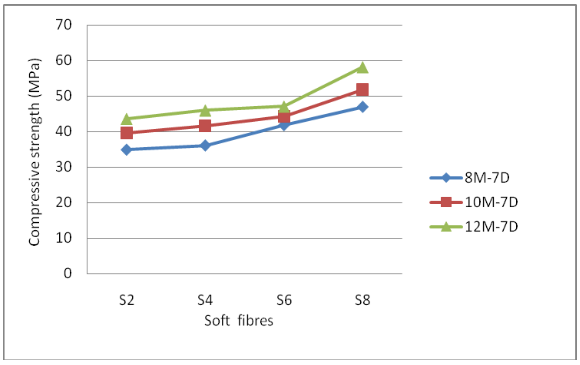

Fig 7. Soft fiber effect on f_{ck} (SFRGPC)(FA: GGBS = 40:60)

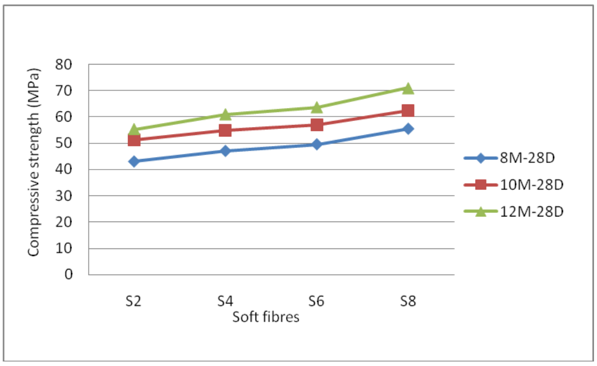

Fig 8. Soft fiber effect on f_{ck} (SFRGPC)(FA: GGBS = 40:60)

From fig5 to fig 8, the 7 days and 28 days compressive strength of Soft Fiber Reinforced GPC is increased with increase in volume fraction of Soft fibers, for any chosen molarity of alkaline activator solution considered. For any volume fraction of the Soft fibers considered with constant Fly ash, GGBS proportion the compressive strength of the Soft Fiber reinforced GPC is increased with increase in the molarity of the alkaline solution.

The variation of compressive strength with combined fibers (Rigid and Soft) is shown in fig 9 to fig 12.

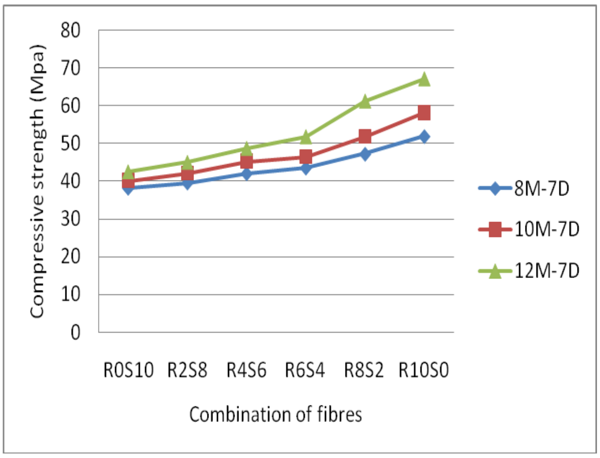

Fig 9. Combined fiber effect on f_{ck} (CFRGPC) (FA: GGBS = 60:40)

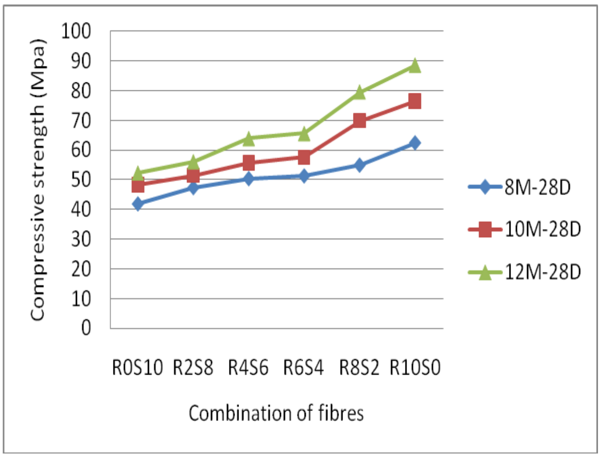

Fig 10. Combined fiber effect on f_{ck}(CFRGPC) (FA: GGBS = 60:40)

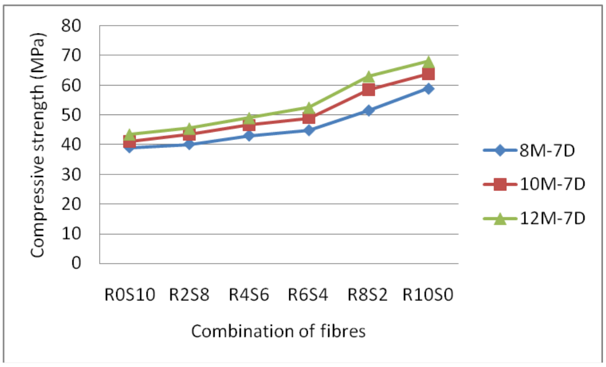

Fig 11. Combined fiber effect on f_{ck} (CFRGPC) (FA: GGBS = 40:60)

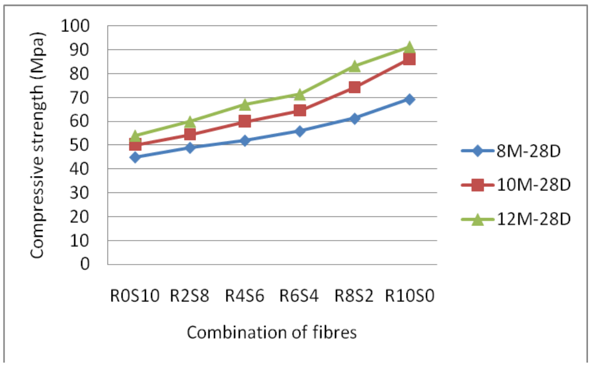

Fig 12. Combined fiber effect on f_{ck} (CFRGPC)(FA: GGBS = 40:60)

From fig 9 to fig 12, the 7 days and 28 days compressive strength of Combined Fiber Reinforced GPC is increased with increase in volume fraction of combination fibers for any chosen molarity of alkaline activator solution considered. For any volume fraction of the combination fibers considered with constant Fly ash, GGBS proportion the compressive strength of the combined Fiber reinforced GPC is increased with increase in the molarity of the alkaline solution. It is observed that the compressive strength for R0S10 combination is found to be less compared to S8 combination, this may be because of the balling effect. It is also observed that the workability is remarkably decreased. Decreased workability may lead to non uniform distribution of the soft fibers. In any volume fraction minimum 40% and above of Rigid fibers is beneficial from compressive strength point of view.

4. MODIFIED BINDER INDEX (P)

To know the effect of fibers on compressive strength of Fiber reinforced geo polymer concrete (FRGPC), modified binder index combining the effects of Binder index , Tensile strength and volume fraction of fibers shall be calculated, for each fiber combination. To account for the reduced effect of soft fibers in combination fibers a factor 0.85 has been introduced, while evaluating modified binder index.

Modified binder index (P) = $B_i \times (\sqrt{F_{ef}})$.....eq(2)

Where F_{ef} is fiber effect. $F_{ef} = (F_{tr} \times V_{fr} + F_{ts} \times V_{fs})$ eq(3)

F_{tr} = Tensile strength of Rigid fiber = 1450Mpa, V_{fr}=Volume fraction of rigid fiber,
F_{ts} =Tensile strength of soft fiber =490.33Mpa, V_{fs}=Volume fraction of soft fiber.

Modified binder index for Rigid, Soft and combination fibers is formulated as follows.

Modified binder index (P_{rf}) = $B_i \times (\sqrt{RF_{ef}})$ ....for Rigid Fibers eq(4)

Modified binder index (P_{sf}) = $B_i \times (\sqrt{SF_{ef}})$ ....for Soft Fibers eq(5)

Modified binder index (P_{cf}) = $B_i \times [\sqrt{RF_{ef}} + 0.85 \sqrt{SF_{ef}}]$ ..for combination fibers eq(6)

The fiber effect for rigid fibers (RF_{ef}), soft fibers (SF_{ef}) and combined fibers (CF_{ef}) is calculated and tabulated in tables 9 &10. Modified binder index for Rigid fiber (P_r), soft fiber (P_s) and combined fibers (P_c) is presented in tables 11 & 12.

Table 9 Fiber effect for Rigid and Soft fibers.

Fiber effect for Rigid fibers RF_{ef}					Fiber effect for soft Fibers SF_{ef}				
Rigid fiber	F_{tr}	V_{fr}	RF_{ef}	$\sqrt{RF_{ef}}$	**Soft fiber**	F_{ts}	V_{fs}	SF_{ef}	$\sqrt{SF_{ef}}$
R2	1450	0.002	2.90	1.70	S2	490.33	0.002	0.98	0.98
R4	1450	0.004	5.80	2.40	S4	490.33	0.004	1.96	1.4
R6	1450	0.006	8.70	2.95	S6	490.33	0.006	2.94	1.72
R8	1450	0.008	11.60	3.40	S8	490.33	0.008	3.92	1.98

Table 10 Fiber effect for Combination of fibers

fiber designation	fiber designation	fiber designation	Binder index	$\sqrt{RF_{ef}}$	$\sqrt{SF_{ef}}$	$0.85\sqrt{SF_{ef}}$	$\sqrt{RF_{ef}} + 0.85\sqrt{SF_{ef}}$
R0S10	R0	S10	3.2	0	2.21	1.88	1.88
R2S8	R2	S8	4	1.70	1.98	1.68	3.38
R4S6	R4	S6	4.8	2.40	1.72	1.46	3.86
R6S4	R6	S4	4.8	2.95	1.96	1.2	4.15
R8S2	R8	S2	6	3.40	0.98	0.83	4.23
R10S0	R10	S0	7.2	3.80	0	0	3.80

Table 11. Modified Binder Index for Rigid & Soft fibers

Molarity	Binder Index	Rigid Fibers				Soft Fibers			
		$P_{rf} = B_i X(\sqrt{RF_{ef}})$				$P_{sf} = B_i X(\sqrt{SF_{ef}})$			
		Modified Binder Index (P_{rf})				Modified Binder Index (P_{sf})			
		R2	R4	R6	R8	S2	S4	S6	S8
8	3.2	5.4	7.7	9.5	10.9	3.2	4.5	5.5	6.4
10	4	6.8	9.6	11.8	13.6	3.9	5.6	6.9	7.9
12	4.8	8.2	11.5	14.2	16.3	4.7	6.7	8.3	9.5
8	4.8	8.2	11.5	14.2	16.3	4.7	6.7	8.3	9.5
10	6	10.2	14.4	17.7	20.4	5.9	8.4	10.3	11.9
12	7.2	12.3	17.3	21.3	24.5	7.1	10.1	12.4	14.3

Table 12. Modified Binder Index for Combination of fibers

Molarity	Binder Index	Combination of fibers					
		$P_{cf} = B_i X [\sqrt{RF_{ef}} + 0.85\sqrt{SF_{ef}}]$					
		R0S10	R2S8	R4S6	R6S4	R8S2	R10S0
8	3.2	6.01	10.816	12.352	13.28	13.536	12.16
10	4	7.52	13.52	15.44	16.6	16.92	15.2
12	4.8	9.02	16.224	18.528	19.92	20.304	18.24
8	4.8	9.02	16.224	18.528	19.92	20.304	18.24
10	6	11.28	20.28	23.16	24.9	25.38	22.8
12	7.2	13.54	24.336	27.792	29.88	30.456	27.36

The effect of modified binder index on Fiber Reinforced Geo polymer concrete is presented in fig 13, fig 14 & fig 15.

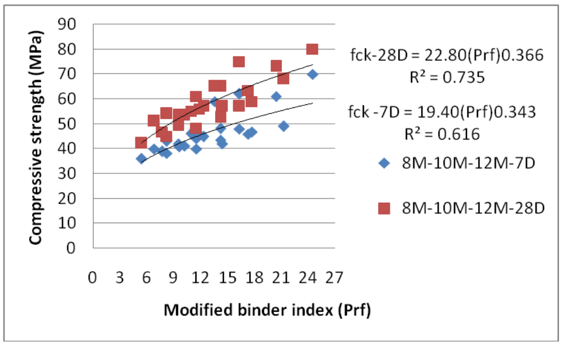

Fig 13. Modified binder index (P_{rf}) effect on Compressive strength of RFRGPC

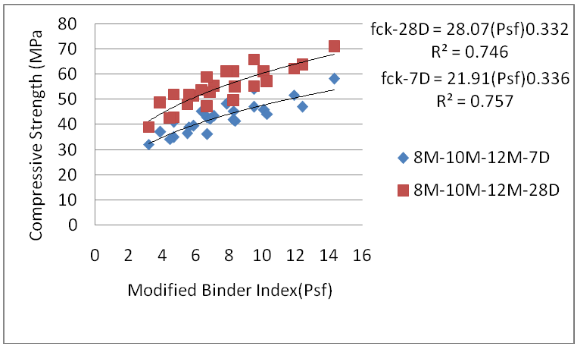

Fig 14. Modified binder index (P_s) effect on Compressive strength of SFRGPC

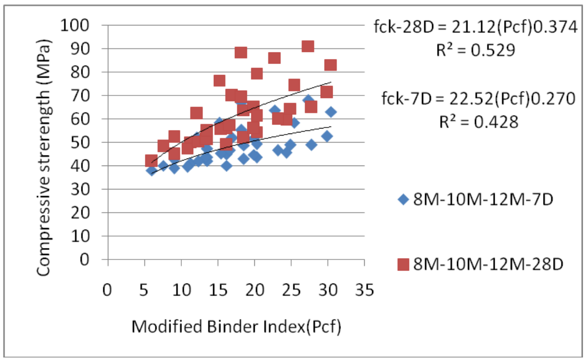

Fig 15. Modified binder index (P_c) effect on Compressive strength of CFRGPC

The proposed modified binder index observed to combine the effects of binder index, molarity and fiber effect , reseanably well in predicting the compressive strengths.

5. CONCLUSIONS

- The 7 days and 28 days Compressive strength of Geo Polymer Concrete reinforced with rigid fibers, soft fibers and combination fibers increased with increase in molarity, for the fly ash to GGBS proportion 40:60.
- In any volume fraction minimum 40% and above of Rigid fibers is beneficial from compressive strength point of view.
- The Compressive strength of Fiber Reinforced Geo polymer concrete is increased with increasing Binder Index.
- Compressive strength of fiber reinforced Geo polymer concrete has increased with increase in the volume fraction of the fibers, irrespective of the fiber type.
- The binder index which combines the effect of molarity, GGBS to Fly ash ratio , can be considered as a unique parameter, in characterizing the compressive strength of Fiber Reinforced Geo polymer Concrete.
- A modified binder index, is proposed as a new parameter influencing the compressive strength of Fiber Reinforced Geo polymer Concrete.

REFERENCES

[1] McCaffrey, R., "Climate Change and the Cement Industry", *Global Cement and Lime Magazine (Environmental Special Issue)*, 2002 pp.15-19.

[2] Gartner E (2004), "Industrially Interesting Approaches to 'Low-CO2' Cements", Cement and Concrete Research, 34(9), 2004, pp.1489-1498.

[3] Central Electricity Authority. (2014). "Report on Fly ash generation at Coal/Lignite Based Thermal Power Stations and Its Utilization in the Country, for the year 2016-2017", Central Electricity Authority, Government of India, New Delhi.

[4] Davidovits, J, "High-Alkali Cements for 21st Century Concretes. In Concrete Technology, Past, Present and Future", Proceedings of V.Mohan Malhotra Symposium, Editor: P. Kumar Metha, ACI SP- 144, 1994, pp.383-397.

[5] Duxson, P., Provis, J.L., Lukey, G.C., Mallicoat, S.W., Kriven, W.M. and van Deventer, J.S.J. (2007). "The effect of alkali and Si/Al ratio on the development of mechanical properties of metakaolin-based geopolymer", Colloids and Surfaces A: Physicochemical and Engineering Aspects, 292(1), 8–24.

[6] Pacheco-Torgal, F., Castro-Gomes, J., and Jalali, S. (2008). "Alkali-activated binders: A review Part 1. Historical background, terminology, reaction mechanisms and hydration products", Construction and Building Materials, 22(7), 1305–1314.

[7] IS 516-1956, Indian Standard methods of Tests for Strength of Concrete.

[8] D.Rama seshu , R.Shankaraiah, B.Sesha Srenivas, (2017), A study on the effect of Binder index on compressive strength of Geopolymer concrete, CWB -3/2017. Pages 211-215.