A STUDY ON SELF-COMPACTING GEOPOLYMER CONCRETE WITH AN ALKALINE ACTIVATOR RATIO AND DIFFERENT ALKALINE ACTIVATOR TO CEMENTITIOUS BINDER RATIOS

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Abstract - *Geopolymer is considered as an inorganic member and it aims in complete elimination OPC which is used in concrete. Geopolymer as a material of construction is gaining its importance day to day. This technology was first coined by a French Professor by name Joseph Davidovits. This mainly utilizes alkaline solutions like silicates of sodium or potassium and hydroxides of sodium or potassium along with industrial by-products like GGBS, fly ash etc. The alkaline solution undergoes a reaction known as polymerization, then reacts with by-products thus produces a binding property. In this work Fly ash and GGBS are used as binder material, alkaline activators like sodium hydroxide flakes and sodium silicate, M-sand as fine aggregates, 12.5mm down coarse aggregates ,6% of water reducing admixture and fresh water were used to produce self-compacting geo polymer concrete(SCGC). Fresh, hardened and durability properties of SCGC are studied and curing of specimens was carried out in ambient Temperature.*

Key Words – self compacting geo-polymer concrete, polymerization, by-products of industry alkaline solutions, Ambient curing.

1.INTRODUCTION

The main requirement for construction is concrete. As per literature survey conducted, concrete is considered as second most utilized material on land. It uses Portland cement as its main product. Cement industry emits greenhouse gas like carbon di-oxide which causes global warming. It causes 68% of global warming. Cement industries emits about 12% of greenhouse gas into the atmosphere. Therefore, in order to eliminate environmental ill effects an alternate binding material should be made use to make concrete.

Geopolymers are mainly considered as inorganic family members which usually forms a mineral links with a particular co-valent bonds. Its Chemical composition is same as zeolite and with an amorphous structure. The alumina and silica present in GGBS and fly ash reacts with alkaline solution and produces a binding property. In this work silicate and hydroxides of sodium is used as it is economical.

2. SCOPE AND OBJECTIVE

i. Scope

The main scope of this present study is to evaluate the various characteristics of SCGC by differing the alkaline to binder ratio and by replacing fly ash by GGBS. The various types of material used in this in this study are fly ash, GGBS, sodium hydroxide, PCE based superplastizer, water and sodium silicate.

To improve the different engineering properties and to cure the SCGC samples under ambient temperature.

ii. OBJECTIVES

1. To study the characteristics of SCGC in its fresh state & mechanical behavior in its harden state.
2. To carry out different durability studies on SCGC.
3. To fix the optimum ratio of alkaline to binder ratio used in the mix.
4. To effectively utilize by products like fly ash, GGBS and to produce an eco-friendly material.

3. MATERIALS USED AND TESTING:

The Various types of materials used in this SCGC are

Fig.1- GGBS

Fig.2-Flyash

Fig.3-NaoH

Fig.4-Na_2Sio_3

Fig.5-M-Sand

Fig.6- Coarse aggregates

Fig.7-Superplastizers

Fig.8-water

All the materials shown are used to produce SCGC which is tested as per Indian standards.

Table-1: Properties of GGBS

Sl.No	Properties	Results
1	colour	White
2	Specific gravity	2.73
3	Fineness by using 90µ sieve	6%

Table-2: Properties of Fly ash

Sl.No	Properties	Results
1	Colour	Grey
2	Specific gravity	2.36

Coarse aggregate-12.5mm down and Fine aggregate –M-sand as per sieve analysis

4.MIXING, CASTING AND CURING:

In this work Sodium hydroxide concentration of 5&10M is prepared and then mixed with sodium silicate. this mix should be prepared one day before casting of specimens and it should be used within 36 hours.

Mixing was carried out in a pan mixer, the dry materials like Fly ash, GGBS and aggregates were dry mixed for 5 minutes. The alkaline solution was then poured to dry mix and this mix was mixed for 5 minutes.

The mix under its fresh state is then transferred to respective molds. The specimens were then cured at ambient temperature and after 24 hours the casted specimens were de-molded and once again cured at ambient temperature.

Fig.9- Mixing of SCGC

Fig 10 –moulds used for casting specimens.

Fig 11–ambient curing of SCGC

5.TEST RESULTS:

i)WORKABILITY

Table-3: workability values for GPC1, GPC2, GPC3& GPC4 mixes all are of 70%-Fly ash and 30%-GGBS.

	GPCM1		GPCM2		GPCM3		GPCM4	
MIX NO.	G1	G2	G3	G4	G5	G6	G7	G8
AAR	4		4		4		4	
Activator to binder	.4		.45		.5		.55	
MOLARITY	5	10	5	10	5	10	5	10
Flow(mm)	778	755	759	752	720	703	695	689
T50(secs)	3	3	3	3	3	4	4	5
J Ring(mm)	5	6	6	7	6	9	9	9
VFUNNEL (secs)	8	9	9	9	11	12	11	12
V-FUNNEL T5 mins(secs)	6	9	9	10	13	15	14	14
L BOX(h2/h1)	.8	.8	1.0	.9	.7	.9	.9	.9
U BOX (mm)	20	22	22	26	24	28	27	28

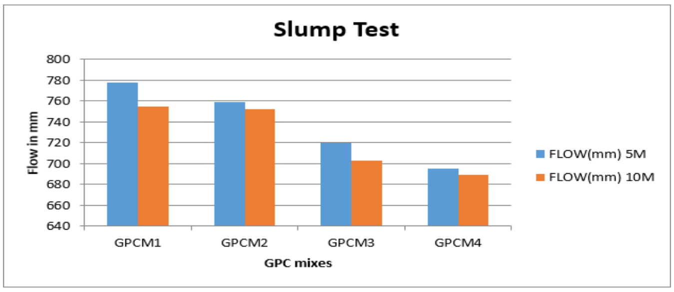

Chart -1: Slump flow test results of SCGC mixes

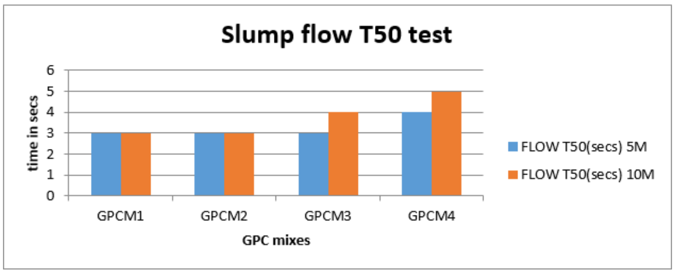

Chart -2: T 50cm slump flow test results of SCGC mixes

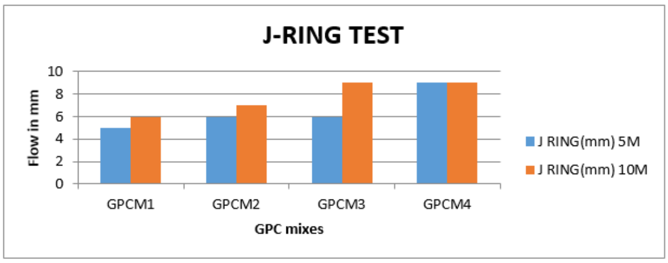

Chart -3: J-Ring test results of SCGC mixes

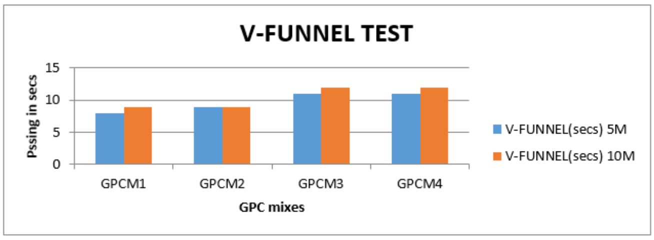

Chart -4: V-Funnel test results of SCGC mixes

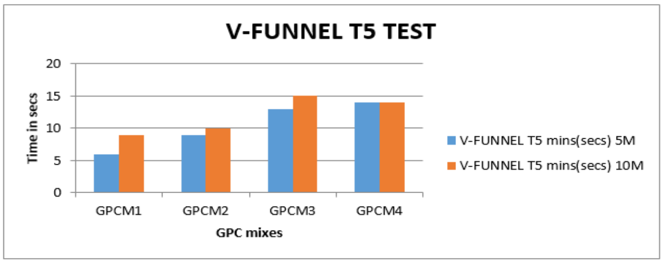

Chart -5: V-Funnel T5 minutes test results of SCGC mixes

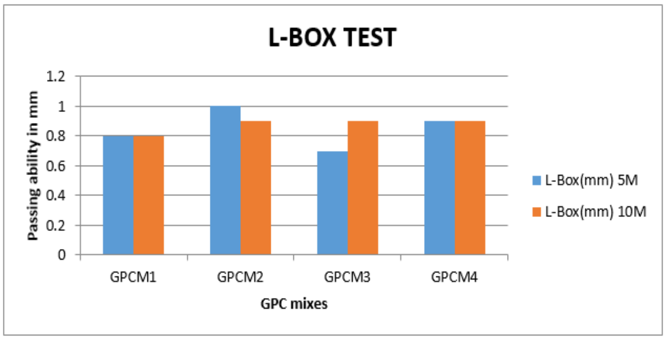

Chart -6: L-Box test results of SCGC mixes

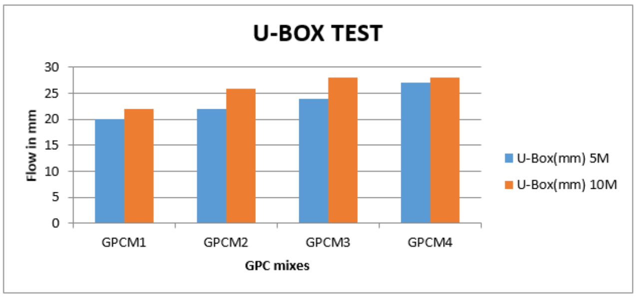

Chart -7: U-Box test results of SCGC mixes

ii) COMPRESSIVE STRENGTH TEST RESULTS:

Fig 11– compressive strength test for SCGC mixes

Table-4: compressive strength test values for GPC1 mix

	Mix.no	AAR	Activator to Binder	Molarity	Compressive Strength(MPa)	
					7days	28days
GPC1 (70% FA+ 30%GGBS)	G1	4	.4	5	32.3	37
	G2			10	38	42.7

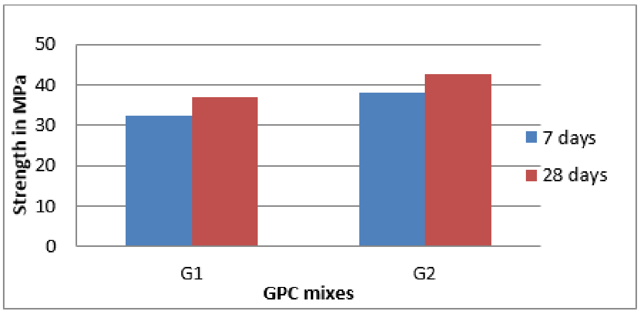

Chart -8: Compressive strength test values for GPC1 mix

Table-5: compressive strength test values for GPC2 mix

	Mix.no	AAR	Activator to Binder	Molarity	Compressive Strength(MPa)	
					7days	28days
GPC2 (70% FA+ 30%GGBS)	G3	4	.45	5	37	42
	G4			10	41	46.8

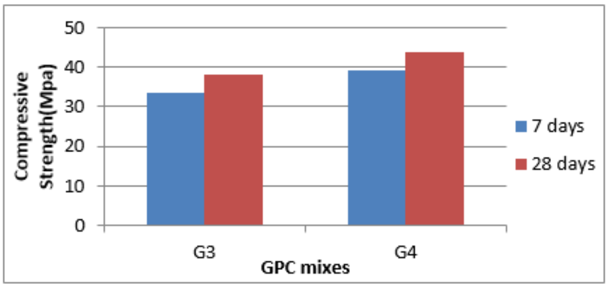

Chart -9: Compressive strength test values for GPC2 mix

Table-7: compressive strength test values for GPC3 mix

	Mix.no	AAR	Activator to Binder	Molarity	Compressive Strength(MPa)	
					7days	28days
GPC3 (70% FA+ 30%GGBS)	G5	4	.5	5	44	52.8
	G6			10	50	54.3

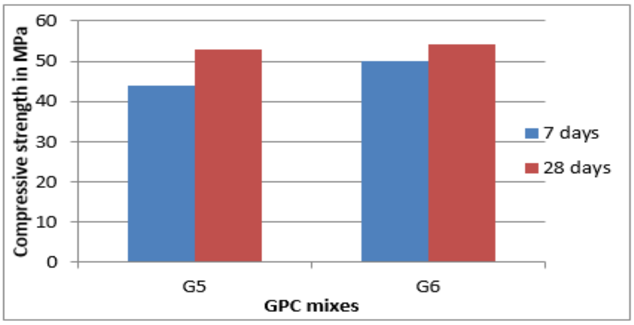

Chart -10: Compressive strength test values for GPC3 mix

Table-8: compressive strength test values for GPC4 mix

GPC4 (70% FA+ 30% GGBS)	Mix.no	AAR	Activator to Binder	Molarity	Compressive Strength(MPa)	
					7days	28days
	G7	4	.55	5	46	53.2
	G8			10	53	57

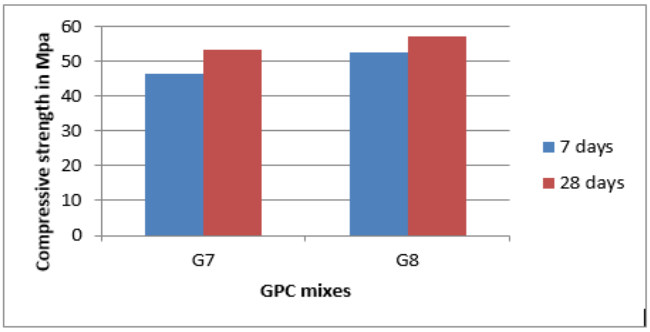

Chart -11: Compressive strength test values for GPC1 mix

iii) **TEST ON SHRINKAGE RESULTS:**

Fig 12–Drying Shrinkage test for SCGC mixes

Table-9: Drying shrinkage test values for GPC mixes

	Trial no.	Initial length (a)	Wet length (b)	Dry length (c)	Drying shrinkage (DS)=((a-b)/c)*100
GPC1	G1	1.756	1.740	162.63	.001
	G2	2.156	2.099	162.6	.004
GPC2	G3	1.165	1.101	162.47	.004
	G4	2.453	2.379	162.89	.005
GPC3	G5	2.543	2.449	162.5	.006
	G6	2.153	2.056	162.53	.006
GPC4	G7	2.189	2.051	162.59	.008
	G8	2.986	1.863	162.63	.008

iv) **DURABILITY TEST RESULTS:**

a) WATER ABSORPTION TEST RESULTS

Fig 13–water absorption test for SCGC mixes

Table-9: water absorption test values for GPC mixes

		GPC1		GPC2		GPC3		GPC4	
Mix.no		G1	G2	G3	G4	G5	G6	G7	G8
Activator to binder ratio		.4		.45		.5		.55	
Alkaline activator ratio		4	4	4	4	4	4	4	4
Molarity		5	10	5	10	5	10	5	10
24hour water(H_2O) absorption	Drying weight of specimen (kg)	8.084	7.981	8.0	7.909	8.022	7.750	8.101	8.147
	Density(kg/m^3)	2395.26	2364.74	23.87.85	2343.41	2376.89	2296.30	2400.30	2413.93
	Wet weight of specimen (kg)	8.093	7.911	8.07	7.924	8.064	7.789	8.116	8.166
	Water absorption percentage	.111	.125	.136	.190	.523	.503	.185	.233

b) SORPITIVITY TEST RESULTS:

c) Fig 14–sorpitivity test for SCGC mixes

Table-9: Sorpitivity test values for GPC mixes

	Mix.no	Alkaline activator ratio	Activator to binder ratio	Molarity	Water(H_2O) Absorbed					
					15 min	30 min	1 hour	24 hour	48 hour	72 hour
GPCM1	G1	4	.4	5	.00003	.00019	.00021	.00029	.00039	.00051
	G2	4		10	.00004	.00019	.00020	.00026	.00037	.00052
GPCM2	G3	4	.45	5	.00002	.00017	.00019	.00026	.00034	.00051
	G4	4		10	.00003	.00019	.00020	.00024	.00034	.00051
GPCM3	G5	4	.5	5	.00009	.00026	.00028	.00036	.00047	.00056
	G6	4		10	.00009	.00024	.00029	.00034	.00043	.00054
GPCM4	G7	4	.55	5	.00006	.00023	.00025	.00032	.00041	.0005
	G8	4		10	.00007	.00022	.00023	.00032	.00043	.0005

b) PERMEABILITY TEST RESULTS:

Fig 15–permeability test for SCGC mixes

Table-11: permeability test values for GPC mixes

	Mix. no	Activator to binder ratio	Alkaline activator ratio	Molarity	Avg. depth of penetration of water(mm)[DIN-1048]
GPC M1	G1	.4	4	5	86.7
	G2		4	10	83.9
GPC M2	G3	.45	4	5	90.6
	G4		4	10	89.8
GPC M3	G5	.5	4	5	138.9
	G6		4	10	129.8
GPC M4	G7	.55	4	5	160.7
	G8		4	10	157.6

c) RAPID CHLORIDE PENETRATION TEST(RCPT):

Fig 16–RCPT test for SCGC mixes

Table-12: RCPT test values for GPC mixes

	Mix. no	Activator to binder ratio	Alkaline activator ratio	Molarity	Coulomb passed[ASTM C-1202-10]
GPCM 1	G1	.4	4	5	5586.9
	G2		4	10	5575.5
GPCM 2	G3	.45	4	5	5559.6
	G4		4	10	5540.8
GPCM 3	G5	.5	4	5	5564.85
	G6		4	10	5532.9
GPCM 4	G7	.55	4	5	5601.5
	G8		4	10	5593.7

3. CONCLUSIONS

1. SCGC reduces environmental ill effects when compared to OPC.

2. For any SCGC mix the workability improves with decrease in alkaline activator to cementitious binder ratio.

3. Compressive strength increases with increase in alkaline activator to cementitious binder ratio.

4. Increase in molarity of NaOH improves compressive strength.

5. The optimum mix for SCGC is when activator to binder ratio is 0.45 and molarity is 5M.

6. The 24-hour water absorption, permeability, sorpitivity, RCPT, Drying Shrinkage, is low for mix having low activator to binder ratio.

7. The casted SCGC mix samples were cured at ambient temperature to check the suitability at in situ condition.

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