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A STUDY ON SELF COMPACTING GEOPOLYMER CONCRETE WITH VARIOUS WATER TO GEPOLYMER SOLIDS RATIOS

Shivaranjan N.S[1], Shiva kumar K.S[2], Dr. D.L Venkatesh Babu[3], Nagaraj V.K[4].

[1]P.G.Student, Department of Civil Engineering, GAT, Bangalore,

[2]Shiva kumar K S. Asst. Professor, Department of Civil Engineering, GAT, Bangalore,

[3]Professor, Department of Civil Engineering, JSSATE, Bangalore.

[4]PhD Research Scholar, Department of Civil Engineering, JSSATE, Bangalore, India.

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Abstract: Geopolymer is taken as an inorganic member and it majorly targets in substituting OPC which is used in producing of concrete. Geo polymer technology as a construction material as a trend is gaining its popularity worldwide towards a sustainable development. Geo polymer technology was implemented by a French Professor by name Joseph Davidovits. This technology mainly uses alkaline activator solutions like silicates of potassium or sodium and hydroxides of potassium or sodium along with by-products of industries like ground granulated blast furnace slag (GGBS), fly ash etc. The alkaline activator solution mainly undergoes geo polymerization and then get reacted with by-products of industries and produces a binding property and then binds the aggregates. In this study Alcco fine and GGBS are used as cementatious binder, alkaline activators like sodium hydroxide flakes and sodium silicate, slag sand as fine aggregates, 12.5mm down coarse aggregates and fresh water were used to produce fibre reinforced geo polymer concrete. Fresh property and hardened property of self-compacting geo polymer concrete are studied and curing of specimens is carried out in ambient condition.

Key Words – self compacting geo-polymer concrete, polymerization, Industrial by-products alkaline liquid solutions, Ambient curing

INTRODUCTION

The main ingredient for any type of construction work is concrete. As per many literature work it is considered as second most used material on land. It mainly utilizes Portland cement as its major ingredient. The major demand for cement as material of construction is increasing in present state. Cement industry emits carbon di-oxide CO_2 is considered as greenhouse gas which is considered as global warming. It causes 69% of global warming. Cement industries emits about 11% of greenhouse gas into the atmosphere. Therefore to eradicate different environmental ill effects an alternate binding source of material should be utilized to make concrete. Different research work have been done in replacing cement, like incorporating by-products of industries as cementitious materials for binding such as saw dust, rice husk ash, metakaolin, micro silica, alccofine, ground granulated blast furnace slag (GGBS), fly ash etc.

Geopolymers are considered as family members of inorganic chemistry which forms mineral chains linked with a particular co-valent bonds. Geopolymers uses alkaline activators and industrial by-products. Geopolymers undergo a polymeric reaction with alkaline activators and GGBS, alccofine. Chemical composition of geopolymers is as zeolite and with amorphous structure. The alumina and silica present in GGBS and alccofine reacts with alkaline activators and produces a binding property. Alkaline activators used in geopolymerization are sodium hydroxide or potassium hydroxide and sodium silicate or potassium silicate. This combination rapidly increases rate of reaction.

SCOPE

1. The scope of this research work is to study the properties of self-compacting geopolymer concrete by varying water to geopolymer solids ratio. Different materials like GGBS, alccofine, sodium hydroxide, lye and sodium silicate are used in different proportions. Water is replaced by Lye which is generated wood ash, wood ash generally is a waste product which is effectively used in producing high pH activator known as Lye.

2. The aim of this study is to evaluate the suitability and performance of self-compacting geopolymer concrete which is alternative to Ordinary Portland Cement (OPC) in the production of concrete.

OBJETIVES

The main objectives will include:

1. To study and understand fresh properties of self-compacting geopolymer concrete with different water to geoplymer solids ratio
2. To study and understand mechanical properties of self-compacting geopolymer concrete with different water to geoplymer solids ratio
3. To eliminate total usage of water
4. To carryout total solid test, pH test, purity test and feather test on lye

MATERIAL USED AND THERE TESTIN

The different types of materials used for fiber reinforced geo-polymer concrete are,

Fig.1- GGBS Fig.2-ALCCO-FINE

Fig,3- NaoH fig.4-Na_2Sio_3

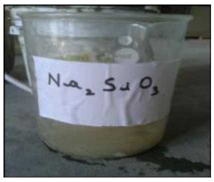

Fig.4- Slag sand fig.5- Coarse aggregates

Fig.6- Lye

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All the above materials required to produce self-compacting geopolymer concrete where tested selected as per Indian standards.

Table-1: Properties of GGBS.

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

Sieve analysis for 12,5mm down coarse aggregate and for slag sand (granulated blast furnace slag) fine aggregate where done as per Indian Standards

Table-2: Sieve analysis for fine aggregates (slag sand) done as per IS 383 – 1970.

Sieve size	**Weight retained in IS sieve (gm)**	**Cumulative % retained in IS sieve**	**Cumulative % passing in IS sieve**	**Zones** Different specifications as per IS 383 – 1970 for percentage passing in IS sieve			
				Zone 1	**Zone 2**	**Zone 3**	**Zone 4**
4.75 mm	0.00	0.00	100.00	90 – 100	90 – 100	90 – 100	95 - 100
2.36 mm	2.80	2.80	97.20	60 – 95	75 – 100	85 – 100	95 - 100
1.18 mm	13.50	16.30	83.70	30 - 70	55 – 90	75 - 100	90 - 100
600 µ	35.60	51.70	48.30	15 34	35 – 59	60 - 79	80 - 100
300 µ	18.20	83.70	16.30	5 – 20	8 – 30	12 - 40	15 - 50
150 µ	14.20	98.50	1.50	0 – 10	0 – 10	0 - 10	0 - 10
Pan	1.1	99.60	0.4	-	-	-	-

Table-3: Sieve analysis for coarse aggregates (12.5 mm) as per Indian standards

Sieve size (mm)	Weight retained in IS sieves (kg)	Percentage weight retained on each IS sieve	Cumulative percentage retained in IS sieves	Cumulative percentage passing in IS sieves
16	0.00	0.00	0.00	100.00
12.5	0.434	4.34	4.34	95.66
10	5.346	53.46	57.8	42.20
4.75	4.132	41.32	99.12	0.88
2.36	0.022	2.20	99.34	0.66
Pan	0.040	-	-	-

Mixing of alkaline activator solution.

In this study behavior of alkaline activator ratio on fresh and hard property is studied. Sodium hydroxide solution of 9M is prepared and mixed with sodium silicate and this mix of alkaline activator solution should be prepared before one day (24hrs) of mixing and casting of geo-polymer concrete specimens. The alkaline activator solution prepared should be used after 24 hours and should be used within 36 hours after mixing. The alkaline activator solution is mixed with supplementary cementitious binder and aggregates on the day of casting.

Mixing, casting and curing of fiber reinforced geo-polymer concrete.

For mixing of fiber reinforced geo-polymer concrete conventional method of mixing, casting and curing was adopted. Mixing was made in a tray and hand mixing was followed, and then the dry materials like supplementary cementitious binder and aggregates were dry mixed for 4 minutes. The alkaline activator solution was then added to dry mix and this mix was again mixed uniformly for 4 minutes, the fresh geo-polymer concrete mix had a very stiff consistency and was dark grey in color. Mixing of concrete should be done within 5 min in any case it should not exceed 5 minutes.

Fig.7- Mixing of self-compacting geo polymer concrete

Fig.8- Mold used for casting specimens.

The concrete under fresh state is transferred to respective molds and compacted. The compacted specimens was then subjected to ambient conditions and after 24 hours of casted specimens were de-molded and subjected to ambient curing.

Fig.9- ambient curing of geo polymer specimens.

Table-4: Workability test results

W/GPS= water to geopolymer solids ratio, AA/CB=alkaline activator to cementitious binder ratio, AAR=alkaline activator ratio

	Mix no.	**AA/ CB**	**AAR**	**Flow (cm)**	**t-50 (sec)**	**J-ring (cm)**	**V-funnel (sec)**
GPC_1 mix W/GPS=	G_1	0.45	2.5	16	7	10	10
	G_2	0.45	2.5	19	7	10	9
	G_3	0.45	2.5	24	6	9	9
0.3	G_4	0.45	2.5	25	6	9	9
GPC_2 mix W/GPS =0.35	G_1	0.45	2.5	16	6	8	7
	G_2	0.45	2.5	19	4	6	5
	G_3	0.45	2.5	24	4	5	5
	G_4	0.45	2.5	25	4	5	4
GPC_3 mix W/GPS =0.4	G_1	0.45	2.5	16	4	5	4
	G_2	0.45	2.5	19	3	4	4
	G_3	0.45	2.5	24	3	3	4
	G_4	0.45	2.5	25	2	3	4

Table-5: split tensile strength of various mix.

	Mix no.	AA/CB	Alcco fine dosage %	AAR	Split tensile strength (MPa)	
					7 days	28 days
GPC_1 mix W/GPS ratios=0.3	G_1	0.45	0	2.5	2.54	3.09
	G_2	0.45	5	2.5	2.88	3.26
	G_3	0.45	10	2.5	3.05	3.77
	G_4	0.45	15	2.5	2.63	3.15
GPC_2 mix W/GPS ratios=0.35	G_1	0.45	0	2.5	2.46	3.12
	G_2	0.45	5	2.5	2.99	3.39
	G_3	0.45	10	2.5	2.78	3.91
	G_4	0.45	15	2.5	2.61	3.22
GPC_3 mix W/GPS ratios=0.4	G_1	0.45	0	2.5	2.19	3.06
	G_2	0.45	5	2.5	2.81	3.15
	G_3	0.45	10	2.5	2.64	3.33
	G_4	0.45	15	2.5	2.53	3.02

Table-6: compressive strength of various mix.

	Mix no.	AA/CB	Alcco fine dosage %	AAR	Compressive strength (MPa)	
					7 days	28 days
GPC_1 mix W/GPS ratios=0.3	G_1	0.45	0	2.5	19.33	24.33
	G_2	0.45	5	2.5	22.33	25.33
	G_3	0.45	10	2.5	24.67	30.67
	G_4	0.45	15	2.5	20.33	22.67
GPC_2 mix W/GPS ratios=0.35	G_1	0.45	0	2.5	19.67	23.33
	G_2	0.45	5	2.5	22.67	26.33
	G_3	0.45	10	2.5	26.33	32.67
	G_4	0.45	15	2.5	22.33	24.67
GPC_3 mix W/GPS `ratios=0.4	G_1	0.45	0	2.5	14.67	21.33
	G_2	0.45	5	2.5	16.33	23.33
	G_3	0.45	10	2.5	19.67	26.67
	G_4	0.45	15	2.5	17.33	20.67

CONCLUSION

1. The industrial by – product like alccofine and GGBS was effectively used to produce self-compacting geopolymer concrete.
2. For any self-compacting geopolymer concrete mix the workability increases with increase in water to geopolymer solids ratios.
3. Increase increase in alccofine percentage as additive material improves workability of mix.
4. Compressive strength increases with decrease in water to geopolymer solids ratios.
5. Increases in alccofine percentage as additive material up to 10% imparts good compressive strength.
6. Split tensile strength of the mix increases with decrease in water to geopolymer solids ratios.
7. Lye (potassium hydroxide lye) extracted from wood ash is effectively utilized as a substitute for water
8. Optimum mix obtained when the water to geopolymer ratio=0.35 and alccofine replacement percentage in GGBS=10%
9. The casted specimens were subjected to ambient conditions (ambient curing) other than oven or steam curing to observe the suitability and stability of self-compacting geopolymer concrete casted at in suite condition.
10. The compressive strength value at 7 days was found to be 80-90% of its 28 days compressive strength value.

REFERENCES

1. Davidovits J (1991), 'Geo polymers: Inorganic Polymeric New Materials' J. Thermal Anal. 37: 1633-1656.

2. Davidovits J., 'Soft Mineralurgy and Geo polymers', Proceedings of Geo polymer 88 International Conference, France, 1988.

3. Davidovits J., 'High Alkali Cements for 21st century Concretes in Concrete Technology, Past, Present and Feature'., Proceedings of V. Mohan Malhotra Symposium, ACI SP-144,pp.383-397, 1994.

4. Joseph Davidovits, (1994), 'Global Warming Impact on the Cement and Aggregates Industries', World Resource Review, Vol 8, No. 2, pp.263-278.

5. Nagaraj. V. K1 Geo polymer Concrete – A Look over 1 Research Scholar, Department of Civil Engineering, JSS Academy of Technical Education, Bengaluru, Karnataka, India

6. Nagaraj. V. K1, Puttaswamy. B. K2A Study on Wood Ash Based Lye as Alkaline Activator in Geo-polymer Concrete P.G. Student, Dept. of Civil Engineering, Sri Venkateshwara College of Engineering, Bengaluru, Karnataka, India1 Assistant Professor, Dept. of of Civil Engg, Sri Venkateshwara College of Engg, Bengaluru, Karnataka, India2

BIOGRAPHIES

SHIVARANJAN N S. PG Student, GAT College, Bangalore, India.

SHIVA KUMAR K S. Asst. Professor, GAT College, Bangalore, India.

Dr. D.L VENKATESH BABU. Professor, JSSATE College, Bangalore, India.

NAGARAJ V K. PhD Research Scholar, JSSATE College, Bangalore, India.