International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 06 | June-2016 www.irjet.net p-ISSN: 2395-0072

AN EXPERIMENTAL STUDY ON STEEL AND GLASS FIBRE REINFORCED GEO-POLYMER CONCRETE USING GGBS AND ALCCO FINE.

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Abstract - Geo polymer 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, fresh water and fibers such as AR glass and Steel fibers were used to produce fiber reinforced geo polymer concrete. Fresh property and hardened property of fiber reinforced geo polymer concrete are studied and curing of specimens is carried out in ambient condition.

Key Words – fiber reinforced geo-polymer concrete, polymerization, Industrial by-products Alkaline liquid solutions, fibers, Ambient curing.

1. INTRODUCTION

Concrete is major ingredient for any type of construction work. Concrete is considered as the second most used material land. It mainly make use of Portland cement as its main product. The demand of cement as material for construction is increasing rapidly from day by day. The Cement manufacturing industry emits carbon dioxide when compared to fossil fuel burning and deforestation. CO_2 is considered as greenhouse gas, this leads to global warming in the atmosphere. When compared to all the greenhouse gas CO_2 contributes about 68% of global warming in atmosphere. Cement industries emits about 10% of greenhouse gas in atmosphere. Therefore to overcome or arrest the various environmental pollution caused by these industries an alternate material for binding should be made use compulsorily to produce concrete. Many researches are made to replace cement, like incorporating various waste materials and industrial by-products as supplementary cementatious materials like saw dust, rice husk ash, micro silica, met kaolin, ground granulated blast furnace slag (GGBS), Alcco fine, fly ash etc.

Geo-polymers are considered as an inorganic family member which forms a mineral molecular chains linked to co-Valente bond. This concrete mainly utilize alkaline liquid solutions and the important material known as industrial by-products. Geo-polymers majorly undergo polymeric reactions with the alkaline liquid solutions and industrial by-product such as Alcco fine, GGBS etc. The Chemical compositions of geo-polymer is similar to as zeolite and its nature is amorphous in structure.

The industrial by-products mainly has alumina and silica which reacts with alkaline liquid solutions and produce a

good binding property. Alkaline liquid solutions used in activation process are the combination of sodium hydroxide or potassium hydroxide and sodium silicate or potassium silicate. Ordinary geo-polymer concrete has good mechanical properties compared to conventional concrete and further to improve the mechanical properties fiber are incorporated in the mix. These fibers improve the tensile strength, compressive strength, toughness and limits the carracks etc.., In this study different percentages of AR glass and steel fibers are incorporated in geo-polymer mix containing different percentages of Alcco fine and GGBS with 12.5mm coarse aggregates and granulated blast furnace slag(GBS or slag sand) as fine aggregates.

2. SCOPE

The main scope of this project work is to study the various properties of fiber reinforced geo polymer concrete by varying the fiber dosage (AR Glass and Steel fibers) and Alcco-fine percentage in GGBS. The various material used in this work are GGBS, Alcco fine, sodium hydroxide, AR glass fibers , steel fibers , water and sodium silicate are used in varying Alcco-fine is replaced by GGBS in various proportions. To improve properties of concrete. Different fibers like AR glass and steel fibers are used to improve mechanical properties of geo polymer concrete.

The major aim of this project is to study suitability and the performance of fiber reinforced geo polymer concrete which is an alternative to Ordinary Portland Cement (OPC) in the concrete production.

3. OBJETIVES

The major objectives are as follows:

1. To understand and study the behavior of fiber reinforced geo polymer concrete in its fresh state and in harden state with different fiber ratios.
2. To study the behavior of Alcco-fine when it is replaced by GGBS in varying proportions.
3. To fix optimum dosage of steel and AR glass fibers.
4. To make use of industrial by product effectively like Alcco-fine and GGBS.

4. MATERIAL USED AND THERE TESTING

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- AR Glass fibres. fig.7- Steel Fibres


Table-1: Properties of GGBS.

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

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	-	-	-

5. 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 cimentitious binder and aggregates on the day of casting.

6. 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.8- Mixing of fiber reinforced geo polymer concrete

Fig.9- 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.10- ambient curing of geo polymer specimens.

Table-4: Workability test results

`	Mix no.	AA/CB RATIO	Alkaline activator ratio	Slump achieved For AR Glass fibers (cm)	Slump achieved For steel fibers (cm)
GPC_1 mix 0% fibers	G_1	0.45	2.5	16	16
	G_2	0.45	2.5	19	19
	G_3	0.45	2.5	24	24
	G_4	0.45	2.5	25	25
GPC_2 mix 0.2% fibers	G_1	0.45	2.5	16	16
	G_2	0.45	2.5	17	17
	G_3	0.45	2.5	22	23
	G_4	0.45	2.5	24	23
GPC_3 mix 0.4% fibers	G_1	0.45	2.5	15	15
	G_2	0.45	2.5	17	16
	G_3	0.45	2.5	20	19
	G_4	0.45	2.5	24	19
GPC_4 mix 0.6% fibers	G_1	0.45	2.5	15	15
	G_2	0.45	2.5	15	15
	G_3	0.45	2.5	20	16
	G_4	0.45	2.5	22	16
GPC_5 mix 0.8% fibers	G_1	0.45	2.5	14	14
	G_2	0.45	2.5	14	13
	G_3	0.45	2.5	19	13
	G_4	0.45	2.5	21	13

Table-5: Compressive strength results of ARG fibers.

	Mix no.	AA/CB ratio	Alcco fine dosage %	Alkaline activator ratio	Compressive strength of ARG fibers (MPa)	
					7 days	28 days
GPC_1 mix 0% fibers	G_1	0.45	0	2.5	21.33	26.67
	G_2	0.45	5	2.5	22.33	27.33
	G_3	0.45	10	2.5	23.33	29.33
	G_4	0.45	15	2.5	16.33	21.67
GPC_1 mix 0.2% fibers	G_1	0.45	0	2.5	22.33	28.67
	G_2	0.45	5	2.5	24.67	30.67
	G_3	0.45	10	2.5	28.67	34.33
	G_4	0.45	15	2.5	21.33	25.33
GPC_1 mix 0.4% fibers	G_1	0.45	0	2.5	28.67	32.33
	G_2	0.45	5	2.5	32.33	39.66
	G_3	0.45	10	2.5	36.66	44.33
	G_4	0.45	15	2.5	22.33	28.33
GPC_1 mix 0.6% fibers	G_1	0.45	0	2.5	26.67	31.33
	G_2	0.45	5	2.5	30.67	36.66
	G_3	0.45	10	2.5	33.6	39.67
	G_4	0.45	15	2.5	21.29	30.67
GPC_1 mix 0.8% fibers	G_1	0.45	0	2.5	24.66	30.33
	G_2	0.45	5	2.5	26.33	35.33
	G_3	0.45	10	2.5	29.67	37.67
	G_4	0.45	15	2.5	27.33	28.33

Table-6: Compressive strength results of STEEL fibers.

	Mix no.	**AA/CB ratio**	**Alcco fine dosage %**	**Alkaline activator ratio**	Compressive strength of Steel fibers (MPa)	
					7 days	28 days
GPC_1 mix 0% fibers	G_1	0.45	0	2.5	24.33	28.67
	G_2	0.45	5	2.5	27.67	30.33
	G_3	0.45	10	2.5	31.67	34.67
	G_4	0.45	15	2.5	24.33	27.67
GPC_1 mix 0.2% fibers	G_1	0.45	0	2.5	24.33	28.67
	G_2	0.45	5	2.5	27.67	30.33
	G_3	0.45	10	2.5	31.67	34.67
	G_4	0.45	15	2.5	24.33	27.67
GPC_1 mix 0.4% fibers	G_1	0.45	0	2.5	24.33	28.67
	G_2	0.45	5	2.5	27.67	30.33
	G_3	0.45	10	2.5	31.67	34.67
	G_4	0.45	15	2.5	24.33	27.67
GPC_1 mix 0.6% fibers	G_1	0.45	0	2.5	28.67	35.33
	G_2	0.45	5	2.5	33.67	37.67
	G_3	0.45	10	2.5	36.6	38.67
	G_4	0.45	15	2.5	24.29	26.33
GPC_1 mix 0.8% fibers	G_1	0.45	0	2.5	26.66	30.33
	G_2	0.45	5	2.5	29.33	34.67
	G_3	0.45	10	2.5	32.67	36.33
	G_4	0.45	15	2.5	30.33	31.33

Table-7: Split tensile strength results of ARG Fibers

	Mix no.	AA/CB ratio	Alcco fine %	Alkaline activator ratio	Split tensile strength of ARG Fiber (MPa)	
					7 days	28 days
GPC_1 mix 0% fibers	G_1	0.6	0	2	2.66	3.29
	G_2	0.6	5	2.5	2.90	3.31
	G_3	0.6	10	3	2.56	3.8
	G_4	0.6	15	3.5	2.10	3.19
GPC_2 mix 0.2% fibers	G_1	0.6	0	2	3.03	3.56
	G_2	0.6	5	2.5	3.30	3.78
	G_3	0.6	10	3	3.09	3.93
	G_4	0.6	15	3.5	2.89	3.36
GPC_3 mix 0.4% fibers	G_1	0.6	0	2	3.35	3.76
	G_2	0.6	5	2.5	3.41	4.11
	G_3	0.6	10	3	3.05	4.39
	G_4	0.6	15	3.5	2.63	3.48
GPC_4 mix 0.6% fibers	G_1	0.6	0	2	3.05	3.58
	G_2	0.6	5	2.5	2.73	3.87
	G_3	0.6	10	3	2.25	4.01
	G_4	0.6	15	3.5	2.16	3.39
GPC_5 mix 0.8% fibers	G_1	0.6	0	2	2.24	3.38
	G_2	0.6	5	2.5	2.44	3.81
	G_3	0.6	10	3	2.05	3.98
	G_4	0.6	15	3.5	1.56	3.38

Table-8: Split tensile strength results of Steel Fibers.

	Mix no.	AA/CB ratio	Alcco fine %	Alkaline activator ratio	Split tensile strength of steel fiber (MPa)	
					7 days	28 days
GPC_1 mix 0% fibers	G_1	0.6	0	2	3.29	3.29
	G_2	0.6	5	2.5	3.31	3.31
	G_3	0.6	10	3	3.8	3.8
	G_4	0.6	15	3.5	3.19	3.19
GPC_2 mix 0.2% fibers	G_1	0.6	0	2	3.33	3.6
	G_2	0.6	5	2.5	3.60	3.83
	G_3	0.6	10	3	3.19	3.99
	G_4	0.6	15	3.5	2.99	3.41
GPC_3 mix 0.4% fibers	G_1	0.6	0	2	3.45	3.86
	G_2	0.6	5	2.5	3.51	4.22
	G_3	0.6	10	3	3.15	4.49
	G_4	0.6	15	3.5	2.73	3.53
GPC_4 mix 0.6% fibers	G_1	0.6	0	2	3.15	3.61
	G_2	0.6	5	2.5	2.83	3.93
	G_3	0.6	10	3	2.55	4.12
	G_4	0.6	15	3.5	2.46	3.44
GPC_5 mix 0.8% fibers	G_1	0.6	0	2	2.54	3.43
	G_2	0.6	5	2.5	2.74	3.96
	G_3	0.6	10	3	2.15	4.03
	G_4	0.6	15	3.5	1.66	3.47

CONCLUSION

1. Alcco fine and GGBS are effectively used to produce fiber reinforced geo polymer concrete.

2. The industrial by – product like Alcco fine and GGBS was effectively and greatly used to produce fiber reinforced geo polymer concrete.

3. For any fiber reinforced geo polymer concrete mix the workability increases with decreasing in fiber percentage.

4. Increase in Alcco fine percentage as additive material improves workability of mix.

5. Compressive strength increases with increase in fiber dosage

6. Increases in Alcco fine percentage as additive material up to 10% imparts good compressive strength.

7. Split tensile strength of the mix increases with decrease in water to geo polymer solids ratios.

8. Optimum mix obtained was fixed when the fiber dosage =0.4% and Alco fine 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 fiber reinforced geo polymer concrete casted at in suite condition.

10. The compressive strength value at 7 days was found to be 75-85% 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

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