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Research Article

DURABILITY CHARACTERISTICS OF BIO MASS ASH AND SLAG BASED GEOPOLYMER CONCRETE

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ABSTRACT

The paper explores the feasibility of using biomass ash and slag based geopolymer concrete and to investigate their strength and durability characterstics. Geopolymer concrete (GPC) was developed using biomass ash and ground granulated blast furnace slag (GGBS) in different percentages and the strength and durability characteristics of this new concrete were investigated in order to explain its utilization potential. Studies are being systematically conducted on these new materials with regards to both strength and durability characteristics. In the present investigation, the Geopolymer concrete was subjected to attack by sulphuric acid for understanding durability aspects of the new concretes. In present research work, bio mass ash and slag based geopolymer was used as the binder, instead of Portland or any other hydraulic cement paste, to produce concrete. The biomass ash-slag based geopolymer paste binds the loose coarse aggregates, fine aggregates and other unreacted materials together to form the geopolymer concrete, with or without the presence of admixtures.

INTRODUCTION

Bio Mass ash and slag based geopolymer was used as the binder, instead of Portland or any other hydraulic cement paste, to produce concrete. Bio mass ash-slag based geopolymer paste binds the loose coarse aggregates, fine aggregates and other unreacted materials together to form the geopolymer concrete, with or without the presence of admixtures. In the present study biomass ash and ground granulated blast furnace slag was used as the base materials or geopolymer materials.

In addition, the amount of energy required to produce OPC is only next to steel and aluminium. As the demand for OPC is continuously increasing, whereas the natural resources are fast depleting and hence there is a need to look for suitable alternatives to OPC. Lime stone based Portland cements are good binders for conventional cement concretes (CCs) which are successfully used in many civil engineering structures. The CCs were found to be less durable in some of the very severe environmental conditions, besides being highly internal-energy-intensive and causing emission of green house gas, CO_2.

Experimental Programme

The testing is carried out to obtain the properties of the different constituent materials. The materials, in general, conformed to the specifications laid down in the relevant Indian Standard Codes of Practice wherever applicable.

Cement

The various tests performed on the Ultratech 43 grade OPC cement and their values are shown in the Table 1.

Table 1 Characteristics Properties of Cement

Sr.No	Characteristics	Results
1	%Consistency of cement	32.5
2	Specific gravity	3.101
3	Initial setting time (minutes)	41
4	Final setting time (minutes)	347
5	Compressive strength (N/mm^2)	
	(i) 3 days	24.10
	(ii) 7 days	34.56
	(iii)28days	47.92
6	Soundness (mm)	1.00
7	Fineness of Cement (gm)	0.50

The results of the tests performed on the fine aggregate such as fineness modulus and its physical properties are shown in Table 2 and 3 respectively.

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Total Weight of Sand taken= 1000gm

Table 2 Sieve Analysis of Fine Aggregate

IS Sieve	Wt. Retained on sieve (gm)	Cumulative %age retained	%age passing
4.75mm	15	1.5	98.5
2.36mm	120	13.5	86.5
1.18mm	107	24.2	75.8
600µ	354	59.6	40.4
300µ	297	89.3	10.7
150µ	90	98.3	1.7
Pan	17	∑F = 2.86	

Fineness Modulus of fine sand = 2.86

Table 3 Physical Properties of Fine Aggregate

Property	Result
Specific Gravity of Fine Aggregates	2.60
Free Moisture Content	2%
Water Absorption	1.82%

Coarse Aggregate used was a mixture of two available crushed stones of 10mm and 20mm size in 40:60 proportions. The sieve analysis and physical properties of coarse aggregate satisfied the requirement of IS: 383-1970 and the results are given in Table 4 and Table 5 respectively.

Total weight of 10mm aggregate = 5000gm

Table 4 Proportioning of Coarse Aggregate

IS Sieve	Cum.% passing of 10mm aggregates (gm)	Cum.% passing of 20mm aggregates (gm)	Proportion 40 : 60 (10mm : 20mm)
80mm	100	100	100
40mm	100	100	100
20mm	100	100	100
10mm	61.0	34.5	45.1
4.75mm	8.0	1.0	3.8

Table 5 Physical Properties of Coarse Aggregate

Property	Result
Specific Gravity of coarse Aggregates	2.70
Free Moisture Content	Nil
Water Absorption	0.15%

Bio Mass Ash

Bio Mass ash obtained from a local thermal power station was used in this research. Bio mass ash is a byproduct from coal fired power stations. Coal is ground into a fine dust prior to combustion and it is the finer ash which is cementitious.

Table 6 gives the characteristics of Biomass ash.

Table 6 Characteristics of Bio mass Ash

S.No.	Properties	Values
1	Chemical composition (% by mass)	
	SiO_2	67.23
	Al_2O_3	16.30
	CaO	3.8
	MgO	3.55
	Fe_2O_3	1.95
	Na_2O	1.98
	SO_3	1.42
2	Ph	9.91
3	Lime reactivity (MPa)	4.53
4	Loss on ignition (%)	7.58
5	Specific surface (m^2/gm)	0.553
6	Specific gravity	2.57

Ground Granulated Blast Furnace Slag

In the present experimental work, ground granulated blast furnace slag was used as the base material. The typical properties of GGBS as calculated are presented in the Table 7.

Table 7 Chemical Composition of GGBS

Composition	GGBS present study (%)
CaO	40.3
SiO_2	43.4
Al_2O_3	12.5
Na_2O	0.9
KO	0.6
MgO	1.5
LOI	2.1

***Physical Properties**:* Specific Gravity of the GGBS was 2.90 and water absorption was 1.38(%).

Water

The water used in the concreting work was the potable water as supplied in the PG Structures lab of our college. Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalis, salts and sugar, organic substances that may be deleterious to concrete. As per IS 456- 2000 Potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly potable tap water was used for the preparation of all concrete specimens.

The details of the mix used in the present study are shown in Table 8, Table 9 and Table 10.

Table 8 Mix Design Proportion of Standard (M 25) Grade Concrete

Mix	Water	Cement	Fine aggregate	Coarse aggregate
M1	190 lt/m^3	414 kg/m^3	446 kg/m^3	622kg/m^3
Prop.	.45	1	1.10	1.50

Table 9 Types of Mixes Used In Investigation

Mix	% Replacement of Cement
M1	0
M2	25% GGBS + 75% BMA
M3	50% GGBS + 50% BMA
M4	75% GGBS + 25% BMA

Table 10 Mix Proportions for Geopolymer Concretes (GPCs)

Constituents (in Kg)	Mix Designation		
	M1	M2	M3
BioMass Ash	342	228	114
GGBS	114	228	342
Fine Agg.	591	591	591
Coarse Agg.	1138	1138	1138
Activator Solution	206	206	206
NaOH	51.75	51.75	51.75
Na_2SiO_3	154.25	154.25	154.25

DISCUSSION OF RESULTS

Compressive Strength

The compressive strength was conducted on various specimens as per the guidelines given in IS 516-1959. The specimens were surface dried before testing the same on Universal Testing Machine of 200 tonnes capacity. The result of compression test at the moist curing age of 7 days and 28 days are presented in Table 11.

Table 11 Compressive Strength Test Results

Mix	Average Compressive Strength (N/mm^2) (7days)	Average Compressive Strength (N/mm^2) (28days)
M1	22.23	33.70
M2	13.69	30.12
M3	15.21	32.50
M4	12.52	30.11

The comparison of compressive strength of various mixes is shown in Figure 1 and 2.

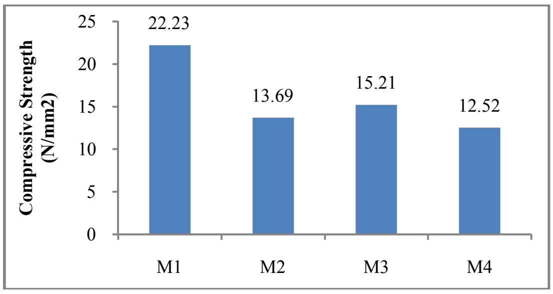

Figure 1 Variation of Compressive Strength of Mixes after 7 Days

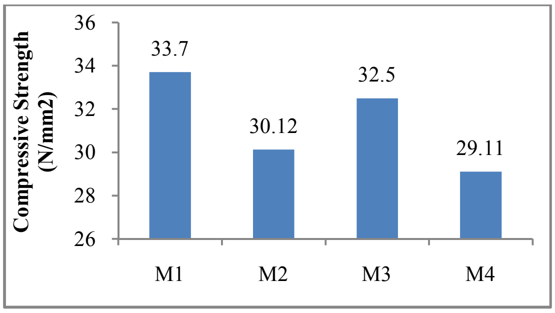

Figure 2 Variation of Compressive Strength of Mixes after 28 Days

It is clear from these tables that, the 28 days compressive strength of M3 mix is almost equal to the reference mix but the 7 days compressive strength of M3 is less than that of reference mix.

Split Tensile Strength Test

The split tensile strength of concrete was conducted on various mixes as per guidelines of IS 516-1970. The test was conducted on universal testing machine. The result obtained for various mixes at the curing age of 7 days and 28 days are presented in Table 12. The comparison of the split tensile strength of various mixes at the age of 7 days and 28 days of curing is shown in Figure 3 and 4 respectively.

Table 12 Split Tensile Strength Test Results

Mix	Average Compressive Strength (N/mm^2) (7days)	Average Compressive Strength (N/mm^2) (28days)
M1	2.9	4.2
M2	1.72	3.7
M3	2.1	3.9
M4	1.59	3.5

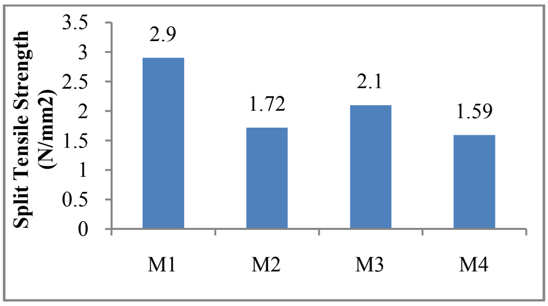

Figure 3 Variation of Split Tensile Strength of Mixes after 7 Days

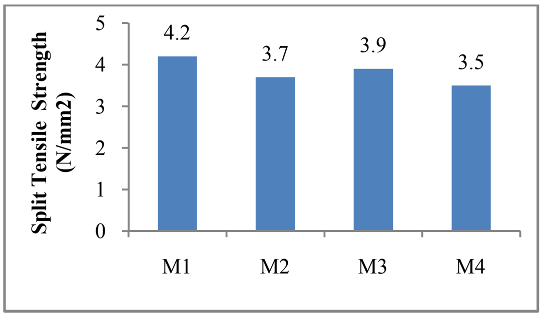

Figure 4 Variation of Split Tensile Strength of Mixes after 28 Days

It is clear from above Table 12 and Figure 3 and Figure 4 that the tensile strength of GPCs follow the similar trend as that of compressive strength.

Durability Test

Sulphuric Acid Solution

In the present experimental work, sulphuric acidic solutions of 2%, 4% and 6% were choosen as the representative acidic media. The composition of different percentage of sulphuric acid solution is given in Table 13. Table 14 represents the results of compressive strength of different mixes after immersing them in concentrated sulphuric acid at 28 days. Figure5, Figure 6 and Figure 7 represents the results of compressive strength results after placing the sample in 2%, 4% and 6% in concentrated sulphuric acid solution.

Table 13 Composition of Conc. Sulphuric Acid Solution

Conc. H_2SO_4 Solution	Conc, Acid (in ml)	Distilled Water (in ml)
2%	11	989
4%	22	978
6%	33	967

Table 14 Compressive Strength Results Conc. Sulphuric Acid Solution at 28 days

Conc. H_2SO_4 Solution	Compressive Strength (N/mm^2)			
	M1	M2	M3	M4
0%	33.70	33.10	32.50	30.11
2%	31.67	28.97	31.42	29.88
4%	29.31	28.08	30.62	28.27
6%	27.12	27.01	29.87	27.97

The perusal to results reported in Figure 5, Figure 6 and Figure 7 reveals that geopolymer concrete shows increased resistance to the attack of acid than normal concrete for different concentrations of sulphuric acids

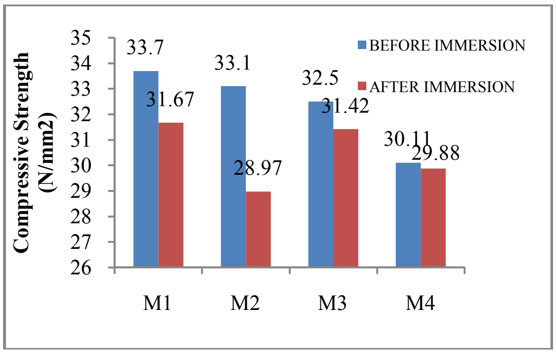

Figure 5 Compression strength comparison of concretes after 28 days of immersion in 2% Sulphuric Acid Sol

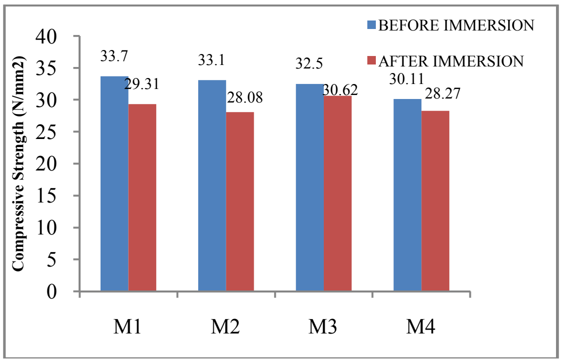

Figure 6 Compression strength comparison of concretes after 28 days of immersion in 4% Sulphuric Acid Sol

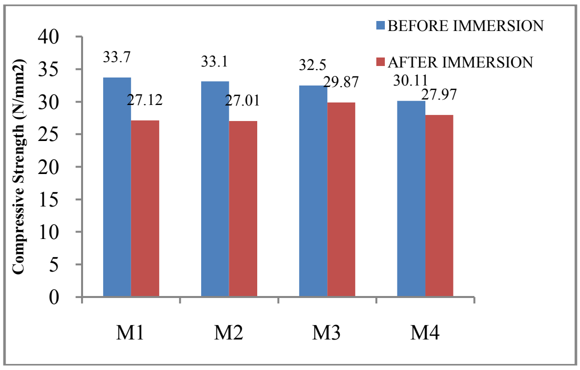

Figure 7 Compression strength comparison of concretes after 28 days of immersion in 6% Sulphuric Acid Sol

CONCLUSIONS

On the basis of the results and discussions of this investigation the following conclusions can be drawn:

- Biomass ash and GGBS can be used as base materials to produce geopolymer reactions using alkali hydroxide-silicate based activator solution.
- The GPCs do not require Portland cement and hence, they can be considered as less energy intensive since Portland cement is a highly energy intensive material. Apart from less energy intensiveness, the GPCs utilize the industrial wastes for producing the binding system in concrete and thus can be considered as highly eco-friendly material.
- The compressive strength of GPC with equal proportions of Bio mass ash and GGBS was found to be comparable to the reference mix at the age of 28 days and thus can be considered as optional proportioning for making GPC using biomass ash and ground granulated blast furnace slag.
- The GPC are found to be highly acid resistant, since even after 28 days of immersion in 2%, 4% and 6% sulphuric acids, the specimens remained intact without any significant change in mass and shape. But in case of OPCs, the specimens had deteriorated severely with very obvious external damaged surfaces accompanied by noticeable bulging. Therefore, GPC could be considered as superior to OPC concrete from the durability considerations.

References

1. ACI Committee 318 (2002), “Building Code Requirements for structural Concrete, American Concrete Institute, Farmington Hills, MI.
2. Bakharev, T. (2005), “Durability of geopolymer materials in sodium and magnesium sulfate solutions”. *Cement and Concrete Research*. 35:1233-1246.
3. Bakharev, T. (2005), “Geopolymeric materials prepared using Class F Fly ash and elevated temperature curing”. Cement and Concrete Research.35: 1224-1232.
4. Bhanumathidas, N. & Kalidas, N. (2002), “Fly Ash for sustainable development”. ARK communications, Chennai, 2002.
5. Cheng, T. W. & J. P. Chiu (2003), “Fire-resistant Geopolymer Produced by Granulated Blast Furnace Slag”. *Minerals Engineering*.
6. Collins, M. P., D. Mitchell, J.G Mac Gregor (1993), “Structural Design Considerations for High Strength Concrete”, *ACI Concrete International* 15(5): 27-34.
7. Davidovits, J (1998) “Soft Mineralogy and Geopolymers”, Proceedings of the Geopolymer 88 International Conference, the Université de Technologie, Compiègne, France.
8. Davidovits, J (1994) “Highly-Alkali Cements for Twenty-first Century Concretes Technology, Past, Present and Future”, Proceedings of V. Mohan Malhotra Symposium, Editor: P. Kumar Mehta, ACI SP-144, 383-397.
9. Davidovits, J (2005) “Green Chemistry and Sustainable Development Granted and False Ideas about Geopolymer Concrete.” International work shop on Geopolymer and Geopolymer Concrete (GGC), Perth, Australia.
10. Duxson P, Provis J L, Lukey G C and van Deventer J S J (2007), “The Role of Inorganic Polymer Technology in the Development of Green Concrete”, Cement and Concrete Research, 37(12), 1590-1597
11. Fernandez-Jimenez A M, Palmo A, and Lopez-Hombrados C (2006a), “Engineering Properties of Alkali-activated Fly Ash Concrete”, *ACI Materials Journal*, 103(2), 106-112.
12. Fernandez-Jimenez A M,de la Torre A G, Palomo A, Lopez-Olmo G, Alonso M M, and Aranda M A G(2006b), “Quantitative Determination of Phases in the Alkali Activation of Fly Ash, part 1, Potential Ash Reactivity”, Fuel,85 (5-, 6), 625-634.
13. Gourley, J. T. (2003), “Geopolymers; Opportunities for Environmentally Friendly Construction Materials”, Paper presented at the Materials 2003 Conference: Adaptive Materials for a modern society, Sydney