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Acid Resistant Characteristic of Flyash Based Geopolymer Concrete

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ABSTRACT

This paper is an attempt to study the acid resistance characteristics of fly ash based Geopolymer concrete. Thespecimenswere immersed in 3 % H2SO4 solution The % of mass loss of 20, 40, 60 MPa Geopolymer concrete were compared with normal concrete of equal strength grade. From the experimental observation it was found that Geopolymer concrete showed excellent resistant to acid attack.

Key words: Geopolymer, Alkali activated alumino silicate, acid resistance.

1. INTRODUCTION

Concrete structures, in many industrial applications, are subjected to aggressive environments containing sulphates, acids, chlorides, seawater etc. In case of normal concrete made with Portland cement the aggressive ions, particularly sulphates, chemically react with the hydrated C3A compounds present in the concrete and form ettringite (3CaO Al2O3 3CaSO4 32H2O). This ettringite causes considerable expansion and even cracking. Further, the corrosion of steel in concrete and alkali aggregate reaction al so may cause deterioration of concrete. This leads to high maintenance and repair costs. The addition of fly ash in concrete is being advocated as one of the few methods to reduce the deterioration of concrete.Sulphate attack of hydrated cement paste takes place when sulphate ions react with calcium hydroxide and calcium aluminate to form gypsum and ettringite. The formation of these two products is responsible for expansion and cracking of concrete. Consequently, the amount of tricalcium aluminate (C3A) in the cement and the amount of Ca(OH)2 in the concrete mixture affect the sulphate resistance. Use of pozzolanic materials such as fly ash for cement replacement is known to improve sulphate resistance of concrete mainly by the consumption of the Ca(OH)2 by the pozzolanic reaction (Ganesh Babu,K. and G. Siva Nageswara Rao, 1996).

2. LITERATURE REVIEW

Bakharev (2005) studied the durability of fly ash based Geopolymer paste using sodium silicate and sodium hydroxide as activators. He studied the deterioration characteristics of Geopolymer samples subjected to 5% sulphuric acid, and found that the % of weight loss after 2 months was only around 3%. He also found that the fly ash activated with sodium hydroxide performed better than the material activated with potassium hydroxide.Song et al.(2005) studied the acid resistance of fly ash based Geopolymer exposed to sulphuric acid (10%) for 8 weeks. It was found that the % of mass loss was less than 3% after 8 weeks. This was mainly due to the low calcium content present in the source material. The SEM image of the sample showed the presence of white colored product (ettringite) and some minute cracks. The occurrence of minute cracks was mainly due to the solubility of basalt aggregate which reacted with acid. Hence, it was concluded that selection of coarse aggregate also influenced the acid resistance behavior.

3. EXPERIMENTAL INVESTIGATION

Concrete deterioration studies were conducted by acid attack. In acid attack test, 3% H2SO4 solution (by volume) was used. The specimens were immersed in acid solution after 90 days of normal curing. The mass loss was measured at regular intervals up to90 days and the compressive strength was measured at the end of 90 days of immersion in acid solution. The acid solution was changed once in fifteen days to maintain a constant pH. The spacing of the specimens in the solution container was as per ASTM C

452 (2006).

Material used Cement: Ordinary Portland cement (OPC) of 53 grade conforming to the requirements of IS: 12269 was used in all investigations.

Fly Ash: According to ASTM C 618, there are two types of fly ashes (Class C or F) based on the CaO content. Fly ashes thus produced fall in the category of class F.

Silica fume: The silica fume used in the present investigation was obtained from Elkem materials.

Activators: Two activators were used in this study - sodium silicate and sodium hydroxide. The chemical composition of the sodiumsilicate solution is presented inTable 1. Sodium hydroxide (NaOH) in pellet form was made into a solution of required concentration by mixing with distilled water**.** The masses of NaOH solids for various concentrations

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are shown in Table 2.

Sand: In the present investigation, well graded river sand was used. The sand was sieved through2.36 mm sieve to remove the larger grains of pebbles or organic matter (if any).

Coarse aggregates: Good quality well graded crushed granite was used as coarse aggregate. For the development of normal concrete and Geopolymer concretes, the coarse aggregates passing through 12.5 mm and 6.3 mm were considered.

Superplasticiser: The superplasticizer (SP) used in this study was a commercially available sulphonated naphthalene formaldehyde (SNF) chloride ion content is < 0.2%.

Table.1.Chemical compositionofsodium silicatesolution

Solids (%)		Liquids	Specificgravity g/cm^3
SiO_2	Na_2O	(%)	
28	8	64	1.48

Table.2.Chemical compositionofsodiumhydroxidesolutions

Molarity(M)	Solid NaOH%	Distilled water%
14	40.4	59.6

Mixproportioningforconcrete: No standard mix design methodology similar to that for normal concreteis availablein the literature for designingGeopolymer concrete. Rather there are guidelines for mixture proportioning published in various studies. In this study, the sol/b ratio and SS/NaOH ratio that resulted in the highest strength for the Geopolymer mortars, was used for the design of the concrete mixtures. Mix details of normal concretes (NC) and Geopolymer concretes are shown in Tables 3 and 4.

Methodsoftesting: The performance of Geopolymer concretes in terms of the corrosion of embedded steel was investigated to assess their suitability to aggressive environments. The corrosion behaviour of steel in Geopolymer concretes was studied in two parts, in terms of the parameters related to the concrete (resistivity, alkalinity and chlioride permeability) and those related to the steel in concrete (potentials) and these were compared with the corresponding normal concretes at equivalent strengths.

4. TEST PROCEDURE

Prisms of 40 × 40 × 160 mm were used in the study. They were demoulded after 24 hours and then stored in a mist room until the age of 28 days, after which the specimens were air dried for two days. Geopolymer concrete specimens were completely immersed along with reference concrete specimens in 3% H2SO4 solution (Fig. 1). The mass losses were measured at regular intervals upto 90 days. After removing the specimens from the solution, the surfaces were cleaned with a soft nylon wire brush under running tap water to remove loose material from the surface. Then the surface of the specimen was dried and the mass was measured.

5. RESULTS AND DISCUSSION

The results of acid attack studies in terms of the weight losses for all the concretes are reported in Table 5 It can be observed from the results that the % of mass loss of Geopolymer concrete is only a fraction of the normal concrete. As stated by previous researchers (Bakharev,2005; Hardjito, D. and B. V. Rangan, 2005, Geopolymer concrete prepared with fly ash possesses high durability in acid environment. The % of mass loss in all the Geopolymer concrete was almost nil in the initial 15 days. The mass loss after 15 days is also due to the removal of some loose sand particles and reaction of very small amounts of CaO (2%) present in the source material i.e. fly ash.

Table.3.Details ofnormal concrete

Mix No	Cement	Silica Fume	Aggregate	Water	slump	w/c
	kg/m^3	kg/m^3	kg/m^3	kg/m^3	mm	ratio
2NC	315	-	1874	185	210	0.59
4NC	356	-	1780	185	135	0.52
6NC	428	22	1720	185	95	0.41

2NC- 20MPa Normal Concrete, 4NC – 40 MPa normal concrete, 6NC- 60 MPa normal concrete

Figure.1.Mortar prisms immersed in 3% H_2SO_4 solution

Table.4.Details of Geopolymer concretes

S. No	Name	w/s	Na_2O toSiO_2 ratio	H_2O toNa_2O ratio
1	2NC	0.57		
2	2GC35	0.24	0.12	12.3
3	2GC45	0.26	0.12	13.44
4	2GC55	0.26	0.14	11.61
5	4NC	0.52		
6	4GC35	0.28	0.14	12.24
7	4GC45	0.24	0.12	12.57
8	4GC55	0.24	0.12	12.22
9	6NC	0.38		
10	6GC45	0.25	0.14	11.14
11	6GC55	0.22	0.12	11.52

2GC25–20 MPaGeopolymerConcrete

Table.5.Acid attack test results

S. No	Concrete Name	90 day Strength (MPa)	Cement content kg/m^3	Initial mass kg/m^3	%Masslosswithimmersionperiod ($3\%H_2SO_4$)					
					3d	5d	15d	30d	60d	90d
1	2NC	31	235	2628	3.38	3.76	8.58	12.97	15.72	25.73
2	2GC35	27	-	2189	0	0	0	0.25	0.38	0.55
3	2GC45	30	-	2261	0	0	0	0.25	0.57	0.85
4	2GC55	26	-	2601	0	0	0	0.25	0.45	0.65
5	4NC	54	178	2444	0.26	0.57	0.65	5.96	14.82	19
6	4NC35	43	-	2299	0	0	0	0.1	0.21	0.75
7	4NC45	47	-	2129	0	0	0	0	0.14	0.2
8	4NC55	46	-	2597	0	0	0	0	0.21	0.5
9	6NC	74	337	2423	0.11	0.37	1.59	3.96	7.48	11.42
10	6GC45	68	-	2338	0	0	0	0	0.15	0.21
11	6GC55	62	-	2274	0	0	0	0	0.1	0.19

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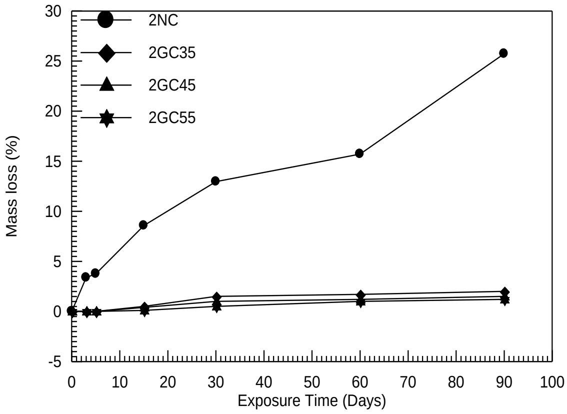

Figure.2.Mass loss with time in acid for concrete

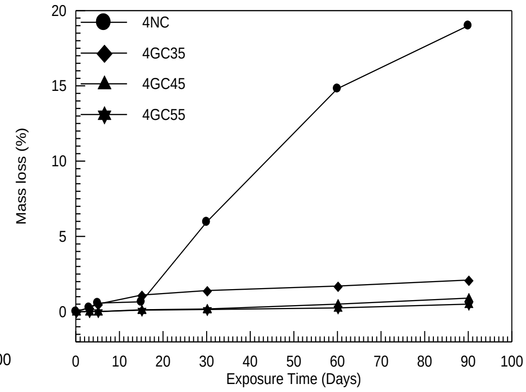

Figure.3.Mass loss with time in acid for40 MPa concrete

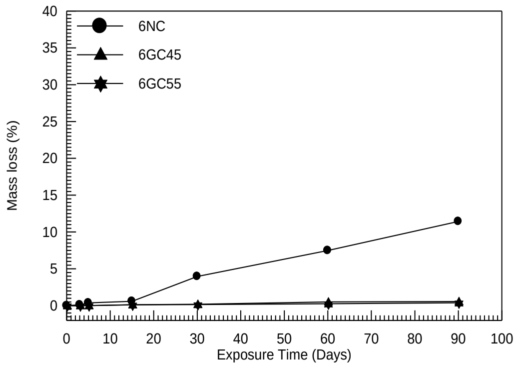

Figure.4.Mass loss with time in acid for 60 MPa concrete

6. CONCLUSION

Based on the above experimental findings it may be concluded that Geopolymer concretes of allstrength (20,40and60MPa) the weight loss in acid exposure was only a fraction compared to normal concrete.This is probably due to the absence of reaction compounds like Ca(OH2). Variation in flyash content did not have any influence on the weight loss, Geopolymer concrete provides excellent resistance to acid attack.

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