Evaluation of performance of Geopolymer Concrete in acid environment

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ABSTRACT: The degradation of concrete by acid attack has been a major problem which needs to be addressed with the utmost concern. This acid attack is primarily due to acid rain in low concentrations. This attack depends upon both type of the acid and the concentration of the acid and the vulnerability of concrete. Portland cement concrete due to high alkanity may be prone to acid attack by acidic environment. The emergence of new alternative materials needs to address this issue by resisting acid attack to a large extent. Geopolymer materials are polymer minerals which are based on silica and alumina compounds. The process of corrosion of geopolymer concrete is tough compared to that of conventional concrete. An experimental study was conducted to evaluate the resistance of geopolymer concrete and Portland cement concrete to acid environment. Durability of the concrete specimens were analyzed by immersing them in 2% concentration solutions for a period of 28, 56 and 112 days, In evaluation of their resistance on basis of change of weight and compressive strength. Results indicated that Geopolymer concrete was highly resistant to sulphuric acid and hydrochloric acid.

Keywords - Geopolymer Concrete, Sulphuric Acid, hydrochloric acid, Silica, Alumina.

1. INTRODUCTION

Durability of concrete is the most crucial property which evaluates the life of concrete. Interactions of concrete with external environment is one of the important factors which indicates the durability of concrete. Among environmental factors like thaw, abrasion and corrosion and acid attack, acid attack is the most threatening parameter. There are many chemical attacks like acid attack, alkali attack etc. [1]. The extent of deterioration during an acid attack on concrete depends on the chemical nature of anions present. Aggregate type and concrete also influence the extent and intensiveness of acid attack. Though ordinary Portland cement (OPC) is the widely used binder in construction industry, its resistance to chemical attacks such as acids, chlorides and sulfates is a major concern. Acid attack has not traditionally attracted much attention, even when cement composites are severely damaged by acids wherein calcium hydroxide is dissolved and the hydrated silicate and aluminium phases are decomposed. In the past few many years geopolymer binders have emerged as one of the possible opportunity to opc binders because of their mentioned excessive early energy and resistance against acid attack [2] apart from its environmental friendliness. Fly ash based geopolymers are one branch in the geopolymer family and these have attracted more attention since the 1990s. As a novel binder the overall performance of fly ash based geopolymers is promising specially in some competitive situations where portland cement concretes are prone to acid environment[3]. Geopolymer binders might be a promising opportunity in the improvement of acid resistant concrete. Given that geopolymers are a unique binder that relies on alumina silicate instead of calcium silicate hydrate bonds for structural integrity they were reported as being acid resistant. Davidovits et al. [4] Determined that metakaoline based geopolymer has very low mass loss while samples have been immersed in 5% sulphuric acid solutions for four weeks Bakharev T. [5] Studied the resistance of geopolymer materials organized from fly ash in opposition to 5% sulfuric acid as much as five exposure and concluded that geopolymer materials have better resistance than ordinary cement counterparts. X.J. Song et al. [6] Performed an accelarated test to evaluate the durability of geopolymer concrete in a 10% sulfuric acid answer for 56 days and reported its its good durability. S.E. Wallah and B.V. Rangan [7] Have shown that geopolymer composites possesses good durability in examination carried out to assess the long time properties of fly ash based geopolymers. Allahverdi Ali and Skavara [8-9]conducted tests to study the mechanism of corrosion of geopolymer cements in high and low concentrations of sulfuric acid. The absence of standard methods to evaluate the performance of cements in acid environments has led to research in different exposure conditions and procedures by various authors making it difficult to correlate the results. The present study is aimed at evaluating the response of Fly ash based geopolymer concrete exposed to sulfuric acid and hydrochloric acid. The study comprised determination of changes in weight and ,compressive strength as a measure of resistance against sulfuric acid. The findings of the prevailing have a look at shall be beneficial in figuring out the applicability of geopolymer substances for use in acid environments.

2. EXPERIMENTAL PROGRAM

2.1. Alkaline liquid

The alkaline liquid is prepared by mixing sodium hydroxide pellets mixed with water in 6 Molarity concentration and sodium silicate solution together at least 24 hours prior to use for
thorough mixing and reaction. Ratio of these solutions is 2.5. The sodium hydroxide with 97-98% purity in pellet form is commercially available..

2.2. Fly Ash

Low-calcium (ASTM Class F) fly ash obtained from the Rayalaseema Thermal Power Plant, Kadapa (Andhra Pradesh) is used for this research.

2.3. Aggregates

In production of Geopolymer Concrete the fine aggregate used is slag which has specific gravity in oven dry condition and Water absorption as 2.8 and 1.9 respectively as per IS 2386, the Coarse Aggregate used was crushed stone up to 70% by weight and remaining 30 % was replaced by Coal washery rejects.

2.4. Geopolymer Concrete

The minimum compressive strength of concrete used for construction is M 25 grade as per I.S: 456- 2000 and it is tried with the 6M molarity Sodium Hydroxide solutions and the constituents are shown in Table 1.

Table 1. Mix proportions of constituent materials (kg/m^3 and litres)

Mix type		GPC
Coarse aggregate	Crushed stone	903
	Coal Washery rejects	387
Fine aggregate	Slag	549
Fly ash		409
Na_2SiO_3		102
NaOH		41 (6M)

2.5. Mixing, Casting and Curing

The geopolymer concrete is manufactured in the laboratory. The dry fly ash and fine aggregates are mixed together in 50-litre capacity mixer for about three minutes. The course aggregates are prepared in Saturated-Surface-Dry (SSD) condition. The alkaline liquid is added to the dry materials and the mixing is continued for another four minutes [9]. It's far determined that a geopolymer concrete stick tough to the mold so oiling the mold could be very crucial to cast every specimen even as casting it in three layers manually. Each layer was given 25 strokes of compaction by standard compaction rod. Fresh geopolymer concrete is very cohesive. After casting the specimens they are kept at room temperature for curing.

3. ACID RESISTANCE

The sulfuric acid and hydrochloric acid resistance resistance of geopolymer concrete is evaluated. To carry the acid attack in the present investigation immersion techniques is adopted. After casting and curing, specimens are immersed in acid solutions. The concentration of sulfuric acid and hydrochloric acid solutions are 2%.. The evaluation is conducted after 28, 56 and 90days from the date of immersion. Solutions are kept at room temperature. The solution is replaced at regular intervals to maintain concentration of solution throughout the test period [10]. The weight of geopolymer concrete decreases when the acid concentration increases and the same effect is reflected after 90 days immersion in acid . The weight of GPC specimen before and after immersion is shown in table 2 and table 3. The compressive strength of geopolymer concrete immersed in H2SO4 and HCL concentrations of is also given in table 2 and table 3. The comparison of compressive strength of specimens with Conventional M25 grade concrete is also shown in the following figures.

Table 2 Weight of GPC Specimens Immersed in H_2SO_4

Mix Type	GPC	GPC Weight Reduction in Percentage	Conventional Concrete(CC)	CC Weight Reduction in Percentage
Initial Weight(in gms)	8092	0	8106	0
Weight of Specimen after 28 days Immersion in H_2SO_4 (in gms)	8047	0.55	8054	0.60
Weight of Specimen after 56 days Immersion in H_2SO_4(in gms)	8014	0.41	8016	0.47
Weight of Specimen after 112 days Immersion in H_2SO_4(in gms)	7984	0.38	7982	0.42

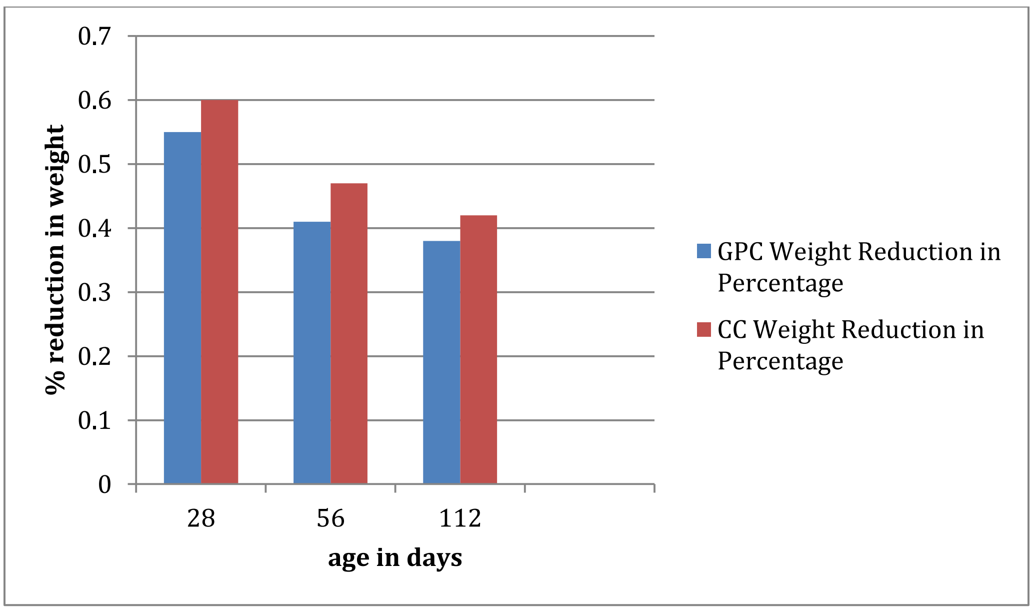

Figure 1 percentage reduction in weight exposed to sulfuric acid

Table 3 Compressive strength of GPC Specimens Immersed in H_2SO_4

Mix Type	GPC	GPC Compressive strength in Percentage	CC	CC Compressive strength in Percentage
Compressive strength in MPa	35.87	0	32.82	0
Compressive strength in MPa after 28 days Immersion in H_2SO_4	33.82	0.61	30.87	0.64
Compressive strength in MPa after 56 days Immersion in H_2SO_4	31.96	0.55	28.72	0.75
Compressive strength in MPa after 112 days Immersion in H_2SO_4	30.14	0.61	26.74	0.69

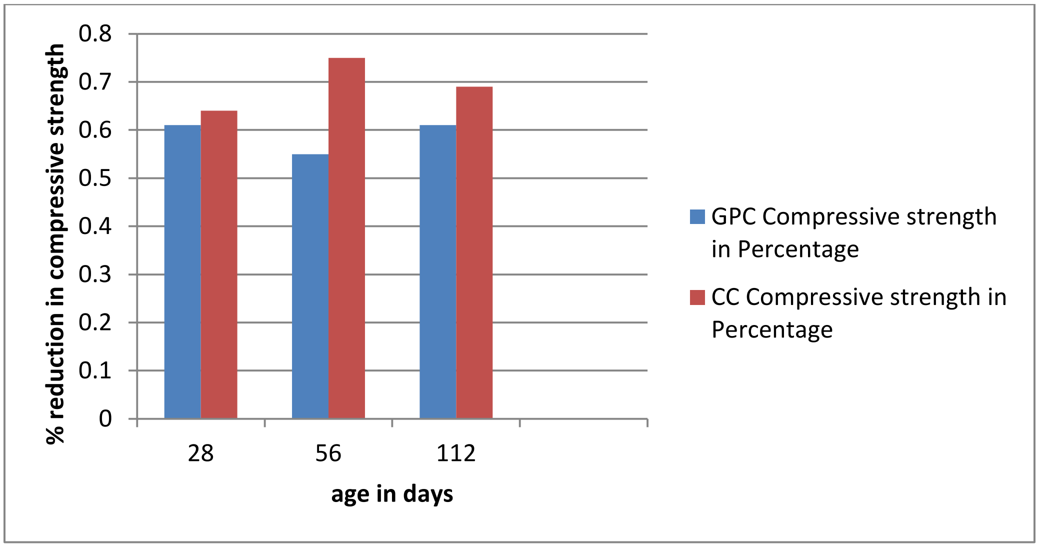

Figure 2 percentage reduction in compressive strength exposed to sulfuric acid

Table 4 Weight of GPC Specimens Immersed in HCL

Mix Type	GPC	GPC Weight Reduction in Percentage	Conventional Concrete(CC)	CC Weight Reduction in Percentage
Initial Weight(in gms)	8096	0	8102	0
Weight of Specimen after 28 days Immersion in HCL (in gms)	8052	0.55	8052	0.62
Weight of Specimen after 56 days Immersion in HCL(in gms)	8023	0.37	8017	0.44
Weight of Specimen after 112 days Immersion in HCL(in gms)	7994	0.36	7986	0.39

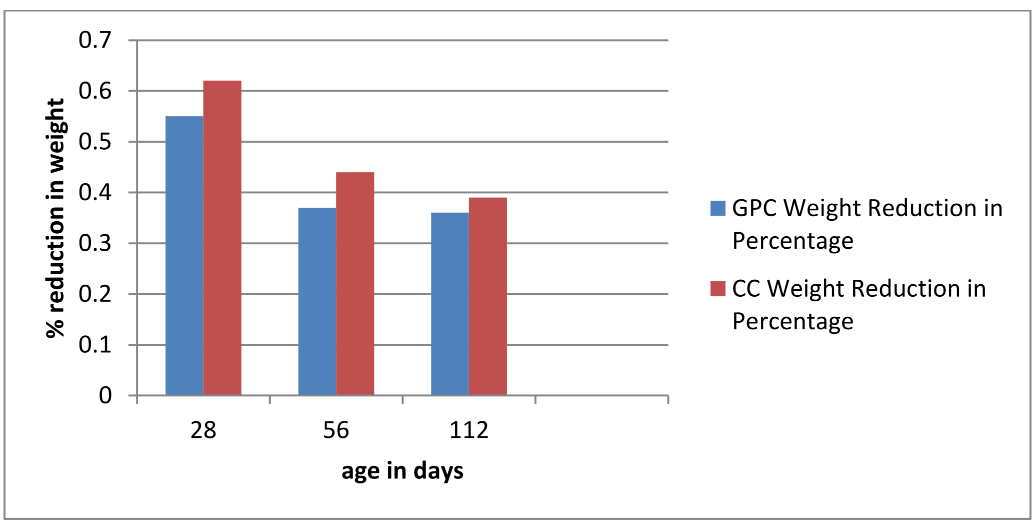

Figure 3 percentage reduction in weight exposed to hydrochloric acid

Table 5 Compressive strength of GPC Specimens Immersed in HCL

Mix Type	GPC	GPC Compressive strength in Percentage	CC	CC Compressive strength in Percentage
Compressive strength in MPa	35.85	0	32.78	0
Compressive strength in MPa after 28 days Immersion in HCL	33.98	0.55	30.77	0.65
Compressive strength in MPa after 56 days Immersion in HCL	32.16	0.56	28.92	0.64
Compressive strength in MPa after 112 days Immersion in HCL	30.78	0.45	27.46	0.54

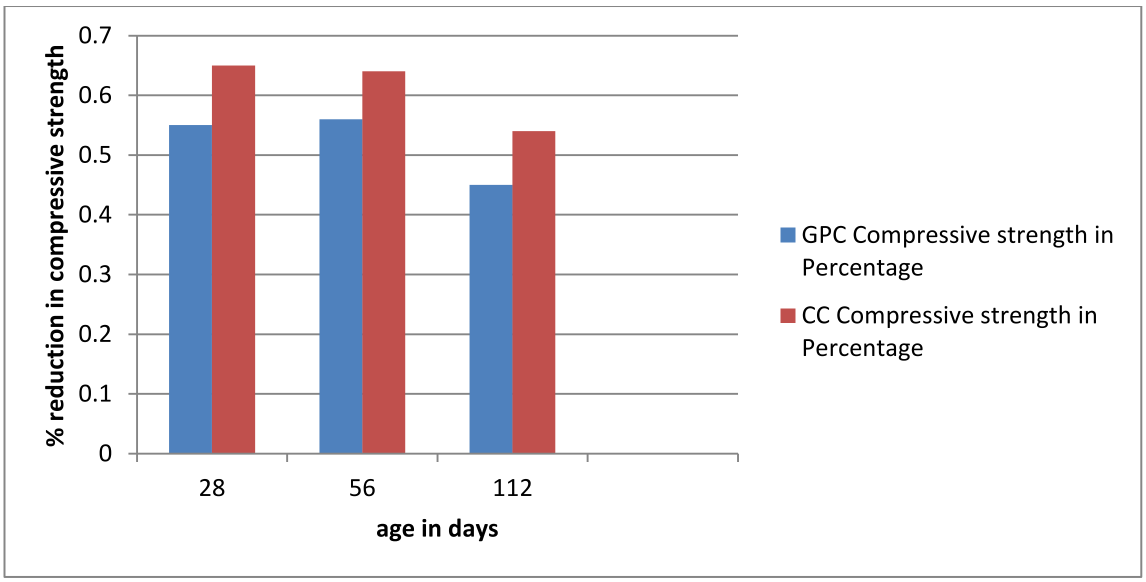

Figure 4 percentage reduction in compressive strength exposed to hydrochloric acid

4. CONCLUSIONS

1.) From figures 1 & 2 it can be concluded that the sulfuric acid resistance of GPC is more compared to the CC

2.) From figures 3 & 4 it can be concluded that the Hydrochloric acid resistance of GPC is more compared to the CC

3.) Due to good resistance to acid attack it can be used in construction of buildings to enhance its durability capacity

4.) The has proven as a good wear and tear resistance to acidic environment

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