

# ACID RESISTANCE OF FLYASH BASED GEOPOLYMER MORTAR UNDER AMBIENT CURING AND HEAT CURING

V.Sreevidya \*, R. Anuradha\*, D.Dinakar\*\*, Dr.R.Venkatasubramani\*\*\*

sreevidya.sankr@gmail.com

\* Assistant Professor, Civil Engineering Department, *Sri Krishna college of Technology, Coimbatore*

\*\* PG Student, Civil Engineering Department, *Sri Krishna college of Technology, Coimbatore*

\*\*\* Professor & Head of Civil Engineering Department, *Sri Krishna college of Technology, Coimbatore*

## Abstract

*An Experimental study was conducted to assess the Acid resistance of flyash based geopolymer mortar specimens of size 50x50x50mm with a ratio of flyash to sand as 1:3. The ratio between solution (Sodium hydroxide and Sodium silicate solution) to flyash were 0.376, 0.386, 0.396 and 0.416. After casting the specimens were subjected to both ambient curing and heat curing. In heat curing the specimens were kept continuously at 60°C for 24 hrs. Durability of specimens was assessed by immersing them in 5% of sulfuric acid and 5% hydrochloric acid for a period of 14 weeks. Evaluation of its resistance in terms of change in weight, compressive strength and visual appearance at regular intervals was carried out. After exposure in the acid solutions for 14 weeks, the samples showed very low weight loss. Results obtained from the present study indicate that Geopolymers are highly resistance to sulfuric acid and hydrochloric acid.*

**Keywords:** *Geopolymer, Durability, compressive strength, weight loss.*

## 1.Introduction

Portland cement concrete industry has grown astronomically in recent years. It will continue to grow as the result of continuous urban development. However, Portland cement concrete poses problems such as durability and Carbon-dioxide emission. Many concrete structures have shown serious deterioration, way before their intended service life, especially those constructed in a corrosive environment. Carbon dioxide emission trading is likely to be a critical factor for the construction industry, in particular, the cement and concrete industry.

The contribution of ordinary Portland cement production worldwide to greenhouse gas emission is approximately 7% of the total greenhouse gas emission to the atmosphere. About half of the carbon dioxide emissions from Portland cement production are due to calcination of limestone, while the other half are due to combustion of fossil fuel. In the year 1995, the global production of ordinary Portland cement was about 1.4 billion tonne, thus emitting about 1.4 billion tonne of carbon dioxide to the atmosphere[1]. Geopolymer has the potential to replace ordinary Portland cement concrete and produce fly ash-based Geopolymer concrete with excellent physical and mechanical properties. Geopolymer concrete has the potential to reduce greenhouse emissions from the concrete industry by 80%.

Geopolymers are a novel binder manufactured by activation of a solid aluminosilicate source material with a highly alkaline activating solution and aided by ambient curing and heat curing[7]. Flyash being by product, rich in alumina and silica, can be used as a source material for manufacture of geopolymer. The study comprised determination of changes in weight, compressive strength and visual appearance of the specimens as a measure of its resistance against acid[8]. The findings of the present study shall be useful in determining durability and hence the applicability of Geopolymer materials for use in acid environments.

## 2. Experimental Investigation

### 2.1 Materials

Class F Fly ash was obtained from Mettur Thermal Power Plant near Mettur, India. It had mineral and chemical composition as in Table-1. Fine sand used was local river sand having specific gravity of 2.6 and fineness modulus of 2.85. Laboratory grade Sodium hydroxide in pellet form (98 percent purity) and Sodium Silicate solution ( $\text{Na}_2\text{O}=15.92\%$ ,  $\text{SiO}_2=31.4\%$  and  $\text{water}=52.7\%$ ).

Table 1 Chemical Composition of Flyash

| Chemical Composition    | $\text{SiO}_2$ | $\text{Al}_2\text{O}_3$ | $\text{Fe}_2\text{O}_3$ | $\text{TiO}_2$ | $\text{CaO}$ | $\text{MgO}$ | $\text{K}_2\text{O}$ | $\text{Na}_2\text{O}$ | $\text{SO}_3$ | LOI |
|-------------------------|----------------|-------------------------|-------------------------|----------------|--------------|--------------|----------------------|-----------------------|---------------|-----|
| Percentage of content % | 58             | 29.08                   | 3.58                    | 1.75           | 3.6          | 1.91         | 0.73                 | 2                     | 1.8           | 2   |

### 2.2 Specimen Preparation and Test Procedure

Geopolymer mortar cube  $50 \times 50 \times 50 \text{mm}$  was used in this test. The flyash to sand ratio was 1:3 by weight and the solution to flyash ratios  $[\text{water} + \text{NaOH} + \text{Na}_2\text{O} + \text{SiO}_2] / \text{FA}$  were varied as 0.376, 0.386, 0.396 and 0.416 respectively. An amount of Sodium hydroxide and Sodium silicate solution were kept constant at 9.6% and 24% at all mixes. Sufficient water was added to give water to Fly ash ratio as 0.376, 0.386, 0.396 & 0.416. Fly ash was first mixed with the activator solution and mixed for 5 minutes before and sand was gradually introduced and further mixed for another 5 minutes. The mix was then transferred into 50 mm cube moulds and compacted. Specimen samples were cured at ambient curing for tested period. Specimens were also cured along with the moulds in a heat chamber for a period of 24 hours at  $60^\circ\text{C}$  and the specimens are allowed to cool at room temperature until the tested period of days.

To study the effects of exposure to acidic environment, specimens were immersed in 5% solution of Sulfuric acid and 5% Nitric acid after 28 days for a period of 14 weeks, tests being carried out at regular intervals. The volume of acid solution was taken as four times the volume of specimens immersed and stirred every week. The solution was refreshed after 7 weeks. The effects of acid on the specimen were constantly monitored through visual inspection, weight change measurements and strength tests during the exposure period.

## 3. Results and Discussion

### 3.1 Visual Inspection

Specimens didn't show any noticeable change in color in sulfuric acid and also in hydrochloric acids as shown in Fig 1. Specimens were seen to remain structurally intact though surface turned a little softer. The deterioration of the surface was seen to increase with time though extent of deterioration among the series of samples could not be easily differentiated through visual inspection.



Fig 1 Specimens after immersing in Acids after 14 weeks

### 3.2 Change in weight

Results of the weight changes for the Geopolymer mortars under both Ambient curing and Heat curing are presented in Chart 1 and Chart 2. In the specimens immersed Sulfuric acid and Hydrochloric acids, a sudden

loss of weight was noticed initially during 3 to 8 weeks. Beyond 12 weeks the weight dropped in the specimens. The weight loss was observed to be gradually decreased with increase in water binder ratio in all the specimens exposed to acidic condition.

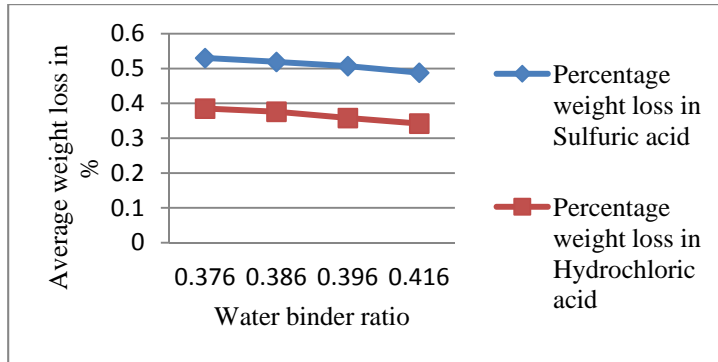


Chart-1: Average weight loss Vs W/B ratio under Ambient Curing

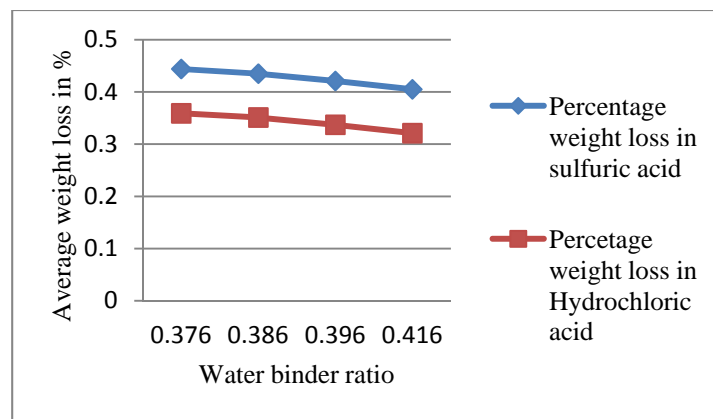


Chart-2: Average weight loss Vs W/B ratio in Heat Curing

### 3.3 Change in Compressive Strength

The compressive strength evolution of Geopolymer mortars in sulfuric acid and hydrochloric acid environment are shown in Chart 3 and Chart 4. At regular intervals, the compressive strength was determined using a digital compression testing machine and the residual compressive strength was calculated as percentage of initial compressive strength.

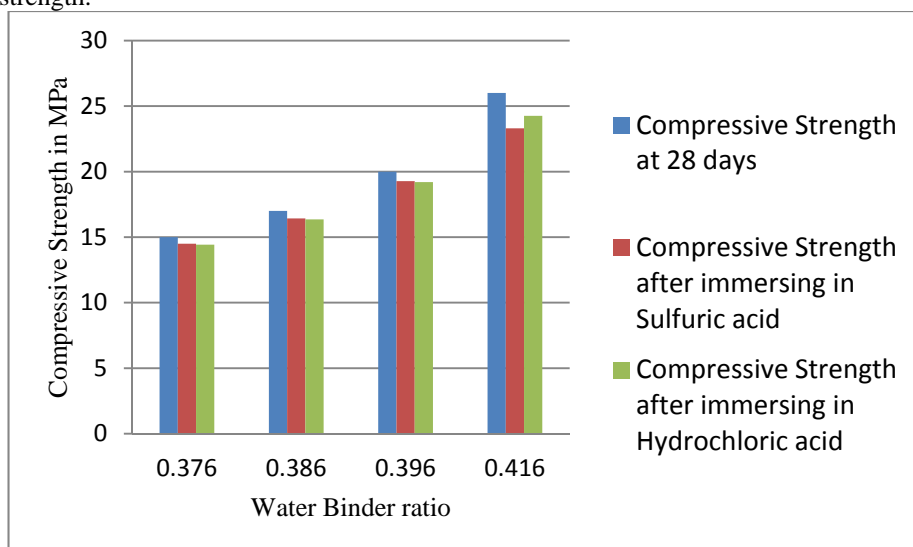


Chart 3 Comparison between compressive strength for 14 weeks and compressive strength after acid resistance under Ambient curing

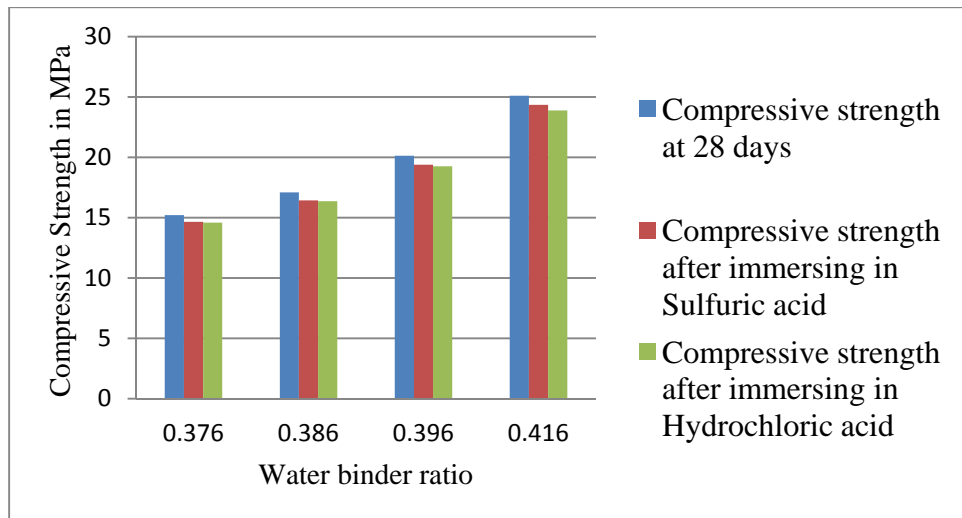


Chart 4 Comparison between compressive strength for 14 weeks and compressive strength after acid resistance under Heat curing

#### 4. Conclusions

On the basis of this study, the following conclusions can be drawn.

1. Geopolymer mortar specimens manufactured from fly ash with alkaline activators remained structurally intact and did not show any recognizable change in color in Sulfuric acid and Hydrochloric acid solution.
2. The loss of weight was observed to be lower in geopolymer mortar specimen when compared with conventional cement mortar.
3. The weight loss was observed to be gradually decreased with increase in water binder ratio in all the specimens immersed in sulphuric acid and hydrochloric acid.
4. Geopolymer mortar specimens showed greater resistance to acid environments when compared with conventional cement mortar specimens.
5. The geopolymer mortar specimens showed very little loss in strength and the percentage of strength loss was observed to be higher in 1:3 ratio of flyash to sand.
6. Geopolymer mortar specimens after immersing in sulphuric acid and hydrochloric acid shows that the compressive strength are more or less same when compared to the conventional cement mortar.

#### 5. References

- [1] Davidovits J. 1994. Properties of geopolymer cement Proceedings of the First International conference on Alkaline Cements and Concretes. Vol. 1, pp. 131-149. SRIBM, Kiev, Ukraine.
- [2] Bakharev T. 2005. Resistance of geopolymer materials to Acid attack. Cem. Concr. Res. 35: 658-670.
- [3] Allahverdi Ali, Skavara Frantisek 2001. sulfuric acid attack on hardened paste of geopolymer cements. Part 1. Mechanism of corrosion at relatively high Concentrations Ceramics-Silikaty. 45(3): 81-88.
- [4] Allahverdi Ali, Skavara Frantisek. 2006. sulfuric acid attack on hardened paste of geopolymer cements. Part 2. Corrosion mechanism at mild and relatively low concentrations, Ceramics-Silikaty. 50(1): 1-4.
- [5] Song X.J, Marosszeky M, Brungs M, Munn R. 2005. Durability of fly ash based geopolymer concrete against sulphuric acid attack. 10 DBMC International Conference on Durability of Building Materials and Components. Lyon, France. pp. 17-20.
- [6] Wallah S.E, Rangan B.V. 2006. Low Calcium Fly ash based Geopolymer Concrete: Long term properties. Research Report GC 2, Curtin University of Technology, Australia. Suresh Thokchom, Dr.ParthaGhosh and Dr.SomnathGhosh, "Acid Resistance of Flyash based Geopolymer mortars", International Journal of Recent Trends in Engineering Vol. 1 No. 6, May 2009, pp.36-40.
- [7] Suresh Thokchom, Dr.ParthaGhosh and Dr.SomnathGhosh "Resistance of flyash based Geopolymer mortar in Sulfuric acid", ARPJN Journal of Engineering and Applied Sciences, Vol. 4, No.1, February 2009'
- [8] Songpiriyakij, S., "Effect of Temperature on Compressive Strength of Fly Ash-based Geopolymer Mortar", Silikaty 48(4), 2007, pp.183-197.