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Durability Properties of Geopolymer Concrete Produced with Recycled Coarse Aggregates and Quarry Stone Dust

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Abstract

Ordinary Portland cement concrete was notorious in the world for its authenticity, adaptability and durability. Concrete material was widely used like water. OPC was prominent in construction but, it was not ecological due to colossal energy devouring in its manufacture and due to issuance of humongous CO2 [1]. Exertion was desired to develop an ecofriendly construction- material for diminishing diffusion of green house gases into atmosphere. The enterprise to evolve an environmental friendly concrete had afford bountiful alternatives. Geopolymer Concrete was the one eminent among them [2].This research paper introduces an experimental studies on durability of Geopolymer Concrete using flyash and recycled aggregates such as Quarry Stone Dust and Recycle Coarse Aggregate. Geopolymer concrete was prepared using flyash as primary source material instead of cement and sand was replaced with Quarry Stone Dust at various proportions such as 0, 20, 40, 60, 80 &100 % and Course Aggregate was replaced with Recycle Coarse Aggregate at various replacements i.e. 0, 20, 40, 60, 80, 100%. Studies on durability performance under acid attack test were made. The acid used was H2SO4 of 5% Concentration. The Specimens are cured in acid for 30, 60 & 90 days. The molarity used was 12M. Cubes (100x100x100 mm) and cylinders (200x100 mm) are cured for 28 days at ambient temperature. After cubes & cylinders were immersed in H2SO4 solution for 30, 60 & 90 days, reduction in strength was observed.

Keywords: Durability,Geopolymer concrete, OPC,Quarry Stone Dust and Recycle Coarse Aggregate

Introduction

Due to its durability, concrete was widely used as constriction material for so many types of structures. To turn down global thermostat by utilizing waste materials has aided in construction because it reduces diffusion of green house gases [3]. Geopolymer Concrete used in this paper was made up of flyash, sand, Quarry Stone Dust, Coarse Aggregate, Recycle Coarse Aggregate & Alkaline solution of NaOH and Na_2SiO_3. These all plays an important role in environmental control of green house stuff [4].In aggressive environments for the performance of structure; durability was the most important requirement [5]. For structural materials, acid resistance was the one of basic property. In aggressive environments, durability of flyash based GPC has been noted to have admirable durability when compared with OPC concrete [7]. When exposed to sulphuric acid, Geopolymer morter made with flyash and varying alkali content showed variable degree of deterioration [8]. GPC was high resistant to H_2SO_4 (in terms of low mass loss i.e. < 3%) [9]. Flyash based Geopolymer Concrete when exposed to 5% H_2SO_4 solution gives outstanding work and had 1.96% of weight loss [10]. Based on above mentioned information, it was noted that GPC shown very good accomplishment on durability property. This research paper aims on studies of durability property of Class F flyash Geopolymer Concrete when immersed in H_2SO_4 of 5% concentration.

Materials

Class F flyash was obtained from Rayalaseema Thermal Power Plant (RTTP) having fineness of 360 (m^2 /Kg) and specific gravity of 2.24.The chemical composition of Class F flyash was shown in table 1. To mobilize class F flyash, alkaline solution was made ready by using Na_2SiO_3 & NaOH. Sand was taken from Pandemeru River near JNTUACEA as fine aggregate having specific gravity and fineness modulus as 2.58, 2.64. Coarse Aggregate (20mm & 10mm) with 2.68 specific gravity was used. Recycled materials like Quarry Stone Dust and Recycled Coarse Aggregate was used for making Geopolymer Concrete. Fine aggregate was replaced with Quarry Stone Dust in different proportions (0, 20, 40, 60, 80, and 100%) where as Coarse Aggregate was replaced with Recycle Coarse Aggregate just as percentages of Quarry Stone Dust.

Particulars	Class "F" flyash	ASTM C 618 Class "F" flyash
Chemical composition		
% Silica(SiO_2)	65.6	
% Alumina(Al_2O_3)	28.0	
% Iron Oxide(Fe_2O_3)	3.0	$SiO_2+Al_2O_3+Fe_2O_3>70$
% Lime(CaO)	1.0	
% Magnesia(MgO)	1.0	
% Titanium Oxide (TiO_2)	0.5	
% Sulphur Trioxide (SO_3)	0.2	Max. 5.0
Loss on Ignition	0.29	Max. 6.0
Physical properties		
Specific gravity	2.24	
Fineness (m^2/Kg)	360	Min.225 m^2/kg

Table 1. Chemical and Physical Properties of Class F Fly Ash

Testing Procedures

Class F flyash based Geopolymer Concrete was made with alkaline Solution ratio [Na_2SiO_3/ NaOH] of 2.5. Strength was maximum when Na_2SiO_3/ NaOH were 2.5 [11]. Molarity of NaOH was chosen as 12. Fine and Coarse Aggregates used were in saturated surface dry condition. Firstly in a pan, flyash and aggregates were dry-mixed. Later alkaline solution was added and then mixed. The cubes (100x100x100 mm) and cylinders (100x200 mm) were casted. Specimens were neatly covered to prevent evaporation. These specimens are leaved at room temperature for one day. Later the cylinders are de-moulded and were ambient cured for 28 days.

Results and Discussion

Resistance to Sulphuric Acid

To know the durability property of Geopolymer Concrete after ambient curing for 28 days, the specimens were engrossed in H_2SO_4 solution of 5% concentration. The specimens are cured for a period of 30, 60 & 90 days. With distilled water the Sulphuric acid was diluted earlier. The pH value of H_2SO_4 was 6.8 to 7. The immersed specimens were examined frequently; if the solution was evaporated add extra solution to maintain the same pH value. Figure 1 and 2 shows progression of compressive and tensile strengths of cube and cylinder specimens.

Figure 1. Reducing 98% conc of sulphuric acid to 5% conc

Figure 2. Specimens left for acid curing (30, 60, 90 days)

Compressive Strength of GPC when exposed to 5% conc. of H2SO4 Sol

The culminations of compression strength values when cubes were immersed in 5% conc of H_2SO_4 Sol and their percentage loss in strengths are pictured in graphical form from Fig. 3 to Fig. 8.

Figure 3. Compressive Strength of GPC Cubes after Immersion in 5% H_2SO_4 at 28, 30, 60 and 90 days for 0% RCA

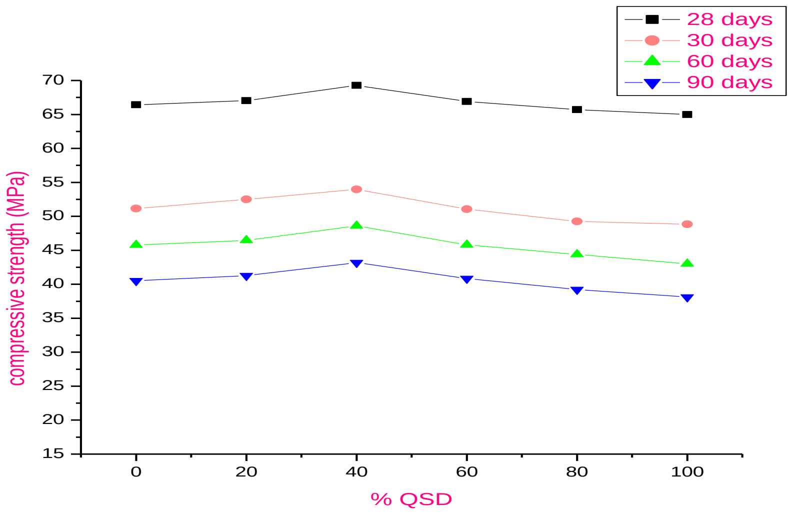

Figure 4. Compressive Strength of GPC Cubes after Immersion in 5% H_2SO_4 at 28, 30, 60 and 90 days for 20% RCA

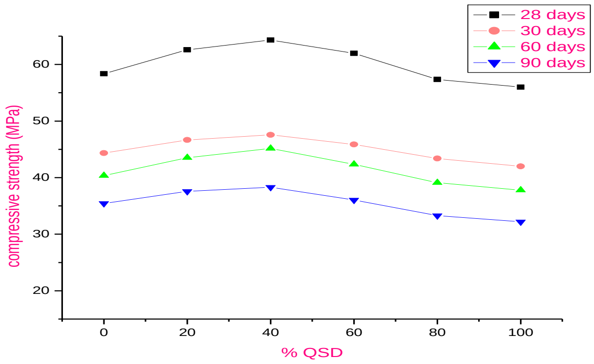

Figure 5. Compressive Strength of GPC Cubes after Immersion in 5% H_2SO_4 at 28, 30, 60 and 90 days for 40% RCA

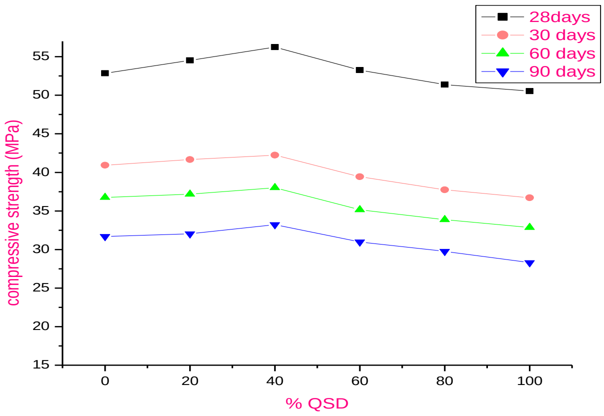

Figure 6. Compressive Strength of GPC Cubes after Immersion in 5% H_2SO_4 at 28, 30, 60 and 90 days for 60% RCA

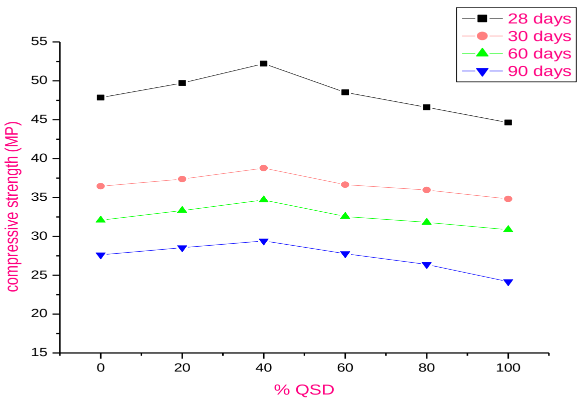

Figure 7. Compressive Strength of GPC Cubes after Immersion in 5% H_2SO_4 at 28, 30, 60 and 90 days for 80% RCA

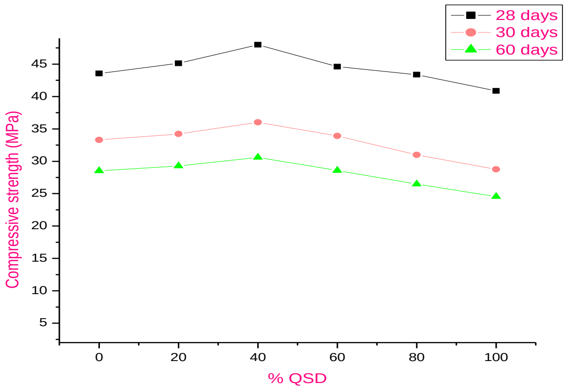

Figure 8. Compressive Strength of GPC Cubes after Immersion in 5% H_2SO_4 at 28, 30, 60 and 90 days for 100% RCA

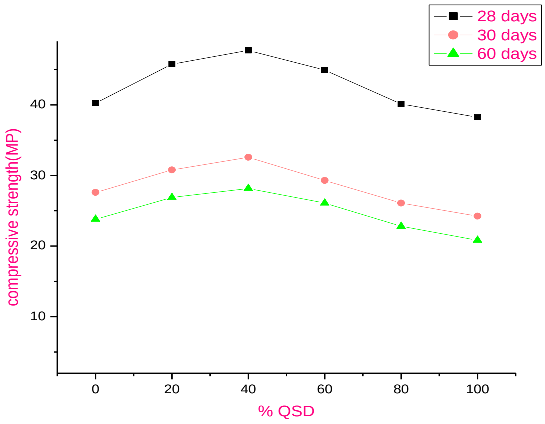

Figure 9. Distorted shapes of cubes when immersed in Sulphuric acid for 90days

The specimens at surface & around the edges were lightly broken. Some fine cracks and aggregates were distinctly noticeable. The specimens after 30 days of exposure to solution of 5% sulphuric acid was not that much distorted though collated to 60 and 90 days of immersion. Geopolymer Concrete cube specimens had loss in its strength after 30, 60 and 90 days after exposure to H_2SO_4 solution. This possibly ascribed to ruination of Alumina-Silicate bond in GPC created by H_2SO_4 attack, since Alumina-Silicate bonding was necessary for strength. Density of GPC cubes were moderately reduced when exposure period was increased. Diminished in density also depends on fineness of flyash [14]. The flyash has smaller particles which lead to denser concrete mixture. Since Geopolymer Concrete produced lower density. The bonding was good because the surface of flyash particles was not smooth and results in weight loss due to H2SO4 attack. In 80% & 100% Recycle Coarse Aggregate proportion, when specimens are immersed in H_2SO_4 solution for 90 days the cube specimens are completely distorted as shown in Figure 9.

Split tensile strength of GPC when exposed to 5% conc. of H2SO4 sol:

The culminations of split tensile strength values are pictured in graphical form from figure 10 to 15.

Figure 10. Split Tensile Strength of GPC Cylinders after Immersion in 5% H_2SO_4 at 28, 30, 60 and 90 days for 0% RCA

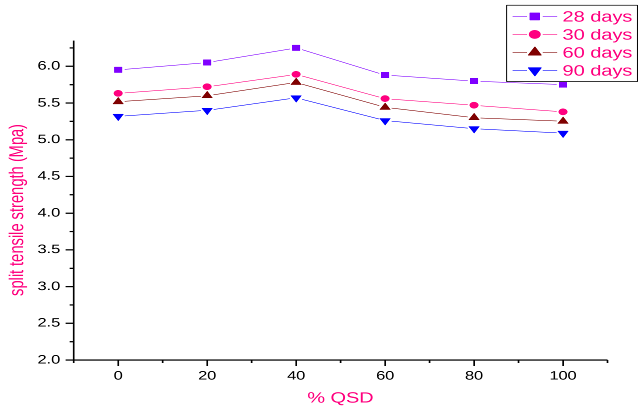

Figure 11. Split Tensile Strength of GPC Cylinders after Immersion in 5% H_2SO_4 at 28, 30, 60 and 90 days for 20% RCA

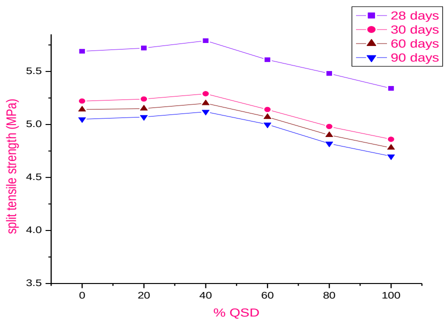

Figure 12. Split Tensile Strength of GPC Cylinders after Immersion in 5% H_2SO_4 at 28, 30, 60 and 90 days for 40% RCA

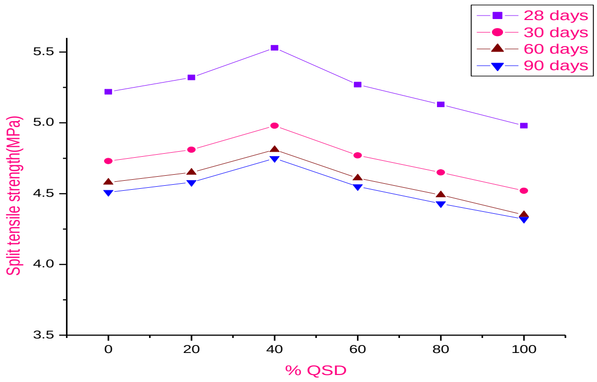

Figure 13. Split Tensile Strength of GPC Cylinders after Immersion in 5% H_2SO_4 at 28, 30, 60 and 90 days for 60% RCA

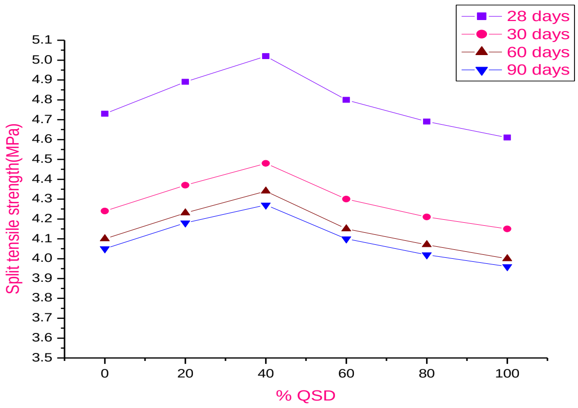

Figure 14. Split Tensile Strength of GPC Cylinders after Immersion in 5% H_2SO_4 at 28, 30, 60 and 90 days for 80% RCA

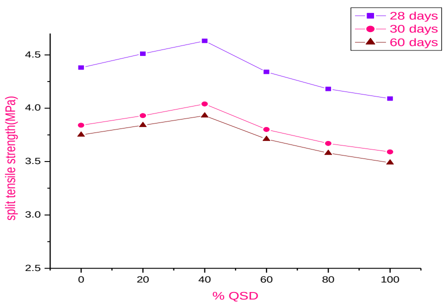

Figure 15. Split Tensile Strength of GPC Cylinders after Immersion in 5% H2SO4 at 28, 30, 60 and 90 days for 100% RCA.

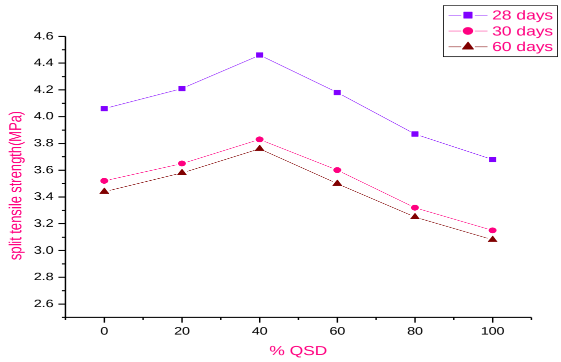

Figure 16. Distorted shapes of cylinders when exposed to Sulphuric acid

Geopolymer Concrete cylinder specimens had loss in its strength after 30, 60 and 90 days after exposure to H2SO4 solution. This possibly ascribed to ruination of Alumina-Silicate bond in GPC created by H2SO4 attack, since Alumina-Silicate bonding was necessary for strength. Density of GPC cylinders were moderately reduced when exposure period was increased. In 80% & 100% Recycle Coarse Aggregate proportion, when specimens are immersed in H2SO4 solution for 90 days the cylinder specimens are completely distorted as shown in Figure 16.

Conclusions

Based on above results, the conclusions were made

1. Compressive strength loss takes place when increase in Recycle Coarse Aggregate percent. This is due to high water absorption. Similarly this was done for split tensile strength.
2. For all mixes, increase in Quarry Stone Dust percent leads to increase in strength, both compression and tension up to 40% beyond that the strength leads to decrease.
3. The Geopolymer Concrete specimens shows little changes in strength and weight when immersed in H_2SO_4 for 30 & 60 days.
4. As curing period increases in Sulphuric acid, weight and strength loss takes place.

5. For mixes 80% & 100% Recycle Coarse Aggregate in place of Coarse Aggregate, the specimens are totally distorted when when immersed in H2SO4 for 90 days of curing.
6. Geopolymer Concrete attains high strength in early stages when collated to OPC concrete.
7. Degradation in strength depends on duration of curing period & concentration of acid solution.
8. When exposed to Sulphuric acid, Geopolymer Concrete cube surface undergo only erosion.
9. The Calcium content was low in flyash based Geopolymer Concrete which leads to better performance when immersed in Sulphuric acid.
10. In aggressive environments Geopolymer Concrete has excellent durability.

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