

# Experimental Investigation on Hybrid Fiber Reinforced Geopolymer Concrete

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**ABSTRACT:** Experimental investigations on the mechanical properties of Geopolymer Concrete (GPC) containing 90% Rice husk ash (RHA) and 10% cement, alkaline liquids, glass fibers and polypropylene fibers have been presented. Here an experiment of investigation has been conducted to study the performance of geopolymer concrete using rice husk ash as the major binding material. Rice husk Ash contains silica in amorphous and highly cellular form. Its leads in increase strength impermeability development and durability. RHA minimizes alkali-aggregate reaction and also reduces the expansion of concrete. Alkaline liquid, Sodium hydroxide and Sodium silicate solution are used in this project as binders. This study analysis shows the impact of glass fibers and polypropylene fibers on the mechanical properties such as Compressive Strength and Split Tensile strength of hardened GPC in ambient curing at room temperature. Mixtures were prepared with alkaline liquid to rice husk ash ratio of 0.4. Glass fibers were added to the mix in the volume fractions of 0.03% volume of the concrete. Polypropylene fibers were added to the mix in the volume fractions of 0.25%, 0.5%, 0.75%.The influence of fiber content in terms of volume fraction on the compressive strength and split tensile strength of GPC is presented. Polypropylene is one of the cheapest & abundantly available polymer. By regression analysis, relationship between split tensile and compressive strength of glass fiber and polypropylene fibre were developed.

**KEYWORDS:** Polypropylene fiber, Glass fiber, Geopolymer, Alkaline liquid, Sodium hydroxide, Sodium Silicate.

## I.INTRODUCTION

Concrete usage around the world is second only to water. Ordinary Portland cement (OPC) is conventionally used as the primary binder to produce concrete. The environmental issues associated with the production of OPC are well known. The amount of the carbon dioxide released during the manufacture of OPC due to the calcinations of limestone and combustion of fossil fuel is in the order of one ton for every ton of OPC produced. In addition, the extent of energy required to produce OPC is only next to steel and aluminium. On the other hand, the abundant availability of fly ash worldwide creates opportunity to utilize this by-product of burning coal, as a substitute for OPC to manufacture concrete.

In 1978, Davidovits (1999) proposed that binders could be produced by a polymeric reaction of alkaline liquids with the silicon and the aluminum in source materials of geological origin or by-product materials such as fly ash and rice husk ash. He termed these binders as geopolymers. Palomo et al (1999) suggested that pozzolans such as blast furnace slag might be activated using alkaline liquids to form a binder and hence totally replace the use of OPC in concrete. In this scheme, the main contents to be activated are silicon and calcium in the blast furnace slag. The main binder produced is a C-S-H gel, as the result of the hydration process.

The water absorption of rice husk ash geopolymer is less than 5% which is low & Apparent Volume of Permeable Voids is less than 12% (which is classified as good). Water to geopolymer solid ratio is the most influential parameter to increase strength, & to decrease the water absorption / Apparent Volume of Permeable Voids & water permeability. Fiber reinforced concrete is relatively new composite material in which fibers are introduced in matrices as micro reinforcement so as to improve the tensile cracking & other properties of concrete .Some type of fibers produce greater

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impact abrasion & shatter resistance in concrete. Addition of glass & polypropylene fibers to concrete increases the split tensile strength & compressive strength of concrete by approximately 20-50%. The compressive & split tensile strength of geopolymer concrete with 90% replacement of cement by rice husk ash have increase as the fiber content increased. The maximum value of all these strengths obtained at 0.03% of fiber content.

## II. MATERIALS USED

### 2.1 MATERIALS

The materials used for making rice husk ash based geopolymer concrete specimens are low-calcium rice husk ash as the source material, fine aggregates, coarse aggregates as the filler and alkaline solution such as sodium hydroxide solution and sodium silicate solution were as binders with water as workability measure.

#### 2.1.1 RICE HUSK ASH

A residual RHA obtained from open field burning. The material was carefully homogenized and prepared in two conditions. Natural RHA (NRHA): the ash was only dried, homogenized, and packed to enhance the transport to the laboratory. Grinded RHA (GRHA): after drying and homogenization process the RHA was ground in a laboratory ball mill by one hour for optimization.

#### 2.1.2 FINE AGGREGATE

In this investigation, the fine aggregate, which was available near karur were used, in which it belongs to zone III was used as fine aggregate. Tests were carried out as per IS: 2386-1968 part III.

#### 2.1.3 COARSE AGGREGATE

In the present investigation, locally available crushed stone aggregate of size 20mm passing and retained in 10mm, used and the various tests, were carried out as per IS: 2386-1968 Part III.

#### 2.1.4 WATER

In the present investigation, portable water was used as said IS 456-2000 for the plain and reinforced cement concrete.

#### 2.1.5 SODIUM SILICATE

Sodium silicate also known as water glass or liquid glass, available in liquid (gel) form. In present investigation sodium silicate 2.0 (ratio between  $\text{Na}_2\text{O}$  to  $\text{SiO}_2$ ) is used as per the manufacture silicate were supplied to the detergent company and textile industry as bonding agent. Some sodium silicate is used for the making of geopolymer concrete.

#### 2.1.6 SODIUM HYDROXIDE

Generally the sodium hydroxides are available in solid state by means of pellets and flakes. The cost of the sodium hydroxide is mainly varied according to the purity of the substance. Since our geopolymer concrete is homogeneous material and its main process to activate the sodium silicate so it is recommended to use the lowest cost i.e. up to 94% to 96% purity. The concentration of sodium hydroxide can vary in different molar. The mass of NaOH solids in a solution varies depending on the concentration of the solution

In this investigation the sodium hydroxide pellets were used. Whose chemical property and physical property are given by manufacturer are as follows for solid sodium hydroxide.

#### 2.1.7 ALKALINE LIQUIDS

A combination of Sodium hydroxide solution & Sodium silicate solution was used as alkaline activators for geopolymerization. Sodium hydroxide is available commercially in flakes & pellets form. For this experimental

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program Sodium hydroxide flakes with 98% purity were dissolved in distilled water to make NaOH solution. Sodium silicate is available commercially in solution form which was used as such.

## 2.1.8 SUPER PLASTICIZER

Glenium b233 is used for the experimental investigation. It is used here for high degree of workability and its retention are required, where delays in transportation are likely or when high ambient temperatures cause rapid slump loss. It facilitates production of high quality concrete.

## 2.1.9 POLYPROPYLENE FIBRE

In this investigation, polypropylene fibers are used as an average diameter of 10  $\mu\text{m}$  and length of 18mm. These fibres have a density of 910  $\text{kg/m}^3$  modulus of elasticity of 3500 MPa and yield strength of 550 MPa. (source: manufacturer's data). Polypropylene fibers are resistant to most of the chemicals and its melting point is high (about 165 degree centigrade).

## 2.1.10 GLASS FIBER

Glass fibers are made of silicon oxide with addition of small amount of other oxides. Glass fibers are characteristic for their high strength, good temperature resistance, corrosion resistance & available at low price. In this investigation alkali resistance glass fibers of 12mm length & 14 microns nominal diameter having density of 2680 $\text{Kg/m}^3$  were used.

## III.MIX DESIGN

### 3.1 MIX DESIGN OF GEOPOLYMER CONCRETE

In the design of geopolymer concrete (GPC mix), coarse and fine aggregates together were taken as 70% of entire mixture by mass. This value is similar to that used in OPC concrete in which it will be in the range of 75% to 80% of the entire mixture by mass. Fine aggregate was taken as 40% of the total aggregates. From the past literatures it is clear that the average density of rice husk ash based geopolymer concrete is similar to that of OPC concrete (2400 $\text{kg/m}^3$ ). Knowing the density of concrete, the combined mass of alkaline liquid and rice husk ash can be arrived.

By assuming the ratios of alkaline liquid to rice husk ash as 0.4, mass of fly ash and mass of alkaline liquid was found out. To obtain mass of sodium hydroxide and sodium silicate solutions, the ratio of sodium silicate solution to sodium hydroxide solution was fixed as 2. Extra water 10% (other than the water used for the preparation of alkaline solutions) by weight of rice husk ash and super plasticizer (gelinium based) 3% by weight of rice husk ash respectively to achieve workable concrete. Using the above procedure the mix proportion was designed.

## IV. ANALYSIS OF TEST RESULTS

### 4.1 INTRODUCTION

A laboratory tests were performed to determine the compressive strength and split tensile strength on cubes, and cylinders for 28 days of curing. Casting of different proportion of Hybrid fiber reinforced geopolymer concrete with cent percent replacement of cement by rice husk ash as chemically activated by sodium hydroxide and sodium silicate, with addition of glass and polypropylene fibers. The test results are analyzed below.

### 4.2 COMPRESSIVE STRENGTH

The average compressive strength of geopolymer concrete with & without polypropylene fibers and glass fibers at the age of 7 days & 28 days with ambient curing are tabulated below.

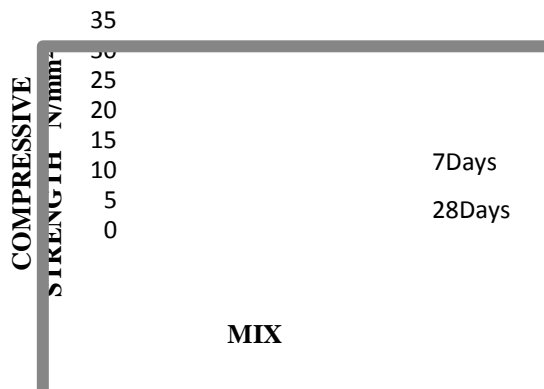
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Table 4.1 : Compressive Strength Values



4.2 .Graph for Compressive Strength

MIX	Age of concrete	Compressive load in KN	Compressive strength in N/mm <sup>2</sup>
GPC	7days	346	15.42
MIX 1	7days	367	16.33
MIX 2	7days	503	22.39
MIX 3	7days	567	25.21
GPC	28days	510	22.62
MIX 1	28days	595	26.44
MIX 2	28days	665	29.51
MIX 3	28days	713	31.68

### 4.3. SPLIT TENSILE TEST

The cylinders replaced in the compression testing machine horizontally. Load is applied gradually the load is applied increasingly at a uniform rate until the specimen fails and the maximum load applied to the specimen during the test is recorded.

MIX	Age of concrete	Split tensile load in KN	Split tensile strength in N/mm <sup>2</sup>
GPC	7days	57	0.82
MIX 1	7days	98	1.39
MIX 2	7days	136	1.93
MIX 3	7days	148	2.12
GPC	28days	80	1.13
MIX 1	28days	125	1.76
MIX 2	28days	168	2.31
MIX 3	28days	201	2.82

Table 4.2 : Split tensile Strength Values

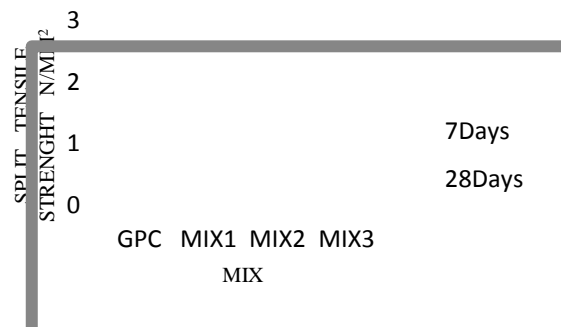


Figure 4.3 Graph for Split Tensile Strength

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## V. CONCLUSION

### 5.1 GENERAL

This chapter deals with the conclusion arrived from experimental investigation on hybrid fiber reinforced geopolymer concrete.

### 5.2 CONCLUSION

In this project, ideal specimens are casted as per the mix proportion and strength studies were done on them. The following conclusions are arrived on the experimental results of the study. Compressive strength and split tensile strength of hybrid fiber reinforced Geopolymer concrete composites increases with respect to the increase in the percentage volume fraction of polypropylene fiber from 0.25 to 0.75 and glass fiber volume fraction as 0.03%. Addition of 0.25% volume fraction of polypropylene fibers and 0.03% glass fibers resulted in an enhanced compressive strength and split tensile strength by 16% and 55% respectively with reference to GPC mix. For addition of 0.5% volume fraction of polypropylene fibers and 0.03% glass fibers, the compressive strength and split tensile strength is increased by 30%, and 104% respectively with reference to GPC mix. Similarly addition of 0.75% volume fraction of polypropylene fibers and 0.03% glass fibers resulted in an enhanced compressive strength and split tensile strength by 40% and 149% respectively with reference to GPC mix.

## ACKNOWLEDGEMENTS

An acknowledgement section may be presented after the conclusion, if desired.

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