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*Research Article*

# Study of strength characteristics of Geo-Polymer Concrete by using Rice husk Ash, Steel fiber and Quarry Dust

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***Abstract***

*Environment pollution is one of the major problems faced by world today. In the field of construction industry mainly, the manufacturing of Portland cement will matter the emission of pollutants results in environmental pollution. To reduce the pollution effect on environment we can use industrial by-products in our construction industry. To produce the geo-polymer concrete the Portland cement is fully replaced with Rice husk ash and the fine aggregate is replaced with quarry dust for the binding of material alkaline liquids are used in this study. Rice husk ash is a by-product from the burning of rice husk at a temperature lower than 6000C.this means that it is in a form that is soft and easy to grind. Rice husk ash is rich in silica about 90%, 5% carbon and 2% K2O. The specific surface of RHA is between 40-100m2/g. The alkaline liquids used in this study Sodium hydroxide (NaOH) and sodium silicate (Na2Sio3). Different molarities of sodium hydroxide solution i.e. 8M and 10M are taken to prepare different mixes. The cube specimens are taken of size 150mm x 150mm x 150mm and the compressive strength is calculated for each of the mix. The geo-polymer concrete specimens are tested for their compressive strength at the age of 7days, mixes of varying sodium hydroxide molarities i.e. 8M and 10M are prepared and they are cured by direct sun-light and strengths are calculated for 7 day. The finding shows that the strength of Geopolymer concrete is increasing with the increase of the molarity of sodium hydroxide.*

***Keywords:*** *Geo-Polymer Concrete, Rice husk ash, Fine Aggregate, Coarse Aggregate, Steel fiber*

## 1. Introduction

If we want to construct any structure, concrete is the main material. The main element to produce concrete is Portland cement. The production of cement increases the production of pollution because of the emission of CO2 during its production. Globally 5% of total carbon dioxide emission is generated by cement industry. Geopolymer concrete, an unindustrialized material in India, is going to be a revolution not only in the research field but also in the construction industry. Geopolymers, an unique class of inorganic polymers are new promising binders and are manufactured by the activation of a solid state alumino-silicate with a highly alkaline activating solution using thermal drive. In the recent past, Geopolymer binders have been found to be the best alternate to cement binders due to its environmental pleasantness. Geo-polymer cement was developed in the year of 1984 to 2008. Geo polymer is an alumino silicate material which binds the materials together. Geo-polymer technology is to reduce the use of Portland cement in cement concrete.

The role of Ordinary Portland cement in geo polymer concrete is replaced by rice husk ash which also possesses pozzolanic properties same as of Ordinary Portland cement and rich with silicate.

## 2. Properties of Material used for the study

### *2.1. Quarry Dust*

The quarry dust is used as a fine aggregate to produce geo-polymer concrete and it was taken from local quarries. It has following properties.

**Table 1** Physical Properties of quarry dust

| Property | Quarry rock dust | Test Method |
|---|---|---|
| Specific gravity | 2.60 | IS 2386 (Part III) 1963 |
| Bulk relative density (Kg/m$^3$) | 1700 | IS 2386 (Part III) 1963 |
| Absorption | 1.30 | IS 2386 (Part III) 1963 |
| Moisture Content (%) | Nil | IS 2386 (Part III) 1963 |
| Fine Particle less than 0.075 mm (%) | 14 | IS 2386 (Part III) 1963 |
| Sieve Analysis | Zone III | IS 383-1970 |

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**Table2.** Chemical composition of quarry dust

| Constituent | Quarry Rockduct (%) | Test Method |
|---|---|---|
| $SiO_2$ | 61.48 | IS:4032-1968 |
| $Al_2O_3$ | 18.72 | |
| $Fe_2O_3$ | 6.58 | |
| CaO | 4.54 | |
| MgO | 2.58 | |
| $Na_2O$ | Nil | |
| $K_2O$ | 3.75 | |

*2.2 Coarse aggregate*

Coarse aggregates of sizes 12mm and 20mm having following properties taken from a local supplier are used in the present study.

**Table3.** Properties of Coarse Aggregate

| Property | Coarse Aggregate | |
|---|---|---|
| | 20 mm | 12 mm |
| Fineness Modulus | 7.58 | 7.54 |
| Specific Gravity | 2.65 | 2.74 |
| Bulk Density | 1524.56kg/m$^3$ | 1513kg/m$^3$ |
| Percentage of Voids | 44.27% | 45.49% |

*2.3 Rice husk ash*

Rice husk ash having high percentage of silica, fine silica will provide a very compact concrete. Combustion of rice husk provides rice husk ash. This rice husk ash contains nearly 85-90 % silica. The rice husk ash also is a very good thermal insulation material.

*2.4 Steel Fiber*

Steel Fiber are distributed throughout a given cross section area. Steel fiber improves resistance to impact or progressive loading, and to resist material fragmentation. Steel Fibers are added to concrete in low volume dosages up to 1%, and have been shown to be useful in shortening plastic shrinkage cracking.

## 3. Preparation of Alkaline Liquids

In this research work the compressive strength of geo-polymer concrete is examined for the mixes of varying molarities of Sodium hydroxide (5M, 10M, and 15M). The molecular weight of sodium hydroxide is 40. To prepare 5M i.e. 5 molar sodium hydroxide solution, 200g of sodium hydroxide flakes are weighed and they can be dissolved in distilled water to form 1 liter solution.

**Table 4.** Weights of NaOH flakes

| Required Molarity | Weight of sodium hydroxide flakes in gm. |
|---|---|
| 5M | 200 |
| 10M | 400 |
| 15M | 600 |

The sodium silicate solution and the sodium hydroxide solution were mixed together at least one day prior to use to prepare the alkaline liquid. When the specimens were cast this solution mixed with other ingredient of concrete.

**Fig1.** Sodium hydroxide in flakes form

*3.1 Procedure to cast geopolymer concrete*

*a)* To cast geo-polymer concrete convention method to cast normal concrete is utilized.

*b)* The mixing is done about 6-8 minutes for proper bonding of all the materials.

c) The sizes of the cubes used are of size150mmX150mmX150mm.

d) Sample name designated as SP1-SP3 as per the different molarity.

*e)* For geo-polymer concrete water curing is not favourable. So for curing purpose geo-polymer concrete cubes directly placed in sun light.

*f)* After that compressive strength testing will be conducted on different cubes.

## 4. Result and discussions

In this research work only compressive strength of geo-polymer concrete were analysed and compared it with conventional concrete. The compressive strength of different geo-polymer concrete cubes are as follow:

**Table5.** Compressive strength

| Sample Designation | Compressive strength in N/mm$^2$ of specimen | | |
|---|---|---|---|
| | 7 days | 14 days | 28 days |
| CC | 16.6 | 24.6 | 28.5 |
| SP-1 | 15.6 | 21.5 | 27 |
| SP-2 | 19.5 | 25.4 | 28.4 |
| SP-3 | 21.4 | 26.2 | 29.5 |

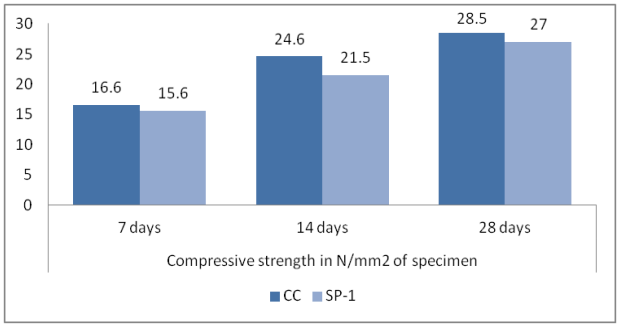


**Fig2.** Compressive strength comparison of CC and SP-1 Sample

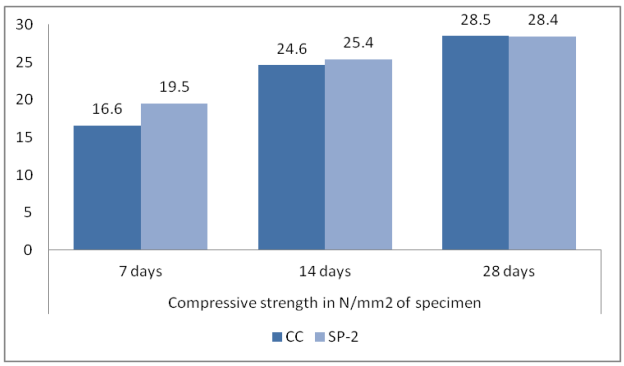


**Fig3.** Compressive strength comparison of CC and SP-2 Sample

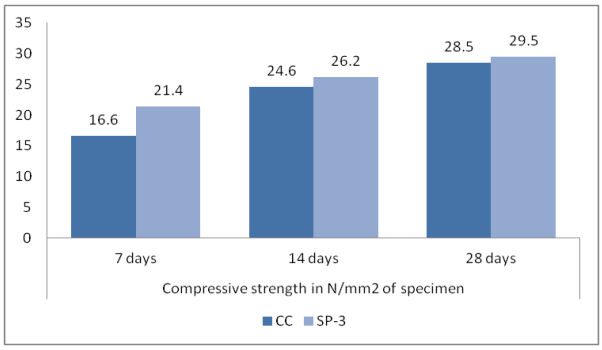


**Fig4.** Compressive strength comparison of CC and SP-3 Sample

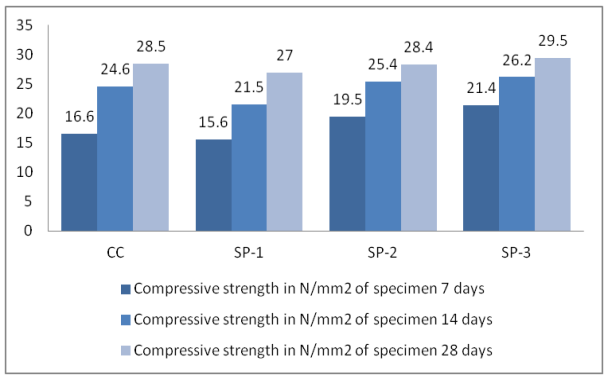


**Fig5.** Compressive strength comparison of CC and other Sample

### *4.1 Workability test*

Workability defined as the ease of placement of concrete. Workable concrete means the concrete which can be implanted and can be compacted easily without any segregation. Workability is a fundamental property of concrete and related with compaction as well as strength. Compaction and workability are very close to each other. We can also be defined workability as the amount of useful internal work necessary to produce full compaction. Both the parameter workability and strength of concrete are inversely proportional. In previous research it is found that strength of concrete decreases with increase in workability of normal concrete affecting the durability of concrete. In this research work workability is observed through slump test. Test reading of workability are as follow:

**Table 6.** Workability Test

| S. No. | Mix | Workability in mm |
|---|---|---|
| 1 | CC | 68 |
| 2 | SP-1 | 72 |
| 3 | SP-2 | 85 |
| 4 | SP-3 | 91 |

## Conclusions

Based on the experimental work reported in this study, the following conclusions are drawn.

1. Greater concentration of sodium hydroxide solution results in higher compressive strength of rice husk ash & quarry dust based geo-polymer concrete.

2. The mix SP-3 gives higher compressive strength, as it has high molarity of sodium hydroxide.

3. We observe that the compressive strength is increased with the increase in the molarity of the sodium hydroxide.

4. Geo-polymer concrete shall also be used in the field of construction works.

5. The geo-polymer concrete shall be effectively used for the beam column junction of the reinforced concrete structure.

6. Due to utilization of steel fiber compressive strength also increased.

7. Using steel fiber in the geo-polymer concrete it is found that it can reduced the sudden cracking.

8. Due to steel fiber is geo polymer concrete, concrete is tougher and more resistant.

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