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# Strength of rice husk ash based mortar

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**Abstract**
With increase in industrialization the use of concrete has increased the production of cement which is not environment friendly as it has increased damages to the nature in search of limestone and energy involved. Rice Husk Ash is a waste product which is rich in silica and improper disposal of rice hush ash (RHA) leads to air pollution and land fill problem. The Rice Husk Ash in presence of Silica – Alkali reactor acts as a binding material and can be used effectively in formation of geopolymer mortar. This study was as such carried out to investigate the properties of geopolymer concrete made with rice husk ash to check the suitability as a construction material. In order to achieve the objectives, the geopolymer mortar is being casted with mixture of Sodium Hydroxide and Sodium Silicate as silica alkali reactor with variable proportion of Alccofine i.e. 10%, 30% and 50% It was observed that the optimum quantity of RHA used in all cases was 70% by weight due to which the increase in compressive strength was measured in time interval of 3 days 7 days and 28 days. The strength of RHA based geopolymer mortar increases with increase in NaOH molarity and curing temperature. Similar trend of increase in strength with age was observed as observed in conventional (cement based) mortar at normal curing. It can be such recommended that RHA based sustainable mortar can be used in place of OPC based mortar.

**Keywords:** cement, fly ash, strength, mix design

## Introduction
Mortar is a workable paste used to bind building blocks such as stones, bricks, and concrete masonry units together, fill and seal the irregular gaps between them, and sometimes add decorative colors or patterns in masonry walls. Cement mortar becomes hard when it cures, resulting in a rigid aggregate structure; however, the mortar is intended to be weaker than the building blocks and the sacrificial element in the masonry, because the mortar is easier and less expensive to repair than the building blocks. Mortars are typically made from a mixture of sand, a binder, and water. Rice husk is a byproduct of agricultural waste generated in rice mills. During milling of paddy 80% weight found out as rice and remaining 20% weight received as husk. This husk is used as fuel in industries to generate steams and other purposes. This husk contains about 75 % organic fickle matter and the remaining 25 % of the weight of this husk is converted into ash during the firing process, this ash is known as rice husk ash (RHA). Typically, RHA contains 80-90% of amorphous silica, 1-2 % Potassium oxide (K2O) and remaining being sunburn carbon. The RHA can be blended with ordinary Portland cement to produce concrete. In this present study, Ordinary Portland cement was replaced by rice husk ash at different percentage to find out the suitable percentage of rice husk ash with the help of compressive and split tensile strength.

## Production of Rice Husk Ash
Properties and characteristics of a material are closely related to that of the parent material and the methods and techniques of its production. This also applies to rice husk ash. Rice husk ash (RHA) is a material produced by the burning of rice husk either through open field burning or under incineration conditions in which temperature and duration are controlled. Open field burning is not encouraged because of pollution problems and it also produces poor quality rice husk ash. The RHA produced from open burning has high carbon content which adversely affects structure performance and also results in a structure of highly crystalline form that is of low reactivity. Thus the RHA in the amorphous form of silica with has the potential to be used for structural concrete is produced through controlled incineration conditions (temperature and duration).

## Chemical properties of Rice Husk Ash

**Table 1**

| Compound | Rice Husk Ash | Broiler Bed Ash | RHA (Umamheswaran batra) |
|---|---|---|---|
| $SiO_2$ | 91.80 | 37.70 | 93.52 |
| $Al_2O_3$ | 0.06 | 1.30 | 0.01 |
| $Fe_2O_3$ | 0.09 | 0.67 | 0.51 |
| CaO | 1.02 | 15.40 | 0.68 |
| $Na_2O$ | 0.06 | 2.79 | 0.40 |
| $K_2O$ | 1.73 | 6.64 | 2.40 |
| MnO | 0.31 | 0.16 | 0.47 |
| $TiO_2$ | - | 0.06 | 0.04 |
| MgO | 0.42 | 4.23 | - |
| $P_2O_5$ | 0.94 | 13.90 | 1.06 |
| SrO | 0.01 | 0.11 | - |

## Alkali Activators
Mixing of the alkaline activators plays an important role, and it affects the GPC properties (Kong *et al.* 2010). NaOH and $Na_2SiO_3$ are used in this study as an alkaline activator. When

water is added to NaOH pellets, heat is generated. Heat plays a major role in the GPC manufacturing and in the geopolymerisation process. NaOH in the form of pellets with 98% purity and sodium silicate solution ($Na_2SiO_3$) with $SiO_2/Na_2O$ between 1.90 and 2.01 were procured commercially

**Fig 1:** NaoH Pellets

**Table 2:** Specification of Sodium Silicate

| Color | Colorless |
|---|---|
| Density (Kg/m$^3$) | 1450-1550 |
| Total Solid Content, by mass % | 45:52 |

**Table 2:** Proportion of NaOH Solution per kg

| Sr No | Molarity | Mass of NaOH (gm) | Mass of water (gm) |
|---|---|---|---|
| 1 | 8 M | 262 | 738 |
| 3 | 12 M | 361 | 639 |
| 5 | 16 M | 444 | 556 |

**Preparation, casting, and curing of Samples**

Before the mixing of the mortar ingredients, aggregate were prepared to the saturated surface dry condition. Sodium hydroxide was prepared 24 hours prior to final mixing. In this study, NaOH and $Na_2SiO_3$ were mixed about 1 hour before the mixing of dry components used in GPC. All the dry ingredients such as RHA, aggregates, and alccofine were dry mixed with the pan mixture. prepared sample of Rice Husk Ash based geopolymer mortar.

Then alkaline activator solution is added at a slow rate to the dry materials. The mixing is done for about 5 minutes to produced alccofine activated fresh mortar. After mixing all the ingredients in pan mixture, the mix is poured into cube moulds and put on the vibrating table for proper compaction. The compaction is done for 1 to 2 minutes. 70.7 mm cubes were prepared for compressive strength tests. A rest period of one day is given to all the specimens. The samples were then cured at the ambient and heat condition at 27°C and 90°C.

**Compression Testing Machine (CTM)**

Compression tests are used to determine how a product or material reacts when it is compressed, squashed, crushed or flattened by measuring fundamental parameters that determine the specimen behavior under a compressive load. These include the elastic limit, which for "Hookean" materials is approximately equal to the proportional limit, and also known as yield point or yield strength, Young's Modulus (these, although mostly associated with tensile testing, may have compressive analogs) and compressive strength. Compression tests can be undertaken as part of the design process, in the production environment or in the quality control laboratory, and can be used to:

**Fig 2:** Compression Testing Machine

- The compression testing machine was used to check the compressive strength of rice husk ash based geopolymer mortar samples at interval of 3, 7 and 28 days
- Assess the strength of components e.g. automotive and aeronautical control switches, compression springs, bellows, keypads, package seals, PET containers, PVC/ ABS pipes, solenoids etc.
- Characterize the compressive properties of materials e.g. foam, metal, PET and other plastics and rubber.

**Compressive Strength of 8M solution specimen at ambient temperature**

From the results it can be seen that, the compressive strength of the specimen increased from 11.7 MPa to 28.45 MPa and from 15 MPa to 33.3 MPa at the ages of 3 days and 28 days for 10% and 30% alccofine respectively. The strength of 30% alccofine specimen is about 20% more than that of 10% alccofine. Also the rate of gain of strength increases after 7 days as shown in fig 4.1

**Table 3:** Compressive Strength of 8M solution specimen at elevated temperature

| Sr. No. | Compressive Strength (N/mm$^2$) | | |
|---|---|---|---|
| | 3 Days | 7 Days | 28 Days |
| GPM1 | 25.41 | 46.2 | 47.81 |
| GPM2 | 30.45 | 52.5 | 54.6 |
| GPM3 | 22.38 | 43.05 | 44.38 |

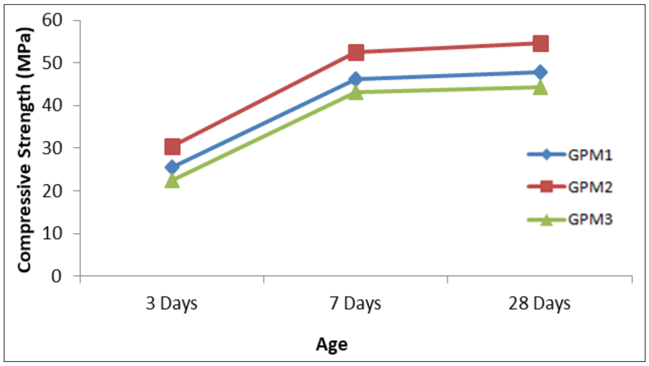


**Fig 3**

## Scanning Electron Microscopy Test (SEM Test)

The scanning electron microscope (SEM) uses a focused beam of high-energy electrons to generate a variety of signals at the surface of solid specimens. The signals that derive from electron-sample interactions reveal information about the sample including external morphology (texture), chemical composition, and crystalline structure and orientation of materials making up the sample. In most applications, data are collected over a selected area of the surface of the sample, and a 2-dimensional image is generated that displays spatial variations in these properties. Areas ranging from approximately 1 cm to 5 microns in width can be imaged in a scanning mode using conventional SEM techniques (magnification ranging from 20X to approximately 30,000X, spatial resolution of 50 to 100 nm). The SEM is also capable of performing analyses of selected point locations on the sample; this approach is especially useful in qualitatively or semi-quantitatively determining chemical compositions (using EDS), crystalline structure, and crystal orientations (using EBSD). The design and function of the SEM is very similar to the EPMA and considerable overlap in capabilities exists between the two instruments.

## Energy Dispersion X-Ray (EDX)

It stands for Energy-dispersive X-ray spectroscopy (EDS, EDX, EDXS or XEDS). It is a technique of analyzing chemical characteristic of a sample. It depends on interaction of some source of X-ray excitation and a sample. It is done by exciting the sample and focusing an electron beam on it. This excitation causes emission of X-RAY from the sample. These individual X-RAYs are picked up by X-RAY detector and converted into electrical voltage signals. The signal produced in these samples act as a basic for element analysis and allows to elemental analysis to heat to be conducted in samples. In this when electron beam is focused on sample it strikes on electron and forcefully take place of that electron this state become very unstable so in order to have stability element release energy in form of X-RAY

## Conclusion

From the result presented in this paper, it may be concluded that the water demand for same workability of cement mortar is increased for increasing the amount RHA in the mix. The use of RHA at 20% replacement level results is good in compression at short and long duration. The used RHA is good for pozzolanic material and replace the OPC at 20% without an effect on the compressive strength at long time.

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