# The Effect of Rice Husk Ash and Fly Ash Used As Supplementary Cementing Material on Strength of Mortar and Concrete

*Archana Katroliya **Archana Tiwari

*M.E.-scholar, department of civil engineering, MITS College Gwalior,
**Associate professor, MITS College Gwalior

## ABSTRACT

To meet out the rapid infrastructure development a huge quantity of concrete is required. Unfortunately, India is not self sufficient in the production of cement, the main ingredient of concrete and the demand exceeds the supply and makes the construction activities very costlier. Hence, currently, the entire construction industry is in search of a suitable and effective waste product that would considerably minimize the use of cement and ultimately reduce the construction cost. In the last decades, the use of residue in civil construction, specially in addition to concrete, has been subject of many researches due to, besides to reduce the environmental polluters factors, it may lead several improvements of the concrete properties. Few of such products have already been identified like Rice Husk Ash (RHA), Fly Ash, Silica Fumes, Egg shell etc. Amongst these RHA and Fly Ash are known to have good prospects in minimizing the usage of cement. India produces about 122 million tons of paddy every year. About 20-22% rice husk is generated from paddy and 20- 25% of the total husk becomes as "RICE HUSK ASH" after burning. Each ton of paddy produces about 40 Kg of rice husk ash.

This paper evaluates how different proportions of rice husk ash (RHA) and fly ash (FA) added to concrete may influence its physical and mechanical properties. Samples with dimensions of 150 X 150 mm were tested, with 0%, 10%, 20%, 22.5% and 25% of cement is replaced by total mass of waste (RHA+FA). Properties like compressive strength were evaluated.

The results were compared with control sample and the viability of adding RHA & FA to concrete was investigated. It has been observed that replacement of 20% cement by waste product was found to increase in compressive strength of concrete.

**KEY- WORD** Rice husk ash, Fly ash, pozzolanic material, compressive strength.

## INTRODUCTION

Cement mortar and concrete are the most widely used construction materials. According to the present state-of-the art concrete is not merely the four component system that is cement, water, fine aggregate and coarse aggregates. Now it is believed that it has many ingredients like fly ash, ground granulated blast furnace slag, silica fumes, rice husk ash, metakaoline and super plasticizers. One or more of these ingredients can be used in concrete and mortar as the situation demand.The use of pozzolanic material is as old as the art of concrete construction. The use of various pozzolans mixed with OPC in optimum proportions improve many qualities of mortar and concrete in fresh and hardened state.

Fly ash is comprised of the noncombustible mineral portion of coal consumed in a coal fueled power plant. Fly ash particles are glassy, spherical shaped "ball bearings" –typically finer than cement particles – that are collected from the combustion air steam exiting the power plant.

Rice husk ash is an agro waste material. Rice husk ash (RHA) is obtained by burning of rice husk in a controlled manner. When properly burnt, it has high silica content and can be used as an admixture in mortar and concrete. India produces about 122 million tons of paddy every year. About 20-22% rice husk is generated from paddy and 20- 25% of the total husk becomes as "RICE HUSK ASH" after burning. Each ton of paddy produces about 40 Kg of rice husk ash. Therefore it is a good potential to make the use of rice husk ash as pozzolanic material for making mortar and concrete.



This paper represents the effect of rice husk ash and fly ash on compressive strength of concrete when mixed in certain proportions in the ordinary Portland cement (OPC) as partial replacement of cement.

The objectives and scope of present study are.

1. To find the optimum mix design with regards to the amount of water, RHA, FA and cement ratio.
2. To investigate the physical properties of the RHA and FA– density (lightweight), strength (compression), water absorption and moisture content.
3. To study the relative strength development with age of (RHA + FA) concrete with control concrete.
4. Use of industrial waste in a useful manner.

5. To conduct compression test on (RHA+FA) and control concrete on standard IS specimen size (150 x 150 x 150) mm.
6. To provide economical construction material.
7. Provide safeguard to the environment by utilizing waste properly.

**Previous Efforts**

Some of the early researches have examined the use of rice husk ash (RHA) in concrete. RHA is highly pozzolanic material. The non crystalline silica and large specific surface area of the RHA is responsible for its high pozzolanic activity.

Al Khalaf and A.Yousif (1984) have investigated the effect of rice husk on pozzolanic behavior of rice husk ash. They studied the actual range of temperature required to burn rice husk to get the desired pozzolanic product. They investigated that up to 40% replacement of cement with RHA can be made with no significant change in the compressive strength as compared to the controlled mix, if the rice husk is burnt under optimum temperature condition (4).



Ismail and Waliuddin (1996) had worked on effect of rise husk ash on high strength concrete. They studied the effect the rise husk ash (RHA) passing 200 and 325 micron sieves with 10- 30 % replacement of cement on strength of HSC. Test result indicated that strength of HSC decreased when cement was partially replaced by RHA for maintaining same value of workability. They observed that optimum replacement of cement by RHA was 10 – 20 % (5). Ramezanianpour et al. 2009, 2010 concluded that burning rice husks at temperature below 700°C produces rice husk ashes with high pozzolanic activity(2).

**Rakesh Kumar *et al*.** ( 2011 ) studied Fly ash is one of such examples, which has been treated as a waste material, in India, till a decade back, and has now emerged not only as a resource material, but also as an environment savior. At present, disposal of such large quantity of fly ash involves man, material and money resources which incur an additional financial burden to the power station. This study was conducted upon utilization of waste material like fly ash for brick manufacturing with different proportions of lime, Quarry Sand, Polymer and Cement.

## Materials and Methods

The work presented in this paper reports an investigation on the behaviour of concrete produced from blending cement with RHA and FA. The physical and chemical properties of RHA, FA and OPC were first investigated. The effect of RHA on concrete properties was studied I.e. Compressive strength test was studied as the time dependent property.

## Fly Ash

Fly ash used in the study was obtained from Parichha thermal power plant, JHANSI (UP),INDIA. Fly ash is finally divided by product obtained from the combustion of pulverized coal in suspension fired furnaces of thermal plant or we can simply called it as waste residue from thermal power stations. There are 70 thermal power stations in our India. Waterpower projects are comparatively very less.

**Table:1 Chemical analysis of Fly Ash: - [ From Parichcha]**

| | |
|---|---|
| SiO2 | 60.20% |
| Al2O3 | 18.45% |
| Fe2O3 | 16.20% |
| MgO | 1.02% |
| CaO | 2.00% |
| SO3 | 1.00% |
| Na2O | 1.00% |



## RICE HUSK ASH

The rice husk ash obtained from Nova. Industries , Malanpur, Gwalior has been used as a fuel. Specifications, Physical Properties and Chemical Composition of this RHA as given by the Supplier are given in table 2 and table 3 respectively.

**Table 2: Physical Properties of Rice Husk Ash**

| | |
|---|---|
| Physical State | Solid – Non Hazardous |
| Appearances | Very fine powder |
| Particle size | 25 microns-mean |
| Colour | Grey |

| | |
|---|---|
| Odour | Odourless |
| Specific gravity | 2.3 |

**Table 3: Chemical Properties of Rice Husk Ash**

| | |
|---|---|
| **SiO2** | **93.80%** |
| **Al2O3** | **0.74%** |
| **Fe2O3** | **0.30%** |
| **TiO2** | **0.10%** |
| **CaO** | **0.89%** |
| **MgO** | **0.32%** |
| **Na2O** | **0.28%** |
| **K2O** | **0.12%** |
| **Loi** | **3.37%** |



**Cement:**

Cement used in the experimental work is **ORDINARY PORTLAND CEMENT** conforming to **IS: 8112:1989.** The physical properties of the cement obtained on conducting appropriate tests and the requirements as per **IS 8112:1989** are given in Table.5

**Table:4**

| **Particulars** | **Requirements of IS:8112-1989** |
|---|---|
| Loss of ignition | 5.0 Max |
| Magnesia (% by mass) | 6.0 Max |
| Sulphuric anhydride | 3.0 Max |
| Insoluble material(%by mass) | 27.464 Max |
| Chloride (%) | 0.1 Max |

**Table 5: Physical Property Of Procured Opc**

| Particulars | Test results | Requirements of IS: 8112-1989 |
|---|---|---|
| Specific gravity | 3.15 | 3.15 |
| Fineness (m2/kg) | 285 | 225 min |
| Normal consistency | 28% | 30% |
| Setting time(minutes)<br>• Initial<br>• Final | <br>175<br>450 | <br>30 min.<br>600 max. |
| Soundness<br>• Le-chatlier expansion | 1 mm | 10 mm max. |
| Compressive strength<br>• 3days<br>• 7 days<br>• 28 days | ---------- | <br>23 min<br>33 min<br>43 min |



**Fine Aggregate:**

Fine aggregate was purchased which satisfied the required properties of fine aggregate required for experimental work and the sand conforms to zone II as per the specifications of IS 383: 1970.

a) Specific gravity = 2.7

b) Fineness modulus = 2.71

**Coarse Aggregate:**

Crushed granite of 20 mm maximum size has been used as coarse aggregate. The sieve analysis of combined aggregates confirms to the specifications of IS 383: 1970 for graded aggregates.

a) Specific gravity =2.64

b) Fineness Modulus = 6.8

**Water:**

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked in to very carefully. Mixing water should not contain undesirable organic substances or inorganic constituents in excessive proportions.

In this project clean potable water was obtained from Department of Civil Engineering, MITS-Gwalior (MP) for mixing and curing of concrete.

**EXPERIMENTAL PROGRAMME**

Experimental programme comprises of test on cement, RHA, FA, cement concrete with partial replacement of cement with RHA and FA.

**A. RICE HUSK ASH**

1) Normal Consistency = 17%
2) Initial and Final Setting time = 195min. and 265min.
3) Specific Gravity = 2.09



**B. ORDINARY PORTLAND CEMENT**

OPC 43 grade cement is used for this whole experimental study. The physical test results on OPC are as follows.

1) Normal consistency = 28%
2) Initial Setting time = 30 min.
3) Final Setting Time = 10 hrs.
4) Specific Gravity = 3.15

**C. TEST ON CONCRETE**

An M20 mix is designed as per guidelines in IS 10262, 1982 based on the preliminary studies conducted in the constituent materials. Tests on fresh concrete are obtained as follows.

1) Slump Test=55mm
2) Compaction factor =0.95
3) Flow Test =78 %.

## MIX- PROPORTION

The test specimen were prepared as per IS code. cement mortar and concrete pastes were prepared using rice husk ash (RHA) and Fly ash (FA). The modified pastes incorporating the RHA and FA by weight cement were prepared and strength results were compared with the strength of plain mix cubes. The mix proportions are summarized in table 6.

**Table 6: Mix Proportion For Cement Mortar**

| Replacement of cement | Quantity of RHA (gm) | Quantity of FA (gm)10% constant | Quantity of cement (gm) | Quantity of Sand (gm) | Quantity of Water (ml) |
|---|---|---|---|---|---|
| 0% | 0 | 0 | 600 | 1800 | 270 |
| 10% | 0 | 60 | 540 | 1800 | 270 |
| 20% | 60 | 60 | 480 | 1800 | 270 |
| 30% | 120 | 60 | 420 | 1800 | 270 |



**Table 7 : Mix proportion for concrete**

| Replacement of cement | Quantity of RHA (kg) | Quantity of FA (kg) | Quantity of cement (kg) | Quantity of sand (kg) | Quantity of water (kg) |
|---|---|---|---|---|---|
| 0% | 0 | 0 | 1.530 | 4.725 | 0.775 |
| 20% | 120 | 0.153 | 1.225 | 4.725 | 0.775 |
| 22.5% | 150 | 0.153 | 1.187 | 4.725 | 0.775 |
| 25% | 180 | 0.153 | 1.167 | 4.725 | 0.775 |

### E. Testing methods

Testing is done as per following IS code. The testing done for compressive strength of cubes as per IS : 516 – 1959..

**Table 8: Compressive Strength Of Mortar**

| S.No. | Replacement of cement | COMPRESSIVE STRENGTH ($N/mm^2$) | | |
|---|---|---|---|---|
| | | 3 Days | 7 Days | 28 days |
| 1 | 0 % | 22 | 35 | 48 |
| 2 | 10 % | 21.92 | 34.80 | 47 |
| 3 | 20 % | 6 | 10.82 | 18.55 |
| 4 | 30 % | 3 | 7 | 15 |

**Table 9: Highest Compressive Strength obtained at different age**

| **MIX** | | | **STRENGTH AFTER CURING IN DAYS in $N/mm^2$** | | |
|---|---|---|---|---|---|
| S.No. | MIX PROPORTION | | 3 Days | 7 Days | 28 days |
| | FLY ASH BY % CEMENT | RICE HUSK ASH BY % CEMENT | | | |
| 1 | **Control mix** | | 14.54 | 20.62 | 30.31 |
| 3 | 10% | 10% | 15.5 | 22.84 | 34.45 |
| 4 | 10% | 12.5% | 12.6 | 19.56 | 32.15 |
| 5 | 10% | 15% | 9.86 | 17.34 | 22 |



**Table 10: Increase or decrease in strength of concrete at 3,7 and 28 days w.r.to % replacement of waste (RHA+FA)**

| Percentage Replacement | Increase or decrease in strength | | |
|---|---|---|---|
| | 3 days | 7 days | 28 days |
| 0-20% | 6.19 | 9.72 | 12.02 |
| 0-22.5% | -15.4 | -5.42 | 5.72 |
| 0-25% | -47.46 | -18.91 | -37.77 |

## TEST RESULTS

Compressive strength test were conducted to evaluate the strength development of mortar and concrete containing various percentage tests of RHA & FA. The strength result are summarized in table- 5

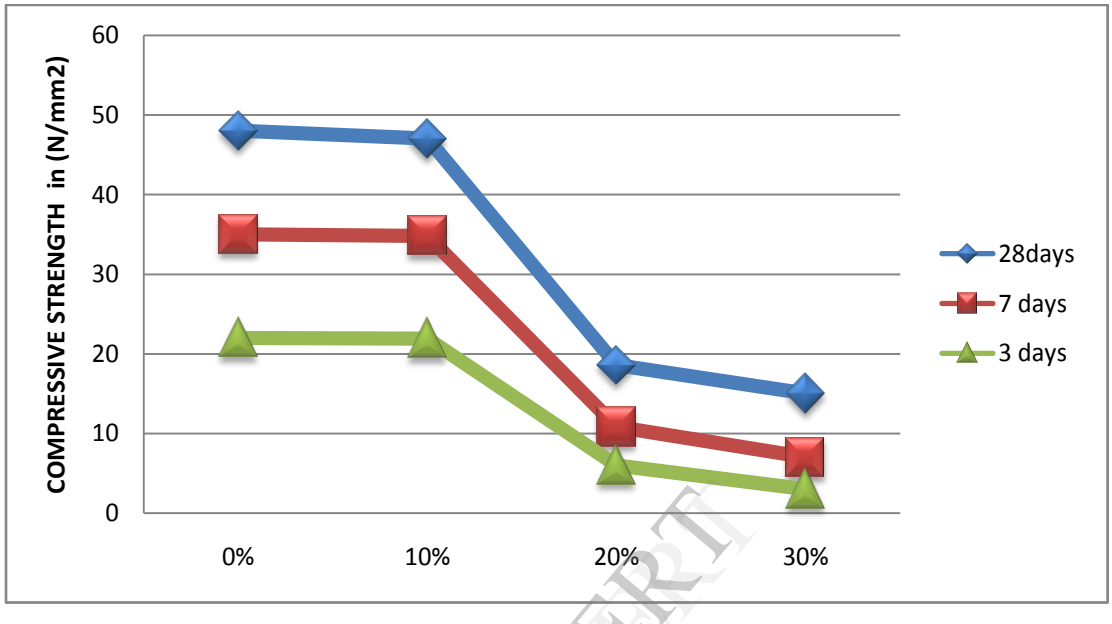


**Fig 1: Compresssive Strength of mortar**



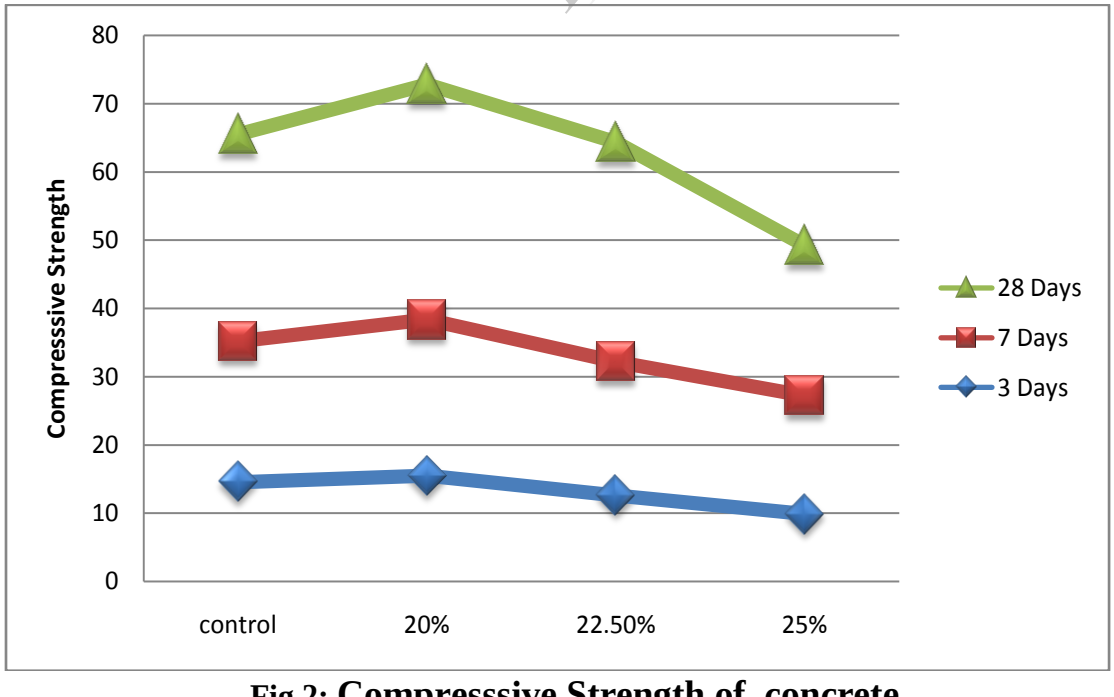


**Fig 2: Compresssive Strength of concrete**

## CONCLUSIONS

The results of the study show that the RHA produced from agro waste can be used as partial replacement of ordinary Portland cement in concrete.

From the test results it can be concluded that if approximately 20% of cement is replaced by equal amount of RHA, there is not any significant depreciation in the compressive strength but it slightly increase. Thus the RHA and FA can be used as partial replacement of cement in the regions where the material is locally available.

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