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# STRUCTURAL PROPERTIES OF RICE HUSK ASH CONCRETE.

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## Abstract

*This research was experimentally carried out to investigate the effects of introducing Rice Husk Ash (RHA) as a Partial Replacement of Ordinary Portland Cement (OPC) on the Structural Properties of Concrete. Rice Husk Ash which is an Agro-Waste and known to be a Super Pozzoland have been used for mass concrete and found to have compressive strength ranging from 33-38.4N/mm$^2$at replacement percentages of 10-25% in a mix of 1:1.5:3. A further study was carried out on its flexural properties to determine their moduli of rupture as well as its tensile strength characteristics for the determination of cracking, the values obtained at 28days are 3, 2.5 and 2.4N/mm$^2$ while the tensile strength values are 1.94, 1.17 and 0.91N/mm$^2$ at replacement percentages of 10%, 20% and 25%. This research has proved that RHA Concrete can be used as a Structural Concrete at suitable replacement percentages. This research therefore is an investigation of the performance of the concrete made of partially replacing OPC with RHA on the structural integrity and properties of RHA concrete.*

*Keywords: Rice Husk Ash, Structural Properties and Concrete*.

## INTRODUCTION

This research is aimed at putting into effective use Rice Hush Ash (RHA) a local additive which has been investigated to be super pozzolanic in a good proportion to reduce the high cost of structural concrete. Rice Husk Ash (RHA) is an agricultural waste product, and how to dispose of it is a problem to waste mangers. While Concrete today has assumed the position of the most widely used building material globally. The most expensive concrete material is the binder (cement) and if such all-important expensive material is partially replaced with more natural, local and affordable material like RHA will not only take care of waste management but will also reduce the problem of high cost of concrete and housing.

There is an increasing importance to preserve the environment in the present day world. RHA from the parboiling plants is posing serious environmental threat and ways are being thought of to dispose them. This material is actually a super pozzolan since it is rich in Silica and has about 85% to 90% Silica content.

A “pozzolan” is therefore defined as “a siliceous or siliceous and aluminum material, which itself possess little or no cementing property, but will in a finely divided form and in the presence of moisture chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementite’s properties. A good way of utilizing this material is to use it for making “high performance concrete” which means high workability and very high early strengths, or consider high workability and long term durability of the concrete.

### Materials

**Rice Husk Ash (RHA);** Rice Husk was burnt for approximately 48hrs in an open air and uncontrolled burning process. The temperature was in the range of 400-600$^0$C**.** The ash collected was sieved through BS standard sieve size 75μm and its colour was grey. Batching was done by volume at replacement percentages of 10, 20, and 25%.

**Cement**

Ordinary Portland cement (OPC) was used in which the composition and properties is in compliance with the Nigerian standard organization defined standard of cement for concrete production.

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**Aggregates**

The project work is restricted to sand collected from the river. The sand was collected to ensure that there was no allowance for deleterious materials contained in the sand.

In this research, granite of 20mm maximum size was used. Proper inspection was carried out to ensure that it was free from deleterious materials. Granite was gotten from zenith quarry in Akamkpa Cross River state.

**Water**

Water plays an important role in concrete production (mix) in that it starts the reaction between the cement and the aggregates. It helps in the hydration of the mix. In this project, the water used was Pipe borne water and free from contaminants.

**Method of Experiment**

Concrete is a mixture of water, cement, aggregate (coarse and fine) and admixture. It is important that the constituent material remain uniformly distributed within the concrete mass during the various stages of handling and that full compaction is achieved, and making sure that the characteristics of concrete which affect full compaction like consistency, mobility and compatibility are in conformity with relevant codes of practice.

**The following tests were carried out in accordance with relevant BS Standards.**

1. The aggregates were tested for physical properties such as: specific gravity, Particle distribution test and bulk density.
2. The fresh concrete was subjected to the following tests.

(i) Slump

While the following properties were tested in the hardened state of the concrete.

(i) Density test
(iii) Compressive strength test.
(iv) Flexural strength test
(v) Split tensile test.

## RESULTS AND DISCUSSION

**Physical Properties of Rice Husk Ash (RHA); Sand and Gravel**

The following physical properties of RHA, sand and aggregate were investigated in the laboratory and the results obtained from the specific gravity test as shown below

**Results of Specific Gravity**

These results show that the specific gravity of RHA varies from 1.5 to 1.56 with an average value of 1.55, while the specific gravity of sand used had a constant value of 1.52

**Particle Size Distribution :** The results of the particle size distribution analysis carried out in this research work are as shown bellow

**Table 1a-Sieve Analysis of RHA (TM = 1500)**

| Sieve Size | Weight Retained | % Retained | % Passing |
|---|---|---|---|
| 2.36 | | 0 | 100 |
| 1.18 | | 0 | 100 |
| 600 | 34 | 5.8 | 93.2 |
| 425 | 41 | 8.2 | 85 |
| 300 | 150 | 30 | 55 |
| 212 | 57 | 11.4 | 43.6 |
| 150 | 81 | 16.2 | 27.4 |
| 63 | 100 | 20.0 | 7.4 |
| Pan | 35 | 7.4 | 0 |

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**Table 1b-Sieve Analysis of Sand (TM =500)**

| Sieve Size | Weight Retained | % Retained | % Passing |
|---|---|---|---|
| 6.3 | | 0 | 100 |
| 5.0 | | 0 | 100 |
| 2.36 | 5 | 0.33 | 99.67 |
| 1.18 | 130 | 8.7 | 90.97 |
| 600 | 429 | 28.6 | 62.37 |
| 425 | 345 | 23.0 | 39.37 |
| 300 | 338 | 22.5 | 16.87 |
| 212 | 126 | 8.4 | 8.47 |
| 150 | 80 | 5.3 | 3.17 |
| 63 | 43 | 2.9 | 0.27 |
| Pan | 4 | 0.27 | 0 |

**Table 1c-Sieve Analysis of Gravel 5-20 (TM=1485)**

| Sieve Size | Weight Retained | % Retained | % Passing |
|---|---|---|---|
| 20 | | 0 | 100 |
| 13 | 4 | 0.3 | 99.7 |
| 10 | 18 | 1.2 | 98.5 |
| 6.3 | 119 | 8 | 90.5 |
| 4.7 | 70 | 4.7 | 85.8 |
| 2.36 | 234 | 15.8 | 70.0 |
| Pan | 40 | 2.70 | 67.3 |

**Table 1d-Sieve Analysis of Gravel 15-25 (TM=1660)**

| Sieve Size | Weight Retained | % Retained | % Passing |
|---|---|---|---|
| 37 | | 0 | 100 |
| 25 | 236 | 14.2 | 85.8 |
| 20 | 993 | 59.8 | 26.0 |
| 13 | 435 | 26.2 | 0 |
| 10 | 0 | 0 | 0 |
| pan | 0 | 0 | 0 |

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**Bulk Density**

The bulk densities of RHA, sand and the coarse aggregate used was found to be 20, 45 and 65kg/m$^3$ respectively.

**Workability (Slump)**

The workability test results are presented in Appendix IV. The workability test results show that RHA concrete can be graded under S2 using the European classification ENV 206:1992 having the slump of 50-90 and by TRRL classification, the workability is described as medium with compacting factor of 0.90 and slump of 50 – 100mm.

**Density**

The density of RHA was investigated and results which are analyzed and presented as a ratio of the mass to that of the volume are given below.

Table 1e. Density Values for Various RHA Concrete Mixes.

| | Age | Percentage Replacement with RHA | | |
|---|---|---|---|---|
| | | 10% | 20% | 25% |
| Average Densities of RHA Concrete in KN/m$^3$ | 7 | 2038 | 1901 | 1948 |
| | 14 | 2052 | 1875 | 1914 |
| | 21 | 2064 | 1909 | 1937 |
| | 28 | 2017 | 1950 | 1902 |

From the above results of density it can be seen that the density of RHA is in the same range for all replacement levels. According to BS 877, it can be classified as light weight concrete.

**Table 1f.The results of the compressive strength of RHA Concrete**.

| | Age | Percentage Replacement with RHA | | |
|---|---|---|---|---|
| | | 10% | 20% | 25% |
| Average Compressive strength N/mm$^2$ | 7 | 12 | 11 | 10 |
| | 14 | 14 | 13 | 12 |
| | 21 | 18 | 18 | 14 |
| | 28 | 22 | 20 | 19 |

**Split Tension Test Results**

The results of our investigations on the 28days RHA concrete are presented in Table 1g. below. From the results it can be seen that the tensile strength results are similar at all replacement percentages which is in line with the projections of the other researchers.

**Table 1g below is the presentation of the results of the split tension test.**

| SN | % Replacement | Breaking Load N/mm$^2$ | Tensile Strength N/mm$^2$ |
|---|---|---|---|
| 1 | 10% | 304738 | 1.94 |
| 2 | 20% | 91500 | 1.165 |
| 3 | 25% | 79500 | 0.91 |

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**Flexural strength investigation**

The flexural strength properties of RHA concrete was investigated in the laboratory, the results of this investigation are presented in table 1h below

The flexural strength $f_b$ (in N/mm$^2$) is given by

$$f_{cf} = \frac{FL}{d1+d2^2}.$$

Where, $F$ = the breaking load (in N)

d1 and d2 are the lateral dimensions of the cross-section (in mm)

L = the distance between the supporting rollers (in mm)

**Table 1h- Flexural Strength Values of RHA Concrete at 1:1$^1/_2$:3 mix**

| SN | % Replacement | Breaking Load N/mm$^2$ | Flexural Strength N/mm$^2$ |
|---|---|---|---|
| 1 | 10% | 7000 | 3.0 |
| 2 | 20% | 6000 | 2.5 |
| 3 | 25% | 4800 | 2.4 |

**CONCLUSION**

From the experiments and analysis of results of findings in this research work, the following facts are established about RHA Concrete.

RHA is a super pozzolan and its use in Civil Construction, besides reducing environmental polluters factors, will bring several improvements to concrete Characteristics. The compressive strength and workability tests suggests that RHA could be substituted for OPC at up to 25% in the production of concrete with no loss in workability or strength. Based on the results of split Tensile Strength test, it is convenient to state that there is no Substantial increase in Tensile Strength due to the addition of RHA. The Flexural strength studies indicate that there is a marginal improvement with 10 to 25% RHA replacement levels. Rice Husk Ash concrete possess a number of good qualities that make a durable and good structural concrete for both short term and long term considerations. It is good for structural concrete at 10% replacement level.

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