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**Compressive strength of concrete with rice husk ash as partial replacement of ordinary Portland cement**

**1. INTRODUCTION**

 **Rice husk ash is an agricultural waste which is produced in millions of tons. Waste managers have found it difficult over the years to dispose this agro-waste. Rice husk ash (RHA) is obtained by the combustion of rice husk and has been found to be super pozzolanic. RHA is a highly reactive pozzolanic material suitable for use in lime- pozzolan mixes and for Portland cement replacement. RHA is very reach in silicon dioxide which makes it very reactive with lime due to its non-crystalline silica content and its specific surface.**

**There is an increasing importance to preserve the environment in the present day world. Rice Husk Ash (RHA) from the parboiling plants is posing a 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 good way of utilizing this material is to use it for making “High Performance Concrete” which means high workability and long-term durability of the concrete.**

**ASTM C618(2) defined pozzolan as a siliceous or siliceous and aluminous materials which in themselves have little or no cementite’s properties but in finely divided form and in the presence of moisture, they can react with calcium hydroxide which is liberated during the hydration of Portland cement at ordinary temperatures to form compounds possessing cementite’s properties.**

**This study investigated the engineering properties of RHA as a material for concrete production. The results shows that RHA is a super pozzolan and very suitable as a partial replacement of OPC. 2. EXPERIMENTAL METHODS**

**2. Materials**

**2.1.1 Rice Husk Ash (RHA).-Rice Husk Ash was burnt for approximately 72hours in air in an uncontrolled burning process. The temperature was in the range of 400-6000C. The ash collected was sieved through BS standard sieve size 75µm and its colour was grey. It was then measured by volume to replace the cement at 10,20and 25%.**

|  |  |  |
| --- | --- | --- |
| **Materials** | **Specific Gravity** | **Chemical Analysis%** |
| Si02 | Al203 | Fe203 | Ca0 | Mg0 | Na03 | K20 | Loi | Na2 0 |
|  | OPC | 2.99 | 20.99 | 6.19 | 3.86 | 65.96 | 0.22 | 0.17 | 0.6 | 1.73 |  |
| RHA | 2.11 | 88.32 | 0.46 | 0.67 | 0.6 | 0.44 | 0.12 | 2.91 | 5.81 |  |
|  | OPC | 3.08 | 23.89 | 8.91 | 2.72 | 51.27 | 4.48 | - | 0.96 | - | 0.18 |
| RHA | 2.16 | 92.99 | 0.18 | 0.43 | 1.03 | 0.35 | - | 0.72 | - | 0.02 |
| Specific Surface | 16196 | Mean particle size | 12.34 | Passing N0:325 (%) | 96.6 |  |  |

**Table 1. Physio Chemical Properties of RHA**

**2.1.2 Aggregates**

**The research 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 is free from deleterious materials. Granite was gotten from zenith quarry in Akamkpa Cross River state.**

**2.1.3 Water**

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

**3. MATERIALS AND METHODS**

**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**

**(i) Density test**

**(iii) Compressive strength test**

 **4. 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.**

* **Results of Specific Gravity -**

**The 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.**

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* **Particle Size Distribution-**

**The results of the particle size distribution analysis carried out in this research work are graphically presented in figure.1 Graphical Presentation of Particle Size Distribution Results of RHA, Sand and Coarse Aggregates used in this investigation**

* **Bulk Density-**

**The bulk densities of RHA, sand and the coarse aggregate used was found to be 20, 45 and 65kg/m3 respectively.**

**Figure 1.**

**Graphical Presentation of Particle Size Distribution Results of RHA, Sand and Coarse Aggregates used in this investigation**



**Table 2. Density Values for Various RHA Concrete Mixes**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   |   |   |   |   |
|   | **Age** | **Percentage Replacement with RHA** |
|   | Days | 10% | 20% | 25% |
| Average Densities | 7 | 2038 | 1901 | 1948 |
| of RHA Concrete in KN/m3 | 14 | 2052 | 1875 | 1914 |
|   | 21 | 2064 | 1909 | 1937 |
|   | 28 | 2017 | 1950 | 1902 |

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 as stated in the methodology and the results are analyzed and presented as a ratio of the mass to that of the volume. Density Values for Various RHA Concrete Mixes table 2 and 3.. 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.

* Compressive Strength of RHA Concrete

The compressive strength of RHA concrete was investigated at 7, 14, 21 and 28days curing age. The summary of the results are presented graphically and tabulated in a figure 2 below for different replacement percentages of RHA.

 5. CONCLUSION

The use of RHA in civil construction works will reduce environmental pollution, improve the quality of concrete, and reduce its cost of production as well as solving the problem of agro-waste management by putting into use this locally found additive (RHA).

Adding RHA to concrete resulted in increased water demand, increase in workability and enhanced strength compared to the control sample. The compressive strength values at 28days were found to be 38.4, 36.5 and 33N/mm2 compared to the control with 37N/mm2. This results show that an addition of RHA from 5-10% will increase the strength and a further addition up to 15- 25%RHA will have a slight reduction in strength of 15% and a decreasing in strength values is pointed out when the levels of RHA are increasing (figure 2).

**Table 3: Density Values for Various RHA Concrete Mixes**

|  |  |  |
| --- | --- | --- |
|  | **Age** | **Percentage Replacement with RHA** |
|  | **days** | **10%** | **20%** | **25%** |
| **Average Compressive** | **7** | **12** | **11** | **10** |
| **strength N/mm2** | **14** | **14** | **13** | **12** |
|  | **21** | **18** | **18** | **14** |
|  | **28** | **22** | **20** | **19** |

**Figure 2.**

**Graphical Representation of the Relationship between Compressive Strength and Age.**

**Demand, increase in workability and enhanced strength compared to the control sample. The**

