An Experimental Study on Partial Replacement of Rice Husk Ash (RHA) With Cement of Concrete

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Abstract: *Concrete is the most commonly used construction material. The demand for concrete is increasing rapidly due to many constructional projects. As we are in modern era we cannot stop up to this, latest development is the admixtures. Lots of research is done on several admixtures which imparts strength, durability and workability to concrete. The paper is about one of such admixtures, Rice Husk Ash (RHA).Carbon free RHA is one of the bet admixtures which impart more strength to concrete than carbonized RHA. The paper differentiates carbon free RHA from carbonized RHA and gives its effects in field of construction and the main objective is to give a brief idea about a new way of processing RHA which leads to a boom in green construction.*

Keywords: Rice Husk Ash (RHA), Carbon Free Rice Husk Ash (SRH), Compressive and Tensile Strength

1. Introduction

Concrete occupies a unique position among modern construction materials. It is the only material manufactured at construction sites. It gives considerable freedom to the architect to mould the structural element to any shape or form, a freedom which is not possible with other materials.

Now a days, performance expectations from concrete structures are more demanding. As a result concrete is required to have properties like high fluidity, self compactability, high strength, high durability, better serviceability and long service life. This increasing demand for producing durable construction materials is the outcome of the fast polluting environment. Supplementary cementitious materials prove to be effective to meet most of the requirements of durable concrete.

Rice Husk Ash (RHA) is found to be superior to other supplementary materials like Slag, Silica Fume and Fly Ash. Due to its high pozzolanic activity, both strength and durability are enriched. Unlike all other industrial by-products RHA has to be produced out of the raw agricultural waste, Husk. The quality of ash is greatly influenced by its method of production. To convert this ash into an active pozzolanic material, certain controlled conditions of production and processing methods have to be followed.

2. Objectives

RHA makes concrete stronger and resistant to corrosion. RHA is produced on combustion of Rice Husk, which is available plenty in southern Asia. But combustion produces lot of carbon dioxide which adversely affects the ecosystem. The paper discusses about the best methods of producing RHA from Rice Husk with minimum emission of carbon dioxide

2.1 Materials

What is 'RHA'?
Rice is the primary source of food for billions of people around the world. Rice Husk is the shell produced during husking of paddy. Most of the husk from the milling is either burnt or dumped as waste in open fields and a small amount is used as fuel for boilers, electricity generation, bulking agents for composting of animal manure etc.

The exterior of rice husk is composed of dentate rectangular elements, which themselves are composed mostly of silica coated with a thick cuticle and surface hairs. The mid region and inner epidermis contain little silica. The typical analysis of rice husk obtained from literature is shown in Table 1.

Table 1: Typical Husk analysis

Property	Range
Bulk Density, kg/m3	96-160
Length of husk, mm	2-5
Hardness (Mohr's scale)	5-6
Ash, %	22-29
Carbon, %	~35
Hydrogen, %	4-5
Oxygen, %	31-37
Nitrogen, %	0.23-0.32
Sulphur, %	0.04-0.08
Moisture, %	8-9

The main content of rice husk is silica. It occurs in several forms within rice husk. It is this silica concentrated in husk by burning which makes the ash so valuable. This ash obtained by burning of rice husk is termed as RHA. Rice husk was burnt approximately 48 hours under uncontrolled combustion process. The burning temperature was within the range 600 to 8500C. The ash obtained was ground in a ball mill (Figure 1) for 30 minutes and its appearance color was grey (Figure 2).

Figure 1: A ball mill.

Figure 2: RHA sample after 30 minutes of grounding

RHA in concrete

Blending of reactive RHA in concrete has become a common recommendation almost in all the international building codes. Owing to its technical and economical advantages, it has gained its importance.

3. Results

Silt Content

The result for silt content is presented in table 2.

Table 2: Silt Content

Description	Sand Layer	Silt Layer	Silt Content
Quantity	775 ml	25 ml	3.23 %

The silt content was found to be 3.23%. The permitted silt content should be within the range of 3-8%. This implies that there is an adequate fine to occupy the voids between the sand particles and this reduces the cement content required for a given workability.

III.I SETTING TIMES:

Table 3 shows the result for setting times test.

Table 3: Setting Times Test

RHA replacement of OPC (%)	0	10	20	30	40	50
Initial Setting Time (minutes)	95	189	191	305	374	429
Final Setting Time (minutes)	150	323	510	685	756	811

The initial and final setting times increases with increase in rice husk ash content. The reaction between cement and water is exothermic leading to liberation of heat and evaporation of moisture and consequently stiffening of the paste. As rice husk ash replaces cement, the rate of reaction reduces, and the quantity of heat liberated also reduces leading to late stiffening of the paste. As the hydration process requires water, greater amount of water was also required for the process to continue.

3.2 Slump Test

Table 4 shows the result for slump test.

Table 4: Actual Water/Binder Ratio and Slump Values

Replacement of OPC with RHA (%)	0	10	20	30	40	50
Actual Water/Binder Ratio	0.5	0.54	0.55	0.56	0.57	0.58
Slump (mm)	15	30	20	25	20	25

Test result indicates that mixes with greater RHA content requires greater water content to achieve a reasonable workability. This was due to the carbon content of the rice husk ash.

3.3 Compressive Strength

Table 5: Compressive Strength of Blocks

Age At Curing % Replacement Level	Compressive Strength (N/mm^2)						Remarks
	1 Day	3 Days	7 Days	14 Days	21days	28 Days	
100%OPC, 0%RHA	0.51	0.91	1.60	2.78	3.63	4.60	The compressive strength generally increases with age at curing and decreases as the RHA content increases.
90%OPC, 10%RHA	0.40	0.70	1.31	2.43	3.35	4.09	
80%OPC, 20%RHA	0.25	0.55	1.14	2.02	2.91	3.65	
70%OPC, 30%RHA	0.15	0.36	0.74	1.35	1.79	2.07	
60%OPC, 40%RHA	0.00	0.15	0.38	0.65	0.91	1.05	
5O%OPC, 50%RHA	0.00	0.06	0.30	0.40	0.42	0.59	

The optimum replacement level of OPC with RHA is 20%. Carbon Free Rice Husk Ash (SRH):

Though there are many advantages, carbon content in rice husk ash makes few properties undesirable. The experiments are being conducted to overcome these disadvantages by obtaining Carbon free Rice Husk Ash nothing but extracting Silica from Rice Husk (SRH).

Researchers have figured out a way to make nearly carbon-free rice husk ash. Heating husks to 800 degrees centigrade (1,472 degrees Fahrenheit) in an oxygen-free furnace drives off carbon, leaving fine particles of nearly pure silica behind.

3.4 Compressive Strength

The reference specimen was prepared with 100% Portland cement and was used for comparison with the concretes with SRH (5 and 10%). Comparison of the data for days of curing time shows that the compressive strength increases when the SRH is added to concrete, especially as a 10% replacement for cement. This increase in strength may partially be due to the pozzolanic reaction. It can be seen that the relative increase in compressive strength attains 80% of the maximum value obtained (91 days) at 7-day curing. The reasons for early compressive strength development of concretes with SRH are due to fineness, amorphous phase, specific area and degree of reactivity of SRH (99.7%).

Mixture	Compressive Strength					
	1 days	3 days	7 days	28 days	63 days	91 days
Control	41.3	65.3	76.9	88.4	88.7	94.6
	42.5	64.9	77.9	86.5	91.8	91.9
	41.7	64.5	79.9	84	90.5	93.2
	43.8	66.1	79.1	85.1	92.6	92.8
SD*	1.1	0.7	1.3	1.9	1.7	1.1
5SRH	47.2	70.7	76.5	90.5	95.4	100.2
	48.6	67.3	83.6	93.7	96.2	95.8
	48.5	73.8	78.9	93.6	95.8	99.6
	46.5	68.5	79.4	91.1	94.2	97.8
SD*	1	2.9	3	1.7	0.9	2
10SRH	44.8	66.5	88.8	101.5	104.5	108.9
	45.7	65.8	87.6	98.5	105.9	107.8
	47.5	63.4	85.4	98.6	105.2	110.7
	45.2	64.1	85.9	99.2	107.6	109.5
SD*	1.2	1.4	1.6	1.4	1.3	1.2

3.5 Splitting Tensile Strength

The splitting tensile strength values of concretes with and without SRH after 28 days of curing as observed in the compressive strength, the splitting tensile strength values of concretes with SRH were higher than concrete control. It can be clearly seen that the increase is not proportional, since the filler effect is more significant in the compressive strength. The increase in splitting tensile strength of concrete with 10% SRH was 12% in relation to control concrete.

3.6 Water Absorption

The effect of SRH is a little significant in concretes at 7 days of curing and, at 28 days, the water absorption values of control concrete was lower as compared to concrete with addition. The water absorption was expected to be lower in concretes with SRH, given that the addition decreases the porosity of materials.

Mixture	Water Absorption	
	7 days	28 days
Control	4.7	3.4
5SRH	4.6	4
10SRH	4.4	3.9

3.7 Chloride Ion Penetration

The results for the test of resistance to penetration of chloride ions into concrete, measured by means of electric charge passed through the specimens (coulomb) at 7 and 28 days, the substitution of SRH for cement yields a significant reduction in the total charge passed at 7 and 28 days. This reduction amounts to 19% and 40% for 5% SRH and 10% SRH, respectively, at 7 days. At 28 days, the same content substitution showed reductions of 24% and 50%. Thus, although the water penetrates in pores of concrete with addition (according to water absorption test), the chloride ions do not penetrate, because of the small pores diameter.

4. Conclusions

From the above test outcomes it is inferred that the use of RHA in civil construction, besides reducing the environmental polluters factors, may bring several improvements for the concrete characteristics. With 10% addition of RHA, the following characteristics will be achieved.

- Adding the ash makes concrete stronger and more resistant to corrosion.
- Compressive strength can be increased up to 30%.
- Water permeability can be reduced up to 60%.
- Chloride penetration can be reduced by up to 60%.

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