Experimental Research on Rice Husk Ash as Replacement to Cement in Construction Industry

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Abstract— For the past few years, various materials were used to supplement cement as an essential component for high performance concrete mix design in the construction industry. Those materials can be natural, industrial wastes, or by- products etc. Most common substitute materials are fly ash, Silica Fume and Rice Husk Ash. The aim of the study is to find the suitability of the rice husk ash as a pozzolanic material for cement replacement in mortar and concrete and to assess the effect of Rice Husk Ash (RHA) on concrete. An attempt has been carried out to establish the strength factor of concrete using RHA as a base material to replace cement and satisfies the structural properties of concrete such as Consistency, compressive strength, flexural strength etc. The replacement levels of the cement by mass: 0, 5, 10, 15, 20 and 25% for rice husk ash were chosen for a curing periods of 3 days, 7 days, 28days and 56days.

Keywords: Rice Husk Ash-. Concret-Compressive strength-Flexural strength.

I. INTRODUCTION

The outer part of white rice grain contains high amount of silica concentration and the concentration is about 80-88%.After removing the outer part, which is named as Rice husk. Then this rice husk is burn up to become a rice husk ash (RHA) and it is contributed about 20% of its weight [Anwar 2001]. RHA is a pozzolanic material and it was stated by [Tashima 2004].The pozzolanic materials are classified into two categories .The first one is natural pozzolans, which can be of volcanic origin and the second one is man-made pozzolans, which includes industrial by-products such as Fly Ash (FA), Rice Husk Ash (RHA), Silica Fume (SF), Ground Granulated Blast Furnace Slag (GGBS) etc. The cost of concrete gets reduced by the replacement of RHA and also the workability improves and has beneficial effect on heat hydration and permeability of concrete. (Sata et al 2007).

In construction industry, Cement is the common flexible material and widely utilized for different purpose. The development of the construction industry at a universal level needs more and more amount of Portland cement for sustainable development. Environmental pollution caused due to manufacture of cement was a major source of pollution to the environment, for example manufacturing of Portland cement is an energy intensive process and releases very large amount of greenhouse gases into the atmosphere, which affect the earth's ecosystem. [1and 2].

Cementitious product , C-S-H (Gel) was obtained when the mineral admixtures react with excess calcium hydroxide by hydration process. The reduction of excess $Ca(OH)^2$ due to pozzolanic reaction improves the durability of concrete by making cement paste more dense and impervious one. The use of pozzolanic material based blended cement concrete is growing rapidly in the construction industry, which will result in saving of energy, environmental protection and conservation of resources.RHA has been successfully used as a pozzolana in commercial production in a number of countries including Columbia, Thailand and India[5]. Mehta and Pirtz [4] found that RHA is very useful to decrease the temperature of mass concrete more than ordinary Portland cement (OPC) concrete. Basha et al 2005. [3] reported that RHA-used concrete holds better strength, low shrinkage and higher durability than OPC concrete. The use of pozzolanic material based blended cement concrete is growing rapidly in the construction industry, which will result in saving of energy, environmental protection and conservation of resources. A large quantity of RHA is also generated from the agricultural sector. These by-products develop serious environmental problems if not utilized properly.

II. EXPERIMENTAL PROCEDURE MATERIALS

2.1 Concrete

In this study, M20 grade concrete with achieved target strength 24 MPa was used. It was designed as per IS method. The design mix procedure was carried out as per IS: 10262-2009.

2.2 Cement

In this investigation, 53 Grade OPC (Ultra Tech Brand) conforming to IS: 8112-1989 was used. The cement sample was tested as per the procedure given in IS: 4031-1988 and IS: 4032-1985. The test results satisfy the requirements of respective codes and are listed in Tables 1.1.

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Table 1 Physical Properties of Cement

S.No	Properties	Obtained Results	Requirement as per IS: 12269-1987
1	Fineness	25%	Not more than 10%
2	Soundness	1.5mm	Not more than 10mm
3	Setting time A) Initial B) Final	 170 min 260 min	 Not less than 30 min Not less than 600 min
4	Compressive Strength A) 3 days 7 days 28 days	40.50 N/mm² 51.00 N/mm² 67.50 N/mm²	Not less than 27 N/mm² Not less than 37 N/mm² Not less than 53 N/mm²
5	Standard consistency	28.50%	-
6	Specific gravity	3.1	-

2.3 Aggregates

The coarse aggregate of 10mm and 20mm size crushed stone angular aggregates conforming to IS 383-1979. The fine aggregate was naturally occurring sand was used conforming to zone II as per IS 383-1979. The properties of fine and coarse aggregates used are presented in Table 2.

Table 2 Properties of Aggregates and Rice Husk Ash

Properties	Fine Aggregate	Coarse Aggregate	Rice Hisk Ash
Water Absorption	2.8%	1.11%	217
Specific Gravity	2.64	2.79	2.67
Density	1738 kg/m³	1570 kg/m³	683 kg/m³

2.4 Rice Husk Ash

Rice Husk Ash is the ash that is obtained by burning the rice husk until it gets reduced by 25%. The Rice Husk for this study was obtained at Chidambaram. These Husks then were grinded until fine ash is being produced. Further to remove the impurities, these ashes were sieved by 600 micron. The usage of RHA reduces the waste from the rice mills. It makes surroundings clean and becomes a partial replacement for cement. Some other methods also involved in collection of Rice Husk Ash. Physical properties of RHA are presented in Table 2.

2.5 Water

Potable water is generally considered fit for making concrete. Water should be free from acids, oils, alkalies or other organic impurities. Water reacts chemically with the cement to form a cement paste in which inert aggregate are held in suspension until cement paste are hardened. and it will also serve as a lubricant in the mixture of fine aggregates and cement. Clean Potable water as acquired from Department of Civil and Structural Engg., Annamalai University was used for mixing and curing of concrete.

Fig.1 Cement

Fig. 2 Fine Aggregate

Fig. 3 Coarse Aggregate

Fig. 4 Rice Hush Ash

III. RESULTS AND DISCUSSION

To find the fresh state and hardened properties of cement mortar and concrete at varying percentages of RHA many experiments were conducted.The RHA percentages correspond to 0%, 5%, 10% ,15%,20% and 25% by weight of cement was used. Different experiments like consistency test, initial and final setting time were carried out on cement mortar in order to find out the water content necessary to produce as a binder (cement + %RHA) paste with standard consistency as specified by the IS: 4031 (Part 4) – 1988[15] and IS:4031 (Part 5)-1988 [15]. Table 3 gives the values of normal consistency, initial and final setting time of cement mortar for varying percentages of RHA. Incorporation of 10% RHA yields optimum in the above tests and presented in Fig. 5.

Table 3 Cement Properties – Consistency & Setting Time Consistency

% of RHA	Consistency in %	Initial setting time (min)	Final setting time (min)
0	41	55	622
5	44	46	542
10	46	34	385
15	47	31	410
20	48	30	406
25	50	32	428

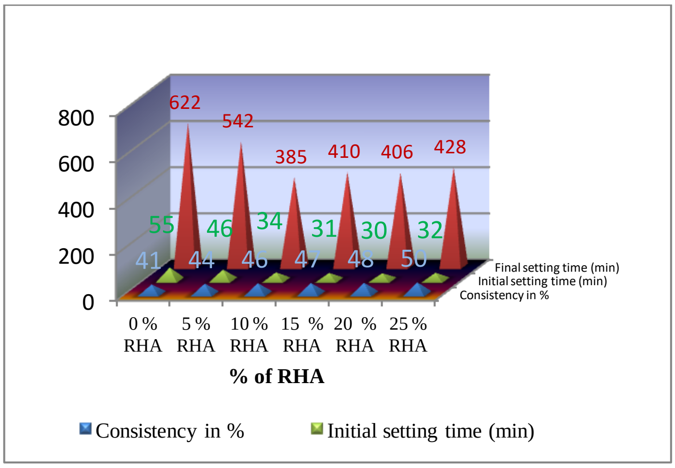

Fig. 5 Properties of Cement Mortar

3.1 Compressive Strength

For curing periods of 3 days, 7 days, 28 days and 56 days the compressive strength were obtained with varying percentages of RHA and it is presented in Fig.. 6. It was found that there was considerable increase in compressive strength from control specimen to specimens with varying percentages of RHA is reported in Table 6. The compressive strength for 3 days and 7 days increases from 11.3MPa to 24.0MPa and 13.4MPa to 26.80Mpa respectively which can be inferred from inferred from table 6. The incorporation of 10% RHA in concrete exhibit an increase of about 15.00% for 56days compressive strength of RHA concrete. The percentage increases in compressive strength from control specimen to specimens with varying percentages of 10% RHA were presented.

It can be inferred that the 28 days compressive strength increases from 25.4 MPa to 29.60 MPa with incorporation of 10% RHA as shown in table6and Fig.6. This 14.19% enhancement of compressive strength of concrete with 10% RHA was attributed to the increase in pozzolanic action when RHA was added in concrete. However, for other variations in RHA, there was a reduction in compressive strength of concrete after the incorporation of RHA of about 15%. When the percentage replacement of Rice husk ash was increased, the compressive strength of Rice husk ash concrete was also found to increase gradually up to 10% replacement and the values gets decreased with the increase in % of RHA.

Table 6 Compressive Strength Properties

% of RHA	3 Days Compressive Strength	7 Days Compressive Strength	28Days Compressive Strength	56Days Compressive Strength
0	11.30	24.00	25.4	26.40
5	12.00	25.30	26.30	27.35
10	13.40	26.80	29.60	30.30
15	12.90	25.85	27.25	29.95
20	11.42	24.92	25.90	26.90
25	10.54	19.00	21.20	22.30

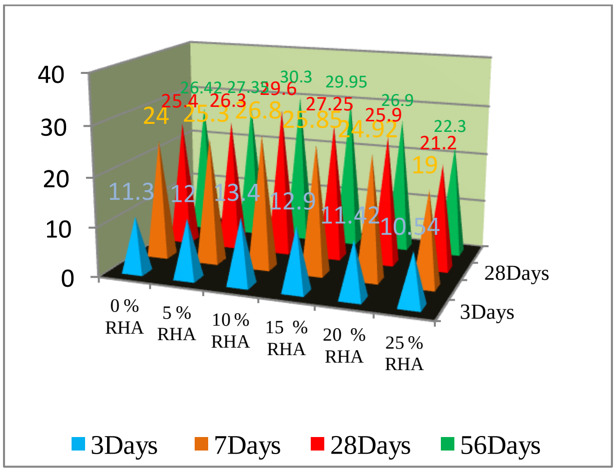

Fig. 6 Compressive Strength Response

3.2 Flexural Strength

The improvement of flexural strength from a period of 3 days, 7 days, 28 days and 56 days for mixes with varying percentages of RHA is presented in Fig. 7. The percentage increase in flexural strength from control specimen to specimens with varying percentages of RHA is reported in Table 7. From Fig. 7, it can be inferred that the 3 days and 7days flexural strength increases from 1.27MPa to 1.78MPa and 1.85MPa to 1.98Mpa respectively. The incorporation of 10% RHA in concrete exhibit an increase of about 38.34% and 31.16% for 7days and 14days compressive strength of RHA concrete. The percentage increase in flexural strength from control specimen to specimens with varying percentages of 10% RHA appear to have optimum flexural strength as presented in the table7. From Fig.. 7, it can be inferred that the 28 days flexural strength increases from 3.53MPa to 5.13MPa with incorporation of 10% RHA.

When RHA was added in concrete, the flexural strength of concrete has been enhanced by 20% due to pozzolanic action caused by adding10% RHA in concrete. However, for other variations in RHA, there was a reduction in flexural strength of concrete after the incorporation of RHA of about 15%. When the percentage replacement of Rice husk ash was increased, the flexural strength of Rice Husk Ash concrete was also found to increase gradually, up to nearly 10% replacement and then decreased.

Table 7 Flexural Strength Properties

% of RHA	3Days Flexural Strength	7Days Flexural Strength	28Days Flexural Strength	56Days Flexural Strength
0	1.27	1.85	4.84	4.95
5	1.48	1.92	4.98	5.22
10	1.78	1.98	5.15	5.44
15	1.23	1.75	4.65	4.89
20	1.08	1.66	4.24	4.31
25	1.02	1.46	3.72	3.92

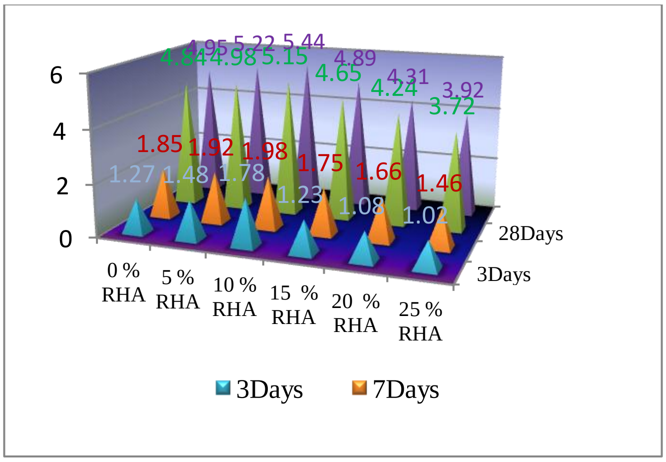

Fig. 7 Flexural Strength Response

IV. CONCLUSION

The possibility of using Rice husk ash as a partial replacement for cement was investigated in the present work. By finding out the physico-chemical characteristics of RHA, its aptness as a cementitious material was evaluated out to study the influence of RHA on concrete (fresh state and hardened state) .To assess the fresh stage properties, Slump values for different % of RHA of concrete mix at a temperature of 320°C was carried out to determine the workability of concrete. Hardened properties like compressive strength and flexural strength properties were evaluated. From the experimental investigation it was found that optimum replacement of Rice Husk ash in cement was to 10% in terms of workability and strength. Incorporation of 10% Rice Husk ash in structural concrete exhibit an increase in compressive strength of about 14.19% which is an optimum ratio that can be used for concrete Similarly. Incorporation of 10% to 15% Rice Husk ash in structural concrete gives an increase in flexural strength of about 10%.

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