Dr. A.M. Pande, S.G.Makarande / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 3, Issue 1, January -February 2013, pp.1718-1723

Effect of Rice Husk Ash on Concrete

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Abstract-
In the last decades, the use of residue in civil construction, especially in addition 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. The world rice harvest is estimated in 500 million tons per year. Considering that 20% of the grain is husk, and 20% of the husk after combustion is converted into ash, a total of 20 million tons of ash can be obtained. This report evaluates how different contents of rice husk ash (RHA) added to concrete may influence its physical and mechanical properties. Samples with dimensions of 15 X 15 cm were tested, with 12.5, 25, & 37.5% of RHA, replacing in mass the cement. Properties like simple compressive strength, splitting tensile strength, water absorption and modulus of elasticity were evaluated. The results were compared to controlled sample and the viability of adding RHA to concrete was verified.

Keywords **- Rice husk ash, compressive strength, splitting tensile strength, water absorption and modulus of elasticity.**

1. Introduction

Rice husk is an agro-waste material which is produced in about 100 million of tons. Approximately, 20 Kg of rice husk are obtained for 100 Kg of rice. Rice husks contain organic substances and 20% of inorganic material. Rice husk ash (RHA) is obtained by the combustion of rice husk.

The most important property of RHA that determines pozzolanic activity is the amorphous phase content. RHA is a highly reactive pozzolanic material suitable for use in lime-pozzolana mixes and for Portland cement replacement. RHA contains a high amount of silicon dioxide, and its reactivity related to lime depends on a combination of two factors, namely the non-crystalline silica content and its specific surface.

Research on producing rice husk ash (RHA) that can be incorporated to concrete and mortars are not recent. In 1973, researchers investigated the effect of pyro processing on the pozzolanic reactivity of RHA. Since then, a lot of studies have been developed to improve the mechanical and durability properties of concrete. The potential reactivity of aggregate was investigated by the results show that adding percentage over 12% of RHA, the expansion is reduced in acceptable levels. In this report, RHA obtained by uncontrolled combustion was added to concrete. Mechanical properties (compressive strength, splitting tensile strength, water absorption and elasticity modulus) were verified. The samples were tested at 7 and 28 days of age.

The Effect of RHA Average Particle Size on Mechanical Properties-

This reports an experimental investigation on the influence of Rice Husk Ash Average Particle Size (APS) on the mechanical properties and drying shrinkage of the produced RHA blended concrete. Locally produced RHA with three different APS (i.e., 31.3, 18.3, and 11.5 μm, respectively) were used to replace cement by 12.5%, 25%, & 37.5% of its weight. Mixture proportioning was performed to produce high workability RHA mixture (200-240 mm slump) with target strength of 40MPa. Incorporation of RHA in concrete resulted in increased water demand, for the mechanical properties, inclusion of RHA provided similar or enhanced mechanical properties when compared to the control Ordinary Portland Cement (OPC) mixture, with finer RHA giving better improvement. Fine RHA exhibited the highest shrinkage value due to the effect of micro fine particles which increases its shrinkage values considerably.

2. Materials used

Rice Husk Ash:

The Rice Husk Ash Used in this work was made in the laboratory by burning the husk using a Ferro cement furnace, with incinerating temperature not exceeding 7000 c. The ash was grinded using Los Angeles mill for 180, 270 and 360 minutes, The XRD analysis were performed to determine the silica form of the produced RHA Powder samples. RHA samples were scanned by electron microscope to show the RHA's multi layered and micro porous surface.

Other Materials:

Other materials used in the concrete mixture were Portland cement, coarse aggregate of 20 mm maximum size and mining sand of 5 mm maximum size as fine aggregate. The fineness modulus for the coarse aggregate and fine aggregate were 2.43 and 4.61 respectively. The Sp used is sulphonated naphthalene formaldehyde condensed polymer based admixture.

Mix proportion:

The purpose of this investigation was to make the concrete with targets of 28-day Compressive strength of at least 40 MPa. Proportion of mixtures was selected basing on these targets. The RHA was trialed to replace for cement with various ratios, namely 0, 12.5, 25, and 37.5 % by mass of cement. Ratio of water per total cement binder (cement plus RHAs) was fixed at 0.48.

3. Effects of adding RHA on the properties of concrete

3.1 Effect of RHA APS on Workability & Density of concrete

The fresh properties of all the concrete mixtures are given. The slump was in the range of (210-230 mm), bleeding was negligible for the control mixture. For concretes incorporating RHA, no bleeding or segregation was detected. The fresh density was in range of (2253-2347 kg/m3), the lowest density values were for mixture this is due to the low specific gravity of RHA which lead to reduction in the mass per unit volume. The concrete incorporating finer RHA resulted in denser concrete matrix.

The SP content had to be increased along with the RHA fineness and percentage, this due to the high specific surface area of RHA which would increase the water demand therefore, to maintain high workability, Sp content rose up to 2.00 % for the mixture.

3.2 Water absorption

The results reveal that higher substitution amounts results in lower water absorption values, it occurs due to the RHA is finer than cement. Adding 10% of RHA to the concrete, a reduction of 38.7% in water absorption is observed when compared controlled mixture.

3.3 Static Modulus of Elasticity:

The values of the static modulus of elasticity were in the range of 29.6 - 32.9 GPa. It can be noted that the addition of RHA to concrete exhibited marginal increase on the elastic properties, the highest value was recorded for mixture due to the increased reactivity of the RHA. Concretes incorporating pozzolanic materials usually show comparable values for the elastic modulus compared to the OPC concrete.

3.4 Splitting tensile strength

All the replacement degrees of RHA researched, achieve similar results in splitting tensile strength. According to the results, may be realized that there is no interference of adding RHA in the splitting tensile strength.

3.5 Drying Shrinkage

The results showed that the RHA average particle size had a significant effect on the drying shrinkage, the 37.5% concrete Mixture exhibited higher shrinkage value than the control. 25% concrete was comparable, while the shrinkage for 12.5% was lower compared to the control. The reduction in the RHA particle size increased the pozzolanic activity and contributed to the pore refinement of the RHA concrete paste matrix. Thus, it can be concluded that the addition of micro fine particles to concrete would increase the drying shrinkage. Many researchers showed that concretes incorporating pore refinement additives will usually show higher shrinkage and creep values. On the other hand, others showed that using pozzolanic materials as cement replacement will reduce the shrinkage.

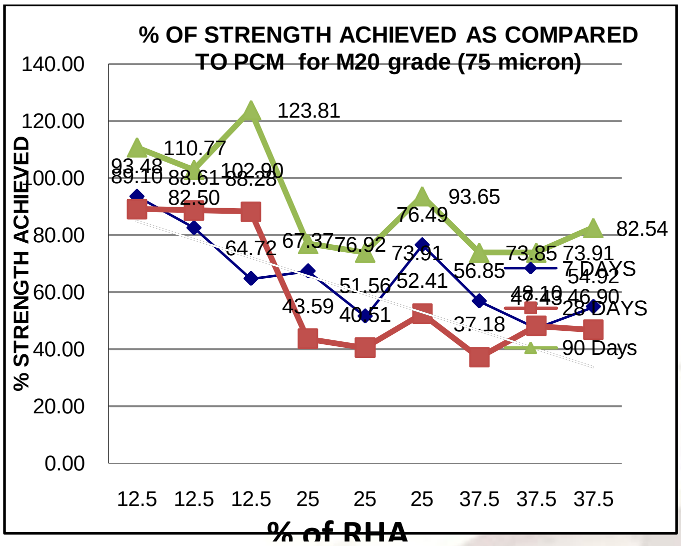
3.6 Compressive Strength:

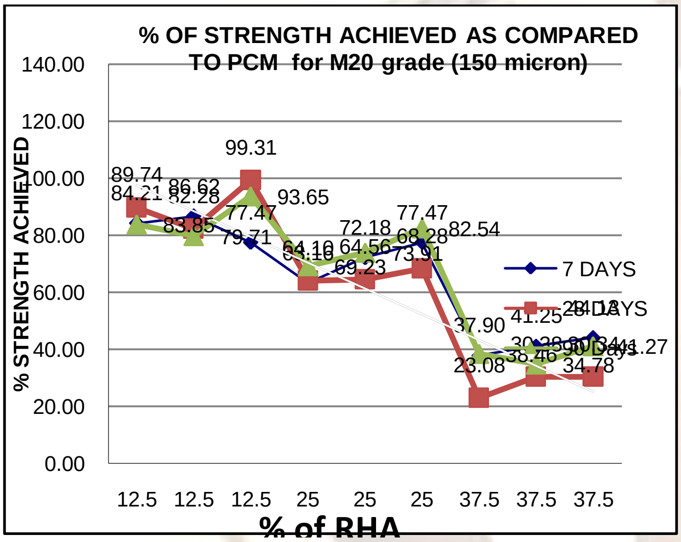
The strength development at various ages is given below. It can be noted that at early ages the strength was comparable, while at the age of 28 days, finer RHA exhibited higher strength than the sample with coarser RHA. This is due to the higher fineness of RHA which may allowed the RHA particles to increase the reaction with Ca(OH)2 to give more calcium silicate hydrate (C-S-H) resulted in higher compressive strength.

4. Results and discussion

Following results shows the effect of percentage and fineness of RHA on the compressive strength of concrete,

4.1 % Strength achieved for M20 grade concrete with 12.5%, 25% & 37.5% RHA:





Days	RHA	% strength achieved (In the avg. range of)	
		75µ	150µ
7 days	12.5%	75-80%	77-80%
7 days	25%	64-68%	65-70%
7 days	37.5%	50-52%	38-41%
28 days	12.5%	88-89%	87-92%
28 days	25%	44-46%	64-68%
28 days	37.5%	40-44%	25-30%
90 days	12.5%	110-114%	82-85%
90 days	25%	80-85%	70-74%
90 days	37.5%	75-77%	39-42%

The % strength achieved can be interpreted as follows:

The average achieved strength is found to be more for 90 days and then it lesser for 28 days and 7 days using 75 micron RHA. The average strength achieved is more for 12.5 % RHA as compared to other proportions. One of the samples recorded to achieve 123.81% strength for 90 days of curing as compared to PCC.

When 150 micron RHA is used, again the average achieved strength is found to be more for 90 days and it is lesser for 28 days and 7 days. The % strength achieved was in the range of 85%-90% for 7 days when compared to PCC. Then, it reduced considerably for 28 and 90 days of curing.

At the least, the minimum achieved strength was for 25% of RHA using 75 micron. After complete 90 days of curing it was 67.37%. For 150 micron the minimum achieved strength was for 37.5% of RHA. After complete 90 days of curing it was 34.78%.

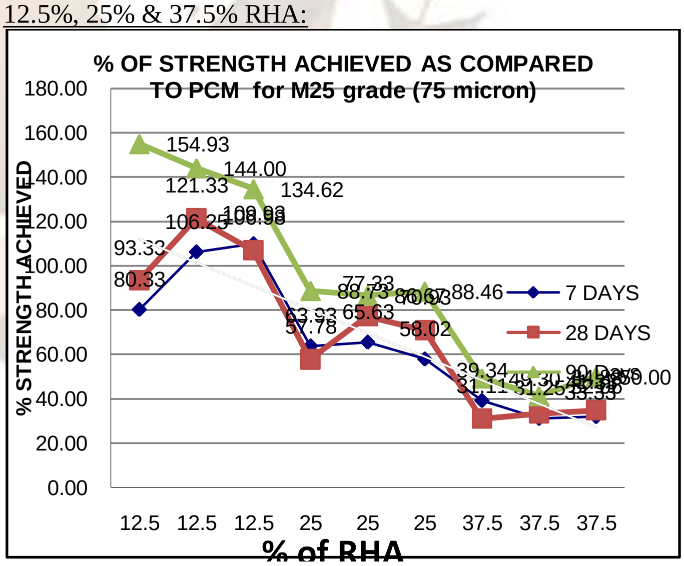
It can also be observed that when finer RHA was used (i.e. 75 micron), the % strength achieved was higher as compared to RHA size of 150 micron.

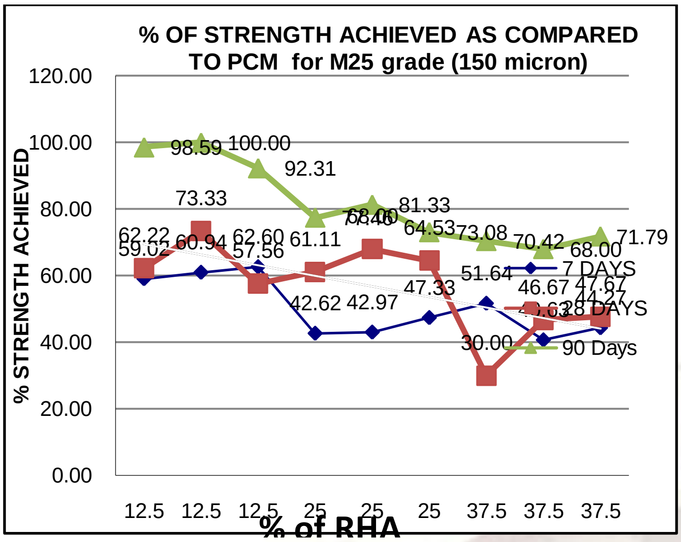
From the above discussion it is observed that, when 75 micron RHA is used, the percentage of strength achieved for 90 days is higher as that of PCC, whereas it is found lesser in case of 28 days & 7 days.

Therefore from all above discussion it can be interpreted that concrete tends to achieve 85-100 % for 12.5 % RHA, and 65-90% for 25% and 37.5% of RHA.

It is observed that strength gain becomes slow when RHA is used and strength is reduced for higher % of RHA for both 75 micron and 150 micron of RHA.

% Strength achieved for M25 grade concrete with 12.5%, 25% & 37.5% RHA:





Days	RHA	% strength achieved (In the avg. range of)	
		75µ	150µ
7 days	12.5%	94-98%	57-59%
7 days	25%	59-62%	43-46%
7 days	37.5%	30-32%	44-47%
28 days	12.5%	105-110%	62-66%
28 days	25%	65-70%	63-65%
28 days	37.5%	30-32%	39-44%
90 days	12.5%	138-142%	95-98%
90 days	25%	86-88%	75-78%
90 days	37.5%	86-88%	75-78%

The % strength achieved can be interpreted as follows:

The average achieved strength is found to be more for 90 days and then it lesser for 28 days and 7 days using 75 micron RHA. The average strength achieved is more for 12.5 % RHA as compared to other proportions. One of the samples recorded to achieve 154.93% strength for 90 days of curing as compared to PCC.

When 150 micron RHA is used, again the average achieved strength is found to be more for 90 days and it is lesser for 28 days and 7 days. One of the samples recorded to achieve 100% strength for 90 days of curing as compared to PCC.

At the least, the minimum achieved strength was for 37.5% of RHA using 75 micron. After complete 90 days of curing it was 33.33%. For 150 micron the minimum achieved strength was for 25% of RHA. After complete 90 days of curing it was 64.53%.

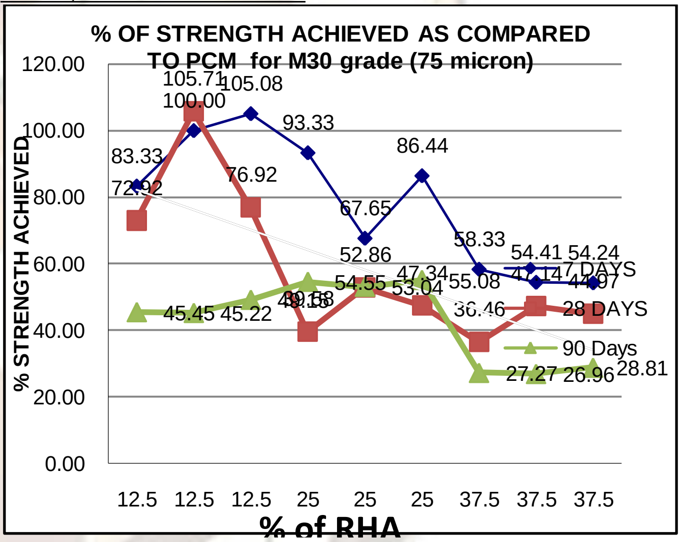
It can also be observed that when finer RHA was used (i.e. 75 micron), the % strength achieved was higher as compared to RHA size of 150 micron. However it showed an steep decline for higher percentages of RHA.

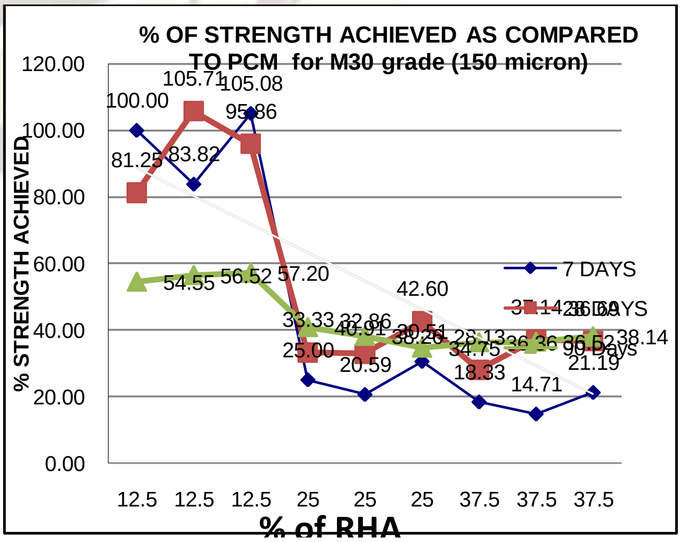
From the above discussion it is observed that, when 75 micron RHA is used, the percentage of strength achieved for 90 days is higher as that of PCC, whereas it is found lesser in case of 28 days & 7 days.

Therefore from all above discussion it can be interpreted that concrete tends to achieve 75-85% for 12.5 % RHA, and 90-110% for 25% and 37.5% of RHA.

It is observed that strength gain becomes slow when RHA is used and strength is reduced for higher % of RHA for both 75 micron and 150 micron of RHA.

<u>% Strength achieved for M30 grade concrete with 12.5%, 25% & 37.5% RHA:</u>





Days	RHA	% strength achieved (In the avg. range of)	
		75μ	150μ
7 days	12.5%	90-95%	50-55%
7 days	25%	75-80%	45-48%
7 days	37.5%	53-56%	15-18%
28 days	12.5%	80-85%	85-90%
28 days	25%	80-85%	85-90%
28 days	37.5%	80-85%	85-90%
90 days	12.5%	45-47%	54-56%
90 days	25%	45-50%	34-36%
90 days	37.5%	45-50%	34-36%

The % strength achieved can be interpreted as follows:
The average achieved strength is found to be more for 7 days and 28 days and then it is lesser for 90 days using 75 micron RHA. The average strength achieved is more for 25 % RHA as compared to other proportions. One of the samples recorded to achieve a maximum strength of 55.08% for 90 days of curing as compared to PCC.
When 150 micron RHA is used, again the average achieved strength is found to be more for 7 days and 28 days and then it is lesser for 90 days. The average strength achieved is more for 12.5 % RHA as compared to other proportions. One of the samples recorded to achieve a maximum strength of 57.2% for 90 days of curing as compared to PCC.
At the least, the minimum achieved strength was for 37.5% of RHA using 75 micron. After complete 90 days of curing it was 26.96%. For 150 micron the minimum achieved strength was for 25% of RHA. After complete 90 days of curing it was 34.75%.
It can also be observed that when finer RHA was used (i.e. 75 micron), the % strength achieved was slightly lesser for this grade as compared to RHA size of 150 micron.
From the above discussion it is observed that, when 75 micron RHA is used, the percentage of strength achieved for 90 days is quite lesser as that of PCC, whereas it is found higher in case of 28 days & 7 days.
It is observed that strength gain becomes slow when RHA is used and strength is reduced for higher % of RHA for both 75 micron and 150 micron of RHA.

5. CONCLUSION

Based on above results of concrete mixes, the following conclusions can be drawn,

- Mixes show higher compressive rather than normal concrete.
- Replacement of 12.5 % of cement with rice husk ash in matrix causes reduction in utilization of cement and expenditures. Also can improve quality of concrete at the age of 90 days.
- Results indicate that pozzolanic reactions of rice husk ash in the matrix composite were low in early ages, but by aging the specimens to 90 days, considerable effect have been seen in strength.
- According to study, addition of pozzolans like rice husk ash to the concrete, can improve the mechanical properties of specimens.

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