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International
Journal
Of Modern Engineering Research (IJMER)

Effectiveness of Use of Rice Husk Ash as Partial Replacement of Cement in Concrete

Mohammad Iqbal Malik[1], Aarif Manzoor[2], Barkat Ahmad[3], Syed Asima[4], Rozi Ali[5]

[1]Assistant Professor, Department of Civil Engineering, IUST, Awantipora
[2, 3, 4, 5,] Civil Engineering Graduate Student, IUST, Awantipora.

ABSTRACT: *India is a major rice producing country, and the husk generated during milling is mostly used as a fuel in the boilers for processing paddy and producing energy through direct combustion. About 21 million tones of Rice Husk Ash (RHA) is produced annually. This RHA is regarded as a waste and has disposal problem because of the fact that it consumes a vast area for dumping. Lots of ways are being thought of for disposing them by making commercial use of this RHA. RHA can be used as a replacement for concrete (5 to 15%).This paper evaluates how different contents of Rice Husk Ash added to concrete may influence its properties. In this study, cement was replaced by waste RHA as 5%,10% and 15% by weight for M-25 mix. The concrete specimens were tested for compressive strength, durability (water absorption) and density at 28 days of age and the results obtained were compared with those of normal concrete. The results concluded the permissibility of using waste RHA as partial replacement of cement up to 10% by weight of cement.*

Keywords: *Rice Husk Ash (RHA) , Concrete, Compressive strength, Density and Durability.*

I. Introduction

Milling of rice generates a byproduct know as husk. The rice grain is protected by husk as its skin. During milling of paddy about 78 % of weight is received as rice, broken rice and bran. Rest 22 % of the weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process. This husk has about 75 % organic volatile matter and the remaining 25 % of the weight of this husk is converted into ash during the burning process, is known as rice husk ash (RHA). This RHA in turn contains around 85 % - 90 % amorphous silica. Hence, RHA can act as a good super-pozzolana.

1.1 Environmental Impact of Cement Production:

In 2007, United States produced 110 metric tons of cement. For every ton of cement produced, approximately one ton of carbon dioxide is released into atmosphere. The cement industry produces about 5% of global man-made CO_2 emissions. Also cement production leads to disturbance to the landscape, dust and noise and disruption to local biodiversity from quarrying limestone which is raw material for cement production. Moreover rice husk ash is regarded as a waste and has disposal problem because of the fact that it consumes a vast area for dumping. There are numerous ways for disposing it by making commercial use of this rice husk ash. Hence, if waste rice husk ash provides an opportunity to be used as partial replacement of cement in concrete, it will help in reducing the CO_2 emissions, soil pollution and amount of dust into the atmosphere. Moreover its usage in concrete will reduce the cost.

About 20 million tons of RHA is produced annually. Rice husk ash which was used in this research finer than cement having very small particle size of 30 microns, so much so that it fills the interstices in between the cement in the aggregate. From previous researches it has been found that Rice Husk Ash minimizes alkali-aggregate reaction, reduces expansion, polishes pore structure and hinders diffusion of alkali ions to the surface of aggregate by micro porous structure .The rice husk ash cement on hydration produces practically no Calcium Hydroxide and hence is superior to Portland cement.

In this research, cement was partially replaced by waste RHA as 5%, 10% and 15% by weight. Concrete specimens were tested for compressive strength, durability (water absorption) and light weight nature for different waste RHA percentages. The results obtained were compared with results of normal M-25 concrete mix and it was found that maximum increase in compressive strength occurred for the concrete mix containing 10% waste RHA as cement. With increase in waste RHA content, water absorption increases indicating decrease in durability. Density of concrete decreased with increase in waste RHA content thus making concrete light weight in nature.

This paper summarized the behavior of concrete involving replacement of cement by waste RHA as 5%,10%and 15% by weight which may help to reduce the disposal problems of waste RHA and will make concrete economical.

II. Materials Used

2.1. Cement and Aggregates

Khyber ordinary Portland cement of 43 grade confining to IS 8112 was used throughout the work. Fine aggregates used throughout the work comprised of clean river sand with maximum size of 4.75mm conforming to zone II as per IS383-1970 with specific gravity of 2.6. Coarse aggregates used consisted of machine crushed stone angular in shape passing through 20mm IS sieve and retained on 4.75mm IS sieve with specific gravity of 2.7.

2.2.Rice Husk Ash

Waste RHA was collected from Paddy fields of Kulgam, J&K. It was then sun dried and burned so as to convert it into ash. The ash was sieved through 90 micron (90µm) Indian Standard sieve. The specific gravity of waste rice husk ash was found to be 2.6. Chemical composition of RHA is presented in TABLE 1. Fig.1 shows RHA.

TABLE 1 – Chemical Composition of RHA

Oxides	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	SO_3	Al_2O_3+Fe_2O_3	Na_2O	K_2O
Percentage	92.99	0.43	0.18	1.03	0.35	0.1	0.61	3.56	0.72

III. Experimental Investigation

3.1. Mix Proportion

The concrete mix design was proposed by using IS 10262. The grade of concrete used was M-25 with water to cement ratio of 0.45. The mixture proportions used in laboratory for experimentation are shown in TABLE 2.

3.2. Test on Fresh Concrete

The workability of all concrete mixtures was determined through slump test utilizing a metallic slump mould. The difference in level between the height of mould and that of highest point of the subsided concrete was measured and reported as slump. The slump tests were performed according to IS 1199-1959.

3.3. Tests on hardened concrete

From each concrete mixture, cubes of size 150mm x 150mm x 150mm have been casted for the determination of compressive strength. The concrete specimens were cured under normal conditions as per IS 516-1959 and were tested at 7 days and 28days for determining compressive strength as per IS 516-1959 .

3.4. Water absorption test

The average dry weight of cube specimens after removing from moulds was measured and the average weight of cube specimens after submerging in water for curing was measured at 28 days of age. The percentage of water absorption was measured for each concrete specimen and it gave indirect measure of durability.

3.5. Light weight character

The average dry weight of concrete cube specimens containing 5%, 10% and 15% waste RHA in place of cement was compared with average dry weight of normal M-25 concrete cube specimens and the percentage decrease in dry weight was measured.

IV. Results And Discussion

4.1. Fresh concrete

The slump values of all the mixtures are represented in TABLE 2. The slump decreases with the increase in waste RHA content. The reason is that rice husk ash is highly porous and hydraulic in nature. It absorbs water for reaction and some amount is trapped in pores also. The variation of slump with waste RHA content is depicted in Fig. 2.

4.2. Hardened concrete

The compressive strength tests are presented in TABLE 3. Compressive strength tests were carried out at 7 and 28 days. An increase in compressive strength was observed up to 10% replacement of cement by waste RHA and thereafter decreasing. The maximum compressive strength measured was 3.25% more than that of reference mix at 28 days corresponding to concrete mix containing 10% waste rice husk ash in place of cement. Compressive strength for concrete mix with 15% waste RHA content was found to be less than that of reference mix. Figure 3 and 4 present compressive strength of all mixtures at 7 and 28 days respectively.

4.3. Water absorption

Water absorption test was carried out for all mixtures and percentage water absorption was measured. The percentage water absorption increased with increase in waste rice husk ash content. The highest value of water absorption was found for concrete mix with 15% waste RHA content. TABLE 4 depicts the percentage water absorption for all mixtures and Figure-5 represents percentage water absorption for all mixtures.

4.4. Light weight character

Average dry weight of cube specimens of each mixture as compared to reference mix was studied and it was observed that density decreased with increase in waste rice husk ash content. The results showed 3.34% reduction in dry weight of concrete cube specimens for concrete mix with 15% waste RHA content as compared to reference mix. Thus, waste RHA concrete is light weight in nature. TABLE 5 depicts the value of dry density and percentage change in dry weight with respect to reference mix and Figure-6 represents dry density of cubes for all mixtures.

Fig.1 – Rice husk ash

Table-2 Mix Proportion

Rice Husk Ash %	w/c ratio	Water (Kg/m^3)	Cement (Kg/m^3)	Fine Aggregate (Kg/m^3)	Rice Husk Ash (Kg/m^3)	Coarse Aggregate (Kg/m^3)	Slump (mm)
0	0.45	191.6	425.80	543.5	0.00	1199.36	60
5	0.45	191.6	404.51	543.5	21.29	1199.36	20
10	0.45	191.6	383.22	543.5	42.58	1199.36	15
15	0.45	191.6	361.93	543.5	63.87	1199.36	10

Table-3 Compressive strength test results

Waste RHA %	Avg. load @ 7days (KN)	Avg. Load @ 28 days(KN)	Avg. Compressive Strength @7 days(N/mm^2)	Avg. Compressive Strength @28 days(N/mm^2)
0%	498	678	22.13	30.13
5%	530	690	23.55	30.67
10%	580	700	**25.78**	**31.11**
15%	490	670	21.78	29.78

TABLE 4 – Water absorption test results for cube specimens of size 150mm x 150mm x 150mm

Waste RHA %	Avg. Dry weight of cube (gm)	Avg. Wet weight of cube (gm)	Water absorbed (gm)	Percentage water absorption
0%	8390	8480	90	1.07%
5%	8350	8450	100	1.197%
10%	8225	8340	115	1.398%
15%	8110	8240	130	1.603%

Table 5 – Light weight test results for cube specimens of size 150mm x 150mm x 150mm

Waste RHA %	Avg. Dry weight of cube (gm)	Avg. dry density of cube (KN/m^3)	Percentage change in weight as compared to reference (%)
0%	8390	24.86	0%
5%	8350	24.74	- 0.483%
10%	8225	24.37	- 1.971%
15%	8110	24.03	- 3.339%

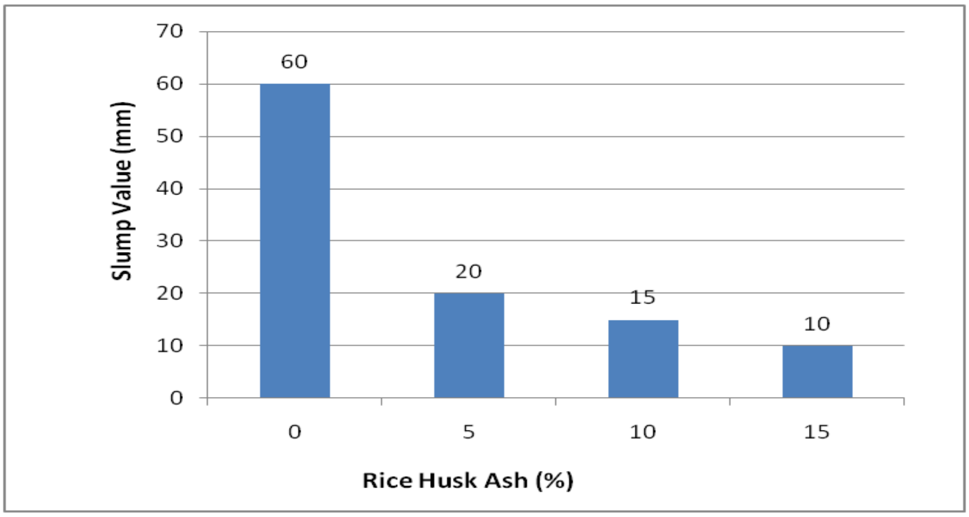

Fig.2 – Variation of slump with waste RHA content.

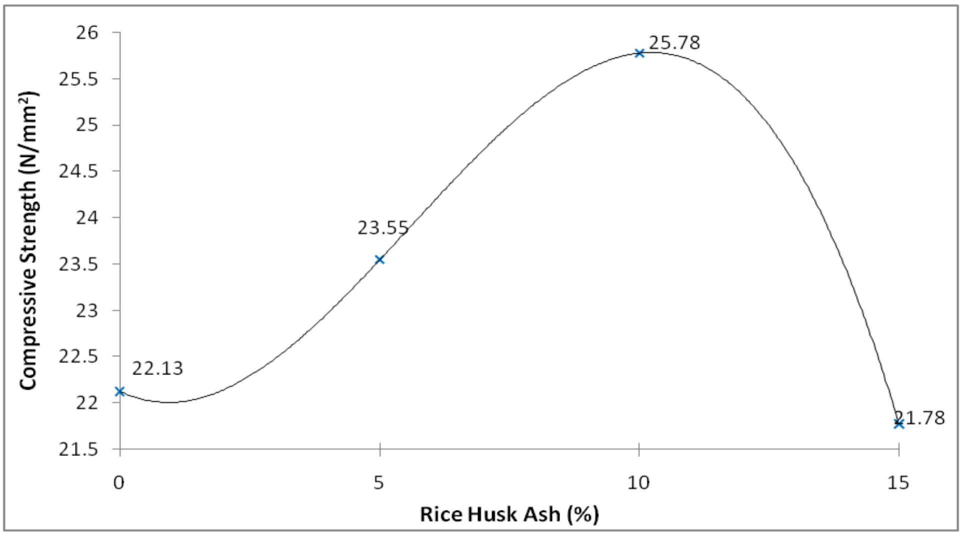

Fig.3 – Compressive Strength of Cubes at 7 Days

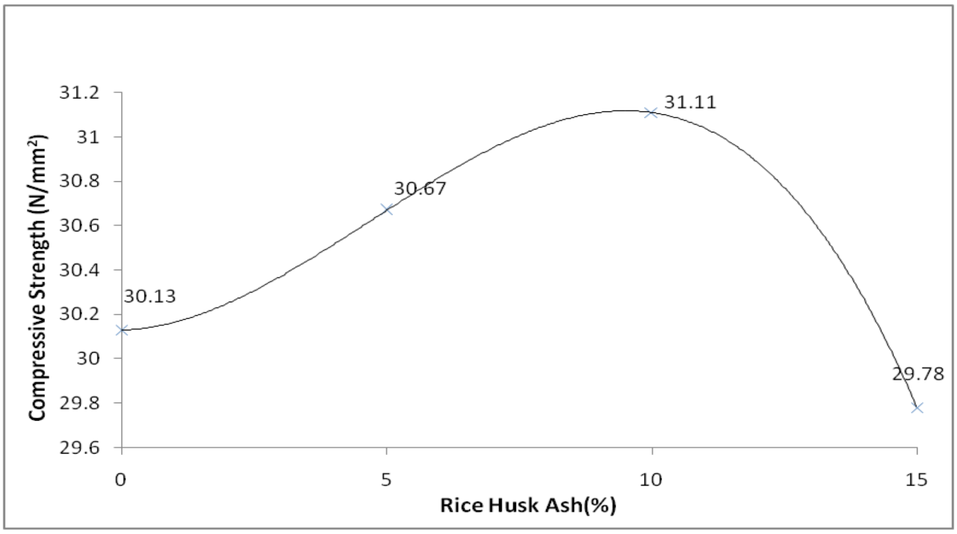

Fig.4 – Compressive Strength of Cubes at 28 Days

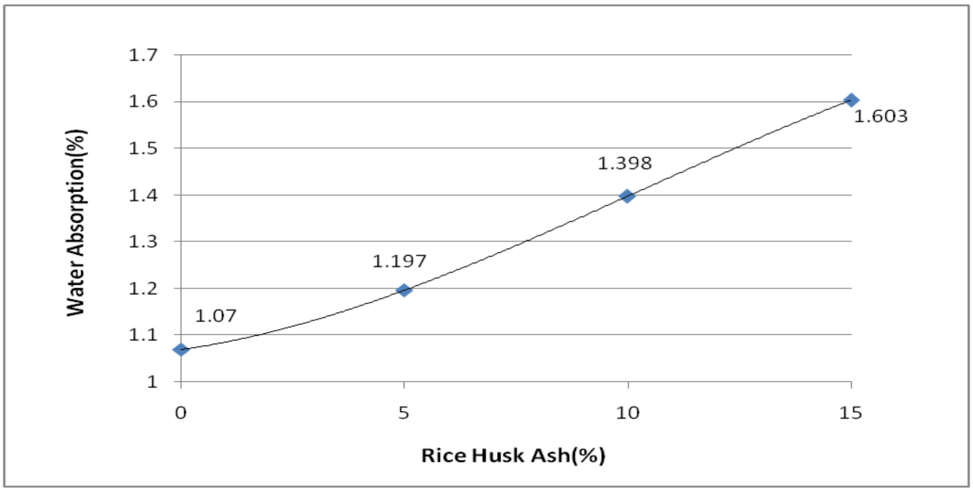

Fig.5 – Percentage water absorption

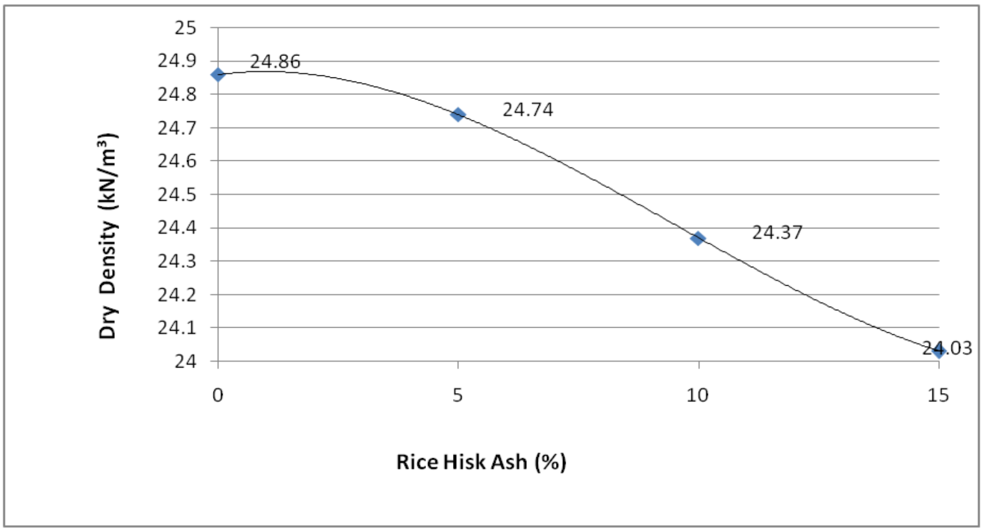

Fig.6 – Dry density of cubes

V. Conclusion

On the basis of results obtained, following conclusions can be drawn:

1. 10% replacement of cement by waste rice husk ash showed 16% increase in compressive strength at 7 days and 3.25% increase in compressive strength at 28 days.
2. The optimum value for cement replacement is 10% as obtained from graph-2.
3. With increase in waste rice husk ash content, percentage water absorption increases.
4. With increase in waste rice husk ash content, average weight decreases by 3.34% for mixture with 15% waste rice husk ash content thus making waste rice husk ash concrete light weight.
5. Workability of concrete mix decreases with increase in waste rice husk ash content.
6. Use of waste rice husk ash in concrete can prove to be economical as it is free of cost.
7. Use of waste rice husk ash will eradicate its disposal problem and reduce carbon emissions (CO_2) thus proves to be environment friendly thus paving way for greener concrete.

In order to be sustainable for future generations we must fully exploit by-product materials like waste rice husk ash. This will reduce the greenhouse gas emissions. It is our duty to take sensible engineering judgments based on facts about byproducts and not on the prejudice of assuming a 'WASTE' is somehow inferior or less suitable.

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