6th International Symposium on Advances in Science and Technology
SASTech
Malaysia | Kuala Lumpur
24 - 25 March, 2012
Scope of the Symposium
Organised by:
Khavaran Institute of Higher Education
Hosted by:
Geospatial Association of South East Asia

PERFORMANCE OF RICE HUSK ASH CONCRETE Exposed To Sea Water

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1. ABSTRACT

As concrete is produced and placed at construction sites, under conditions far from ideal, we do often end up with construction problems and a host of workmanship related problems. Rice Husk Ash Concrete has evolved as an innovative technology, capable of achieving the status of being an outstanding advancement in the sphere of concrete technology. The utilization of Rice Husk Ash (RHA) will reduce the dumping of rice husk as well as reduce the construction cost. In reality many of the concrete structures exposed to severe environmental conditions such as exposure to sea water in case of marine structures and severe aggressive conditions in case of fertilizer industry, the durability of concrete structure is important. In consideration of this aspect this study is aimed to test the RHA concrete exposed to sea water. The studies on Rice Husk Ash concretes exposed to marine atmosphere for various ages showed that RHA replacement range of 5% to 7.5 % showed better compressive strength and 12.5% replacement showed less water absorption than other replacements at all ages and for all three grades of concretes.

2. INTRODUCTION

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, producing energy through direct combustion and/or by gasification. Rice milling generates husk as a by-product. 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 contains about 75 % organic volatile matter and the balance 25 % of the weight of this husk is converted into ash during the firing process, which is known as rice husk ash (RHA). Rice husk is usually burnt approximately 48 hours under uncontrolled combustion process. The burning temperature is within the range of 600 to 850 degrees C. The ash obtained is ground in a ball mill for 30 minutes and its appearance in color is grey. This RHA in turn contains around 85% - 90% amorphous silica. So for every 1000 kgs of paddy milled , about 220 kgs (22 %) of husk is produced, and when this husk is burnt in the boilers , about 55 kgs (25 %) of RHA is generated [15][16].

About 20 million tones of RHA is produced annually in India. This RHA is a great threat to environment causing damage to the land and the surrounding area in which it is dumped. In the present investigation, cement is replaced by rice husk ash at different percentages ranging from 0 % to 20 % to study its effect on compressive strength and water absorption. In this paper only 0-12.5% replacement results are considered. The investigation is also aimed at the study of the impact on compressive strength of these mixes when exposed to sea water [1][2].

3. IMPORTANCE OF STUDY

The objective of the study is to utilize the agricultural waste of rice husk produced in the world to the tune of 132 million tones in a meaningful and useful way. Each cubic metre of normal and high performance concrete usually requires about 250 kg and 400-500 kg of cement respectively. World cement production peaked in 2010 to 3 billion tonnes per year, a 7% increase from 2009 production. Total energy consumption in cement manufacturing is about 5 TJs per 1000 ton as of 2001. In addition, each ton of cement also releases about 1 ton of carbon dioxide to the atmosphere. Some recent solutions developed to reduce cement consumption in concrete is partial cement replacement with substitutes. Substantial energy and cost savings can result when industrial by-products are used as a partial replacement for the energy intense Portland cement. The use of by-products is an environmentally friendly method of disposal of large quantities of materials that would otherwise pollute land, water and air [9]. RHA is one such substitute which reduces the consumption of cement, thereby saving raw material base, power and environment [5,6,7,8]. The focus of the present study is to investigate the usefulness of rice husk ash concrete exposed to sea water which is of interest to many researchers and engineers [3][4][5].

4. EXPERIMENTAL PROGRAMME

2.1 Materials Used

2.1.1 Cement:

Cement used in the experimental work is PORTLAND POZZOLONA CEMENT conforming to IS: 1489 (Part1)-1991[10] . The physical properties of the cement are obtained by conducting the tests specified as per IS: 269/4831[12] and cement conforms to the requirements as per IS 1489-1991[10].

2.1.2 Rice Husk Ash:

Rice Husk Ash used in the present experimental study was obtained from *Orissa, INDIA.* General specifications, Physical Properties and Chemical Composition of this RHA used in this study which are furnished by the supplier are given in Table-1, Table-2 and Table-3 [9].

Table 1 : Specifications of Rice Husk Ash

Silica	90% minimum
Humidity	2% maximum
Mean Particle Size	25 microns
Color	Grey
Loss on Ignition at 800^{0}C	4% maximum

Table 2: Physical Properties of Rice Husk

Physical State	Solid – Non Hazardous
Appearance	Very fine powder
Particle Size	25 microns – mean
Color	Grey
Odour	Odourless
Specific Gravity	2.3

Table 3: Chemical Properties of Rice Husk Ash

SiO_2	93.80%
Al_2O_3	0.74%
Fe_2O_3	0.30%
TiO_2	0.10%
CaO	0.89%
MgO	0.32%
Na_2O	0.28%
K_2O	0.12%
Loi	3.37%

2.1.3 Fine Aggregate:

Fine aggregate (sand) used in this experimental work conforms to zone III as per the specifications of IS 383: 1970 [11].

2.1.4 Coarse Aggregate:

Crushed granite of 20 mm maximum size has been used as coarse aggregate. The sieve analysis of combined aggregates conforms to the specifications of IS 383: 1970 [11] for graded aggregates. The specific gravity of coarse aggregate is 2.70.

2.1.5 Water:

In this project potable water free from organic substance was used for mixing as well as curing of concrete.

2.1.6 Super Plasticizers:

Conplast SP430A2 which complies with IS: 9103 [13] Type 'G' as a high range water reducing admixture for obtaining a workable mix was used.

2.2 Mix Design for M20-Grade Concrete:

The mix proportions arrived for M 20 grade concrete designed as per IS 10262 – 2007[14] are presented in Table 4. Cement in proportions of 0%, 5%, 7.5%,10%, and 12.5% is replaced with RHA.

Table 4: Mix Proportion of M20 grade RHA Concretes for Different Replacements

S.No	RHA Replacement	Cement	Fine aggregate	Coarse aggregate	W/b Ratio	S.P. Dosage in ml/6 cubes
1	0%	1	1.55	3.54	0.5	-
2	5 %	0.95	1.55	3.54	0.5	10
3	7.5 %	0.925	1.55	3.54	0.5	12
4	10 %	0.9	1.55	3.54	0.5	14
5	12.5 %	0.875	1.55	3.54	0.5	16

5. PREPARATION AND TESTING OF CONCRETE SPECIMENS

All ingredients were placed in the mixer except water and mixed in the dry condition. Initially 80% of water is added and mixed for 75 seconds. The remaining

Quantity of water is then added to the concrete mix replaced with RHA in different percentages by weight of cement and mixed for 45 seconds. Super plasticizer dosages as mentioned in Table no. 4 have been added to maintain the workability of 75 mm for all the mixes mentioned above in Table no. 4. Specimens were cast in 100x100x100mm cube moulds and SP in proportionate dosages was added for all mixes to maintain a workability of 75mm for all mixes. The specimens were compacted using table vibrator. For all specimens a constant compaction time of 50 seconds was adopted. All Samples were water cured for 28 days before carrying out all investigations. A total of 150 samples were cast and tested in the laboratory to study the sea water effect and rate of water absorption of Rice Husk Ash Concretes. The parameters investigated are compressive strength and rate of water absorption.

TESTING OF SPECIMENS FOR COMPRESSIVE STRENGTH

Test specimens of size 100 mm x 100 mm x 100 mm were exposed to sea water. The specimens are placed in the compression testing machine in such way that the centre of steel plate of the compression testing machine passes through the centre of the specimen. The load was applied gradually at a rate of 5KN/minute until the specimen showed the first crack. The maximum load applied to the specimen was recorded from the compressive strength testing machine. The compressive strength is then calculated by dividing the maximum load carried by the specimen by the actual cross sectional area. The real dimensions of the specimen were taken into account while calculating the cross sectional area.

For each variation, average of three specimens was taken for the compressive strength provided the individual variation was not more than 15% on the average. The compressive strengths for different replacements of - M20 grade concrete is shown in table 5 and Figure 1.

Table 5: Compressive strengths for different replacements of M20 grade concrete in MPa

Replacement → Age ↓	0%	5%	7.50%	10%	12.50%
28	30	31.6	32.33	32	31.5
56	30	31.33	32.02	30	29.8
90	31	31	31.6	29.1	28.2

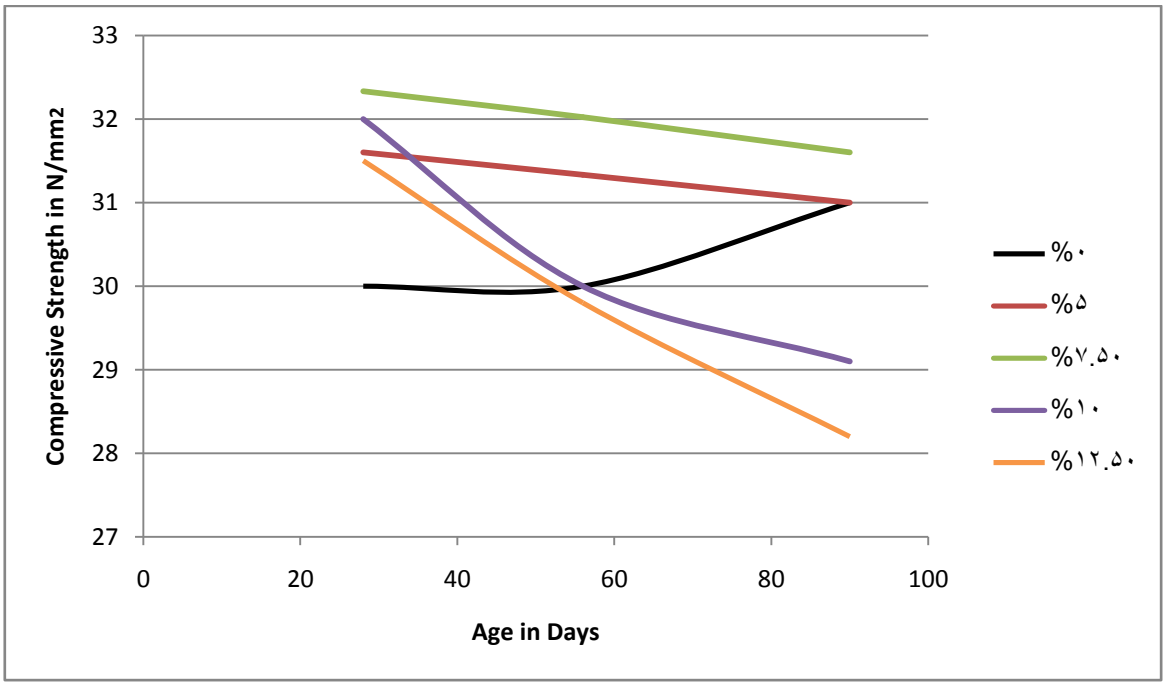

Fig 1. Variation of compressive strength with different replacements for sea water exposure

WATER ABSORPTION TEST

This is a simple test to determine the rate of water absorption of concrete. RHA concrete samples with the replacements of 0%, 5%, 7.5%**,** 10% and 12.5% were cast three each and water cured for 28 days. The cubes were air dried and kept in the oven for one day till the moisture evaporates.

The heated samples were soaked in water for 5 minutes, 10 minutes , 30 minutes, 1 hour, 2 hours so on till the specimens got saturated and each of the specimens' weights were taken. Tests were carried out for M20 grade of RHA concretes and the results and discussions are presented in Table 6.

Table 6:- WATER ABSORPTION TEST FOR M20 GRADE RHA CONCRETE

S. No	Normal weight (kgs)	5 Min	10 Min	30 Min	1 hr	2 hr	3 hr	4 hr	5 hr	6 hr	7 hr	8 hr	9 hr
0%	2.534	2.567	2.577	2.594	2.604	2.614	2.617	2.619	2.620	2.621	2.623	2.625	2.625
5%	2.427	2.461	2.470	2.484	2.493	2.502	2.505	2.506	2.507	2.507	2.507	2.507	2.507
7.5%	2.492	2.521	2.529	2.539	2.548	2.557	2.562	2.564	2.565	2.565	2.565	2.565	2.565
10%	2.425	2.455	2.465	2.472	2.482	2.491	2.494	2.496	2.498	2.498	2.498	2.498	2.498
12.5 %	2.407	2.444	2.452	2.464	2.472	2.480	2.482	2.484	2.485	2.485	2.485	2.485	2.485

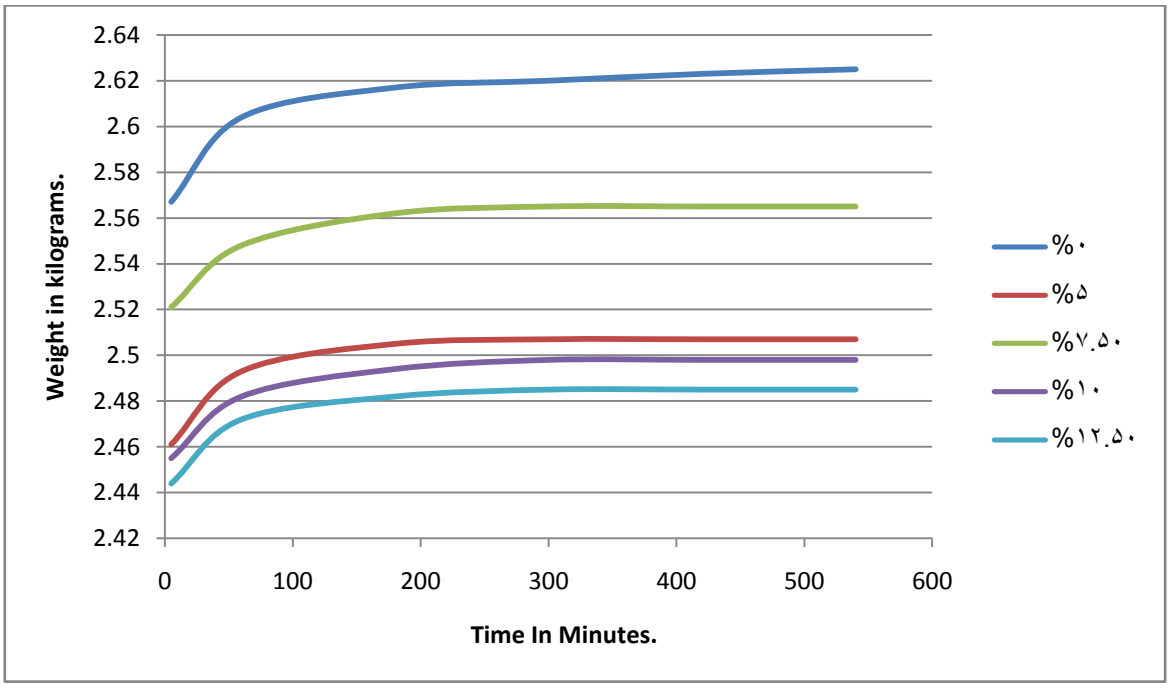

Fig 2. Variation of rate of water absorption for different RHA Concretes.

6. RESULTS AND DISCUSSIONS

The results of the experiments and tests conducted are presented in this paper. The data obtained from the laboratory tests were analyzed, computed and discussed to understand the behaviour of RHA concrete exposure to seawater.

Concrete cubes of size 100x 100x100mm were cast and were tested for compressive strength and the results were presented in Tables 5 for 0%, 5%, 7.5%, 10 % and 12.5% of RHA replacement of cement for M20 grade of concrete at room temperature, after 28 days of water curing.

From the results of the present study, the above mentioned replacement range of 5% to 12.5% was selected for this study of durability aspects. Sea water from the nearby source of Bay of Bengal was collected, analyzed and used for this study. Sea water has been changed from time to time to maintain its p^H constantly at 7.0 and uniform throughout the study. From fig. 2 it can be observed that the rate of water abortion of RHA Concretes appears to be lower than that of normal concrete for all percentages of rice husk ash replacement. This indicates that the RHA Concretes have lesser porosity

compared to normal concrete. However 7.5% RHA Concrete appears to have higher water absorption compared to other percentages of RHA. Apart from 7.5% the water absorption of other concretes reduced with increase of percentage of RHA replacement indicating that the porosity reduces when the percentage of RHA is increased. It is not clear why the 7.5% replacement of RHA is behaving differently.

Considering the results of strength and water observation it may be observed that a new chemistry and specific reaction might have taken place in 7.5% RHA Concrete as it has shown similar performance of normal concrete to the strength and water absorption [9].

7. CONCLUSIONS

The following conclusions can be drawn from the research:

1. Comparative study on Rice Husk Ash concrete with various replacement percentages of RHA showed that, a replacement level of 7.5% RHA in concrete performs and shows better compressive strength than other replacements. Hence, 7.5 % RHA replacement may be recommended as the optimum replacement level.
2. The studies on Rice Husk Ash concretes exposed to marine atmosphere for various ages showed that an RHA replacement range of 5% to 7.5 % showed better compressive strengths than other replacements at all ages and for all three grades of concretes.
3. It can be concluded that for M20 grade RHA concrete subjected to seawater exposure for 28 days and 56 days the 7.5% replacement showed better compressive strengths. Also seawater exposure to 90 days it shows better compressive strength than normal concrete though not as good as other replacements.
4. The studies on the rate of water absorption capacity of Rice Husk Ash concretes, it was concluded that RHA concrete was hydrophilic in nature and absorbs water at a slower rate than normal concrete, indicating its impervious nature.

5. It appears that the 7.5% RHA Concrete performs almost similar to normal concrete in case of strength and water absorption parameters
6. Hence RHA Concrete with a 7.5 replacement of cement may be used in place of normal concrete due to its suitable performance for construction needs.
7. More research in this area is needed so that higher level of replacement can be achieved without compromising the strength and other properties.

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