Compressive Strength and Durability Properties of Rice Husk Ash Concrete

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Abstract- *Concrete making materials come from the earth's crust. Thus, it depletes the natural resources every year creating ecological strains. On the other hand, human activities on earth produce solid wastes such as industrial wastes, agricultural wastes and wastes from rural and urban societies in considerable quantities of over 2500 million tons per year. Among the solid wastes, the most prominent materials are fly ash, blast furnace slag, rice husk (converted into ash), silica fume and materials from construction demolition. The utilization of RHA as a pozzolanic material in cement and concrete provides several advantages, such as improved strength and durability properties, reduced materials cost due to cement savings, and environmental benefits related to the disposal of waste materials. In the present investigation, Portland cement will be replaced by Rice Husk Ash at various percentages and its effect on the compressive Strength and its Durability properties like water absorption and rapid chloride permeability test is studied. Till date it is studied that there is reduction in compressive strength at earlier ages with the increasing RHA content in M30 grade of concrete The addition of superplasticizer shows a higher compressive strength than the control concrete at the RHA content. The porosity of RHA Concrete decreased from 10% to 18% when the replacement level increased from 5% to 20%. The saturated water absorption was decreased when the mixture containing 10% RHA by 16.60% for M30 grade concrete.*

Keywords- Rice Husk Ash Concrete, Experimental investigation, Compressive strength, Water Absorption Test, Rapid Chloride Permeability Test (RCPT).

I. INTRODUCTION

Rice milling generates a byproduct know as husk. This surrounds the paddy grain. 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, is known as rice husk ash (RHA). 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. Pozzolanas are materials containing reactive silica and/or alumina which on their own have little or no binding property but, when mixed with lime in the presence of water, will set and harden like cement. Pozzolanas are an important ingredient in the production of alternative cementing materials to Portland cement (OPC).

Alternative cements provide an excellent technical option to OPC at a much lower cost and have the potential to make a significant contribution towards the provision of low-cost building materials and consequently affordable shelter. Pozzolanas can be used in combination with lime and/or OPC. When mixed with lime, pozzolana will greatly improve the properties of lime-based mortars, concretes and renders for use in a wide range of building applications. Alternatively, they can be blended with OPC to improve the durability of concrete and its workability, and considerably reduce its cost.

II. EXPERIMENTAL PROGRAM

3.1 Cement- The cement used was Birla Cement Ordinary Portland cement (53 grade cement) .The cement was procured from local markets and in one lot to maintain uniformity throughout the investigation. The different properties of cement are: specific gravity-3.15, normal consistency-27.5%, fineness-3%, initial setting time-40minutes, and final setting time- 470 minutes.

3.2 Fine Aggregates- The available sand confirming to IS 383:1970 is used as fine aggregate in the present investigation. The specific gravity was 2.86 in accordance with IS 2386-1963.

3.3 Coarse Aggregate -The coarse aggregate used is locally available. The maximum nominal size of aggregate is 20 mm. Aggregate are the major ingredient of concrete. They contribute about 70-75 % of the total volume, provide a rigid skeleton structure for concrete & act as economical space fillers .The specific gravity was 2.80

3.4 Water:-Ordinary tap water was used for mixing and curing operations.

3.5 Rice Husk Ash –Rice Husk Ash was obtained from Hi-Tech agro industries, Pune in Maharashtra State, India. The physical and chemical properties of rice husk ash is as follows.

Table 1- Physical and Chemical Properties of Rice Husk Ash

Sr. No	Parameters	Values
1	Fineness passing 45 micron	96%
2	Specific gravity	2.06
3	Specific surface (nitrogen absorption) m^2/kg	27400
4	Silicon dioxide (SiO_2)	87.20%
5	Aluminium oxide (Al_2O_3)	0.15%
6	Ferric oxide (Fe_2O_3)	0.16%
7	Calcium oxide (CaO)	0.55%
8	Magnesium oxide (MgO)	0.35%
9	Sulphur trioxide (SO_3)	0.24%
10	Carbon (C)	5.91%
11	Loss on ignition	5.44%
12	Pozzolanic activity	84%
13	Particle size (µm)	7

III. MIX PROPORTION

The mixture proportions for the controlled concrete of M30 and M60 grades were arrived at from the trial mixes. M30 grade was selected based on the consideration as medium strength concrete and it is used normally in the design of columns. M60 grade was selected based on the consideration of high strength concrete, which is generally used for prestressed concrete work. The identification mix proportions and quantity of materials of concrete mixture are given in Tables 2. Table 2 also contains the measured slump both with and without SP and its dosage for different percentage of cement replacement.

Table 2. Mix Proportion for M30 Grade Concrete Mixtures

Mix Designation	BC	BR1	BR2	BR3	BR4
Rice husk ash as CRM (%)	0	5	10	15	20
w/b ratio	0.43	0.43	0.43	0.43	0.43
Cement (kg/m^3)	420	399	378	357	336
Rice husk ash (kg/m^3)	0	21	42	63	84
Sand (kg/m^3)	621	582	542	503	464
Coarse aggregate (kg/m^3)	1108	1108.	1108	1108	1108
Water (lit/m^3)	180.60	180.60	180.60	180.60	180.60
SP (%)	0.4	0.4	0.8	1.4	2.8

Note: BC - Control Concrete BR1 - 5% Rice husk ash BR2 - 10 % Rice husk ash BR3-15% CRM - Cement Replacement Material SP-Superplasticizer

IV. TEST CONDUCTED

A. Compressive Strength-

The cube specimen was placed in the machine of 2000kN capacity. The load was applied at a rate of approximately 140 kg/sq.cm/min until the resistance of the specimen to the increasing load can be sustained. Results are presented in Tables 3

Table 3. Effect of Rice Husk Ash on Compressive Strength of M30 Grade Concrete for 28 days.

Sr.no	w/c ratio	Mix ID	RHA Content (%)	Compressive Strength (N/mm^2)
1	0.43	AC	0	30.77
2	0.43	AR1	5	33.78
3	0.43	AR2	10	39.08
4	0.43	AR3	15	25.20
5	0.43	AR4	20	20.79

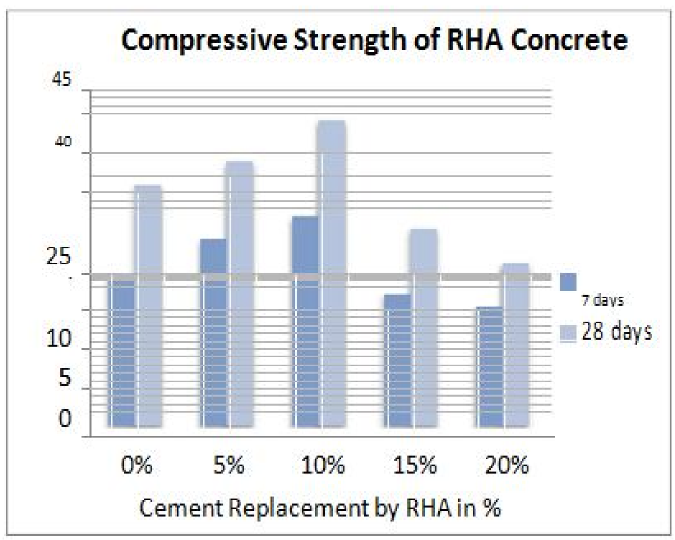

Fig.1 Comparison of Compressive strength with different % of RHA

B. Water Absorption Test-

Saturated Water Absorption (SWA) is a measure of the pore volume or porosity in hardened concrete, which is occupied by water in saturated condition. The test results of saturated water absorption of concrete for various percentages of rice husk ash are shown in Table 6.2.The addition of super plasticizer showed lesser SWA values up to 10% rice husk ash content.

Table 4. Saturated Water Absorption of M30 Grade Concrete

Sr.no	Mix ID	RHA Content (%)	Saturated Water Absorption @ 28 days
1	BC	0	1.40
2	BR1	5	1.34
3	BR2	10	1.20
4	BR3	15	1.56
5	BR4	20	1.98

C. Rapid Chloride Permeability Test-

RCPT is based on the principle that negatively charged chloride ions are attracted to a positive electrode and consists of measuring the total charge passed through a sample over the six hours test duration when a direct current potential difference of 60V is applied across the end of the samples. The quality of material is quantitatively assessed based on the total charge passed during the test, which is considered to be the measure of the chloride permeability of concrete. Test results for the resistance to penetration of chloride ions into concrete of 28 days after casting, measured in terms of the electric charges passed through the specimens in Coulombs for M30 grade concrete.

From the results using current and time, chloride permeability is calculated in terms of total charge passed in Coulombs at the end of 6 hours by using the formula given in Eq.

$Q = 900 \times 2 \times (Io+I30+I60+\cdots\cdots\cdots+I330+I360)$

Where, Q: Charge passed (Coulombs)

Io: Initial current

I30: Current at the 30 minutes

Table 5. RCPT Ratings

Charge Passed (coulombs)	Chloride Ion Penetrability
>4,000	High
2,000-4,000	Moderate
1,000-2,000	Low
100-1,000	Very Low
<100	Negligible

Table 6. Result for Rapid Chloride Permeability Test

Sr.no	Mix ID	RHA Content (%)	Total Charge Passed Coulombs @ 28 days
1	CC	0	2134
2	CR1	5	1952
3	CR2	10	1802
4	CR3	15	1644
5	CR4	20	1518

V. CONCLUSION

Being on organic and fibrous material rice husk ash absorbs more water and hence necessity as addition of SP to improve the workability properties of RHA concrete. The increase in compressive strength for 5% and 10% of cement replacement by RHA are 10% and 27% at 28 days, respectively, for M30 grade concrete. The saturated water absorption was decreased when the mixture containing 10% RHA by 16.60% for M30 grade concrete. The reduction in porosity was 18% for M30 grade concretes respectively at the RHA content 10% when compared to control concrete. The presence of RHA in the concrete mixtures caused considerable reduction in the volume of the large pores at all ages and thereby reducing the chloride ion penetration.

VI. FUTURE SCOPE

1) Other levels of replacement with Rice husk ash can be researched.

2) The study may further be extended to know the behavior of concrete whether it is suitable for pumping purpose or not as present day technology is involved in RMC where pumping of concrete is being done to large heights.

3) For use of Rice husk ash concrete as a structural material, it is necessary to investigate the behavior of reinforced Rice husk ash concrete under flexure, shear, torsion and compression.

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REFERENCES

[1] Carlos A. R. da Silva, Jorge L. Akasaki, Michele Beniti Barbosa, “Possibility of adding the rice husk ash to the concrete”, Civil Engineering Department, FEIS/UNESP, Brazil, February 2011, pp 550-559

[2] Ghassan Abood Habeeb & Hilmi Bin Mahmud, “Study on properties of rice husk ash and its use as cement replacement material”, Department of Engineering and Material Research, University of Malaya, Kuala Lumpur, Malaysia, March 21, 2010, pp 185-190

[3] Godwin A. Akeke, Maurice E. Ephraim, Akobo, I.Z.S and Joseph O. Ukpata,”Structural properties of rice husk ash concrete”, Department of Civil Engineering, Cross River University of Technology, Calabar, Nigeria. International Journal of Engineering and Applied Sciences, Vol.3, May 2013, pp 203-209

[4] Mauro M. Tashima S.D.Nagrale, Dr.Hemant Hajare, Pankaj R. Modak,”Utilisation of rice husk ash”, International Journal of Engineering Research and Applications, Vol. 2, August 2012, pp.001-005

[5] Mehta, P. K. (1977). “Properties of blended cements made from rice husk ash.” Journal Of American Concrete Institute, Vol. 74, No. 9, pp. 440-442.

[6] Saraswathy, V. and Song, H.-W. (2007). “Corrosion performance of rice husk ash blended concrete.” Construction and Building Materials, Vol. 21, No. 8 pp. 1779-1784

[7] Satish D. Kene, Pravin V. Domke, Sandesh D. Deshmukh, R.S.Deotale,”Assesment of strength of concrete by using rice husk ash”, International Journal of Engineering Research and Applications (IJERA), Vol. 1, March 2011, pp 524-534

[8] Seshagiri Rao, M. V. and Prasada Rao, A. (1995). “Durability of rice husk ash cement concrete.” Proceedings of the National Conference on Civil Engineering Material sand Structures, India, pp. 71-75.

[9] Shetty M. S.,”Concrete Technology”, S. Chand & Co. Ltd., New Delhi, 4th edition, pp 218-322

[10] Zhang, M. H. and Malhotra, V. M. (1996). “High – Performance concrete incorporating rice husk ash as a supplementary cementing material.” Materials Journal, ACI, Vol. 93, No. 6, pp. 629-636