International Journal of Engineering & Technology, 7 (3.31) (2018) 6-9

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Rice Husk Ash as an Admixture of M_{30} grade Concrete Exposed to Sulfate Environment

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Abstract

In the present critique, Rice Husk Ash (RHA) partly replaced with cement in the quotient of 0%, 5%, 10%, 15%, and 20% to fruitage M30 grade Concrete. Concrete cubes divulged to Magnesium Sulfate and Sodium sulfate concentrations of 1%, 3% and 5% for the perpetuation of 28, 60and 90 days. The Experimental data demonstrate that RHA improved the counteraction to sulfate attack on concrete and can be used as an Admixture, 10% as most favorable replacement quotient of RHA in cement.

Keywords: *Admixture; Concrete; Magnesium Sulfate; Rice Husk Ash (RHA); Sodium Sulfate.*

1. Introduction

Agricultural, industrial by- products utilization in the concrete production was center of attention to canvassers all- around the world. In present scenario more than ten billion tons of concrete had been utilized by construction industry [1].The growth in population causes an increase in demand for energy, house, food, clothing, and concrete. Year 2050 use of concrete expected to increase up to 18 billion tons [2].Each ton of cement manufactured produces 0.7–1.1 tons Carbon Dioxide [3]. Use of pozzolanic materials reduces carbon (CO_2) emissions [4-5]. Natural Pozzolans as an admixture in concrete exhibits improvement of strength and durability characteristics of the concrete. [6-15]Copyright of utilization of RHA was made in 1924 [17]. Incineration of rice husk under restricted temperature– time circumstances gives ash which contains silica [18].

Sulfate attack against concrete structures was one of problem. The sulfates are present natural state in from the soil, groundwater, and seawater. [19–23].Sulfate ions weakens C–S–H coagulate through discharge of the calcium compounds. This course of action leads to failure of C–S–H gel stiffness and in general corrosion of the cement paste medium [24]. The attack by sulfate ions on concrete was a convoluted course and depends on a lot of parameters [25]. Use of natural pozzolanic material as a replacement of ordinary cement partially in concrete has been found to improve the confrontation of concrete to sulfate attack [26-28]. To investigate the most favorable level of replacement of RHA in M30 grade concrete and their function in the sulfate environment are the main objectives of present study.

2. Experimental

2.1. Materials

The Binding materials that used in the study, includes Portland cement and Rice Husk Ash, manufactured in India their chemical compositions and properties presented in **Table 1**. OPC 53 Grade used according to IS 12269. Rice Husk Ash obtained from Rice processing Mill. Crushed stone with a density of 2.71x10^3 kg/ m^3, a maximum particle size of 20 mm, and a fineness modulus of 7.17 used as the coarse aggregate. Fine aggregate used was river sand with a density of 2.62x10^3 kg/m^3 and a fineness modulus of 2.74. In all mixtures, Volume percentages of fine and coarse aggregate kept the same.

Table 1: Chemical compositions (%) and properties of Binding materials

Compound (%)	Cement	Rice Husk Ash
Sio_2	22.10	93.80
Al_2O_3	5.24	0.74
Fe_2O_3	4.80	0.30
MgO	4.50	0.32
Cao	57.96	0.89
Na_2O	0.20	0.28
K_2O	1.20	0.12
SO_3	3.00	0.80
Loss of Ignition	0.90	3.37
Mean Particle Size	--	6μm
Specific Surface	320(m^2/kg)	340(m^2/kg)
Specific gravity	3.10	2.20

2.2. Mix Proportions

The concrete mix design supervised according to IS 10262.Five set of samples, a control mix without Rice Husk ash and four mixtures consist of 5, 10, 15 and 20 % of Rice Husk Ash as a replacement for cement were studied. The water-cement quotient stayed consistent for all mixes. Concrete mix proportions tabulated in **Table 2**.

Table 2:.Mix Proportions Rice Husk Ash Blended Concretes

Mix	Cement (Kg/m^3)	RHA (%)	FA (Kg/m^3)	CA (Kg/m^3)	WATER (Kg/m^3)	W/C
M0	450	0	524	1229	188	0.42
M5	427.50	22.50	520	1225	188	0.42
M10	405	45.00	516	1221	188	0.42
M15	382.50	67.50	512	1217	188	0.42
M20	360	90.00	508	1213	188	0.42

2.3. Preparation, Curing and Testing of Specimens

A total of 360 cube Specimens prepared. The variable in the mixtures was the Rice Husk Ash in the ratios of 5%, 10%, 15%, and 20 % of the cement content added as partial replacement of cement. The mixtures were cast into the molds by vibration. The specimens remolded after one day. The test specimens cured in water and sulfate solutions of concentrations of 1% SO4-(10,000 mg/l) 3% SO4-(30,000 mg/l), and 5% SO4-(50,000 mg/l) The Solutions are prepared by mixing Sulfates (Magnesium sulfate and Sodium Sulfate) with Water The Concentrations of the sulfate solutions are checked Periodically and solutions are changed after every months according to the experimental design.
The cubes of 10 cm made for the compressive strength test. For all results, an average of results from three specimens maintained. The Compressive Strength of Hardened concrete was measured and tested according to IS Specification at the age of 28, 60 and 90 days, the specimens were taken out of the water and tested for strength.

3. Results and Discussion

The compressive strength of Rice Husk Ash replaced concrete in various percentages cured in water and different concentrations of 1%, 3% and 5% of $MgSO_4$ and Na_2SO_4, For 28, 60, 90days were obtained by testing the cube specimens in compression testing machine**.**

3.1. Concrete Specimens Cured in Water

The Rice Husk Ash replaced concrete cubes cast in the molds for determining the compressive strength. The tests conducted after 28, 60, 90 days of curing in water.

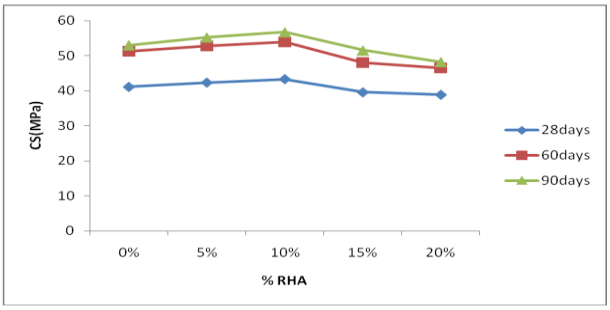

Fig. 1: RHA Concrete cured in Water

Figure 1 surmise that compressive strength of 0%, 5%, 10%, 15% and 20% RHA replaced concrete cubes cured in water. Compressive Strength Increase of 10.15MPa from 28days to 60days and 1.73MPa from 60days to 90days for 0% RHA replacement observed. Compressive strength increase of 10.41MPa from 28days to 60days and 2.48MPa from 60days to 90days for 5 % RHA replacement observed. Compressive strength increase of 10.59MPa from 28days to 60days and 2.80MPa from 60days to 90days for 10 % RHA replacement observed. Compressive strength increase of 8.55MPa from 28days to 60days and 3.38MPa from 60days to 90days for 15 % RHA replacement observed. Compressive strength increase of 7.69MPa from 28days to 60days and 1.60MPa from 60days to 90days for 20 % RHA replacement observed. From above observation there was an increase of compressive strength from 28days to 60days and from 60days to 90days. The maximum compressive Strength was 56.72MPa observed at 10% replacement for Exposure of 90days.

3.2. Concrete Specimens Cured in Magnesium Sulfate Solutions

The Rice Husk Ash replaced concrete cubes cast in the molds for determining the compressive strength. The tests conducted after 28, 60, 90 days of curing in 1% Concentrations of Magnesium Sulfate.

3.2.1 Specimens Cured in 1 % Magnesium Sulfate Solution

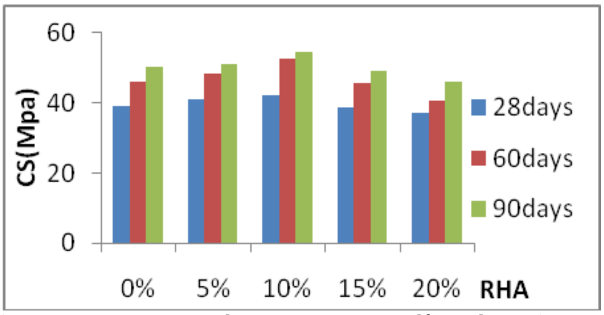

Fig. 2: RHA Concrete cured in 1% Magnesium sulfate solution ($MgSO_4$)

Figure 2 surmise that compressive strength of 0%,5%,10%,15% and 20% RHA replaced concrete cubes cured in 1% Magnesium Sulfate Concentration. Compressive Strength Increase of 6.98MPa from 28days to 60days and 4.21MPa from 60days to 90days for 0% RHA replacement observed. Compressive strength increase of 7.51MPa from 28days to 60days and 2.49MPa from 60days to 90days for 5 % RHA replacement observed. Compressive strength increase of 10.26MPa from 28days to 60days and 1.98MPa from 60days to 90days for 10 % RHA replacement observed. Compressive strength increase of 6.93MPa from 28days to 60days and 3.39MPa from 60days to 90days for 15 % RHA replacement observed. Compressive strength increase of 3.26MPa from 28days to 60days and 5.5MPa from 60days to 90days for 20 % RHA replacement observed. From above observation there was an increase of compressive strength from 28days to 60days and from 60days to 90days. The maximum compressive Strength was 54.55MPa observed at 10% replacement for Exposure of 90days.

3.2.2. Specimens Cured in 3 % Magnesium Sulfate Solution

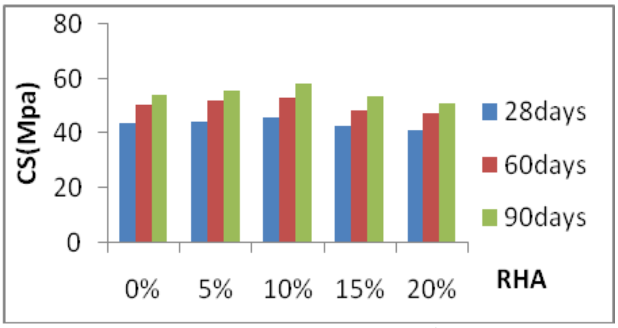

Fig. 3: RHA Concrete cured in 3% Magnesium Sulfate Solution ($MgSO_4$)

Figure 3 surmise that compressive strength of 0%,5%,10%,15% and 20% RHA replaced concrete cubes cured in 3% Magnesium Sulfate Concentration. Compressive Strength Increase of 6.70MPa from 28days to 60days and 3.87MPa from 60days to 90days for 0% RHA replacement observed. Compressive strength increase of 7.70MPa from 28days to 60days and 3.63MPa from 60days to 90days for 5 % RHA replacement observed. Compressive strength increase of 7.29MPa from 28days to 60days and 5.16MPa from 60days to 90days for 10 % RHA replacement observed. Compressive strength increase of 5.56MPa from 28days to 60days and 5.42MPa from 60days to 90days for 15 % RHA replacement observed. Compressive strength increase of 6.60MPa from 28days to 60days and 3.67MPa from 60days to 90days for 20 % RHA replacement observed. From above observation there was an increase of compressive strength from 28days to 60days and from 60days to 90days. The maximum compressive Strength was 58.26MPa observed at 10% replacement for Exposure of 90days.

3.2.3. Specimens Cured in 5 % Magnesium Sulfate Solution

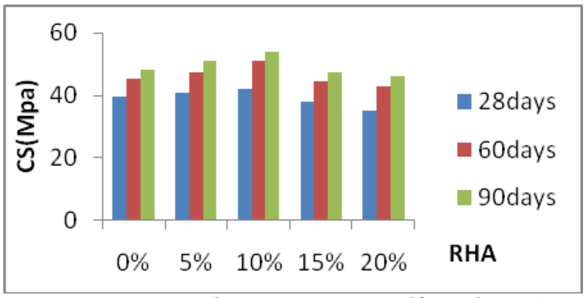

Fig. 4: RHA Concrete cured in 5% Magnesium Sulfate Solution ($MgSO_4$)

Figure 4 surmise that compressive strength of 0%,5%,10%,15% and 20% RHA replaced concrete cubes cured in 5% Magnesium Sulfate Concentration. Compressive Strength Increase of 5.55MPa from 28days to 60days and 3.14MPa from 60days to 90days for 0% RHA replacement observed. Compressive strength increase of 6.63MPa from 28days to 60days and 3.62MPa from 60days to 90days for 5 % RHA replacement observed. Compressive strength increase of 9.1MPa from 28days to 60days and 2.61MPa from 60days to 90days for 10 % RHA replacement observed. Compressive strength increase of 6.78MPa from 28days to 60days and 2.64MPa from 60days to 90days for 15 % RHA replacement observed. Compressive strength increase of 7.83MPa from 28days to 60days and 3.07MPa from 60days to 90days for 20 % RHA replacement observed. From above observation there was an increase of compressive strength from 28days to 60days and from 60days to 90days. The maximum compressive Strength was 53.69MPa observed at 10% replacement for Exposure of 90days.

3.3. Concrete Specimens Cured in Sodium Sulfate Solutions

The Rice Husk Ash replaced concrete cubes cast in the molds for determining the compressive strength. The tests conducted after 28, 60, 90 days of curing in 1% Concentrations of Sodium Sulfate.

3.3.1. Specimens Cured in 1 % Sodium Sulfate Solution

Figure 5 surmise that compressive strength of 0%,5%,10%,15% and 20% RHA replaced concrete cubes cured in 1% Sodium Sulfate Concentration. Compressive Strength Increase of 9.96MPa from 28days to 60days and 4.01MPa from 60days to 90days for 0% RHA replacement observed.

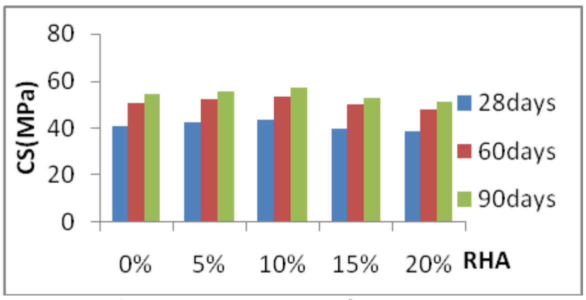

Fig. 5: RHA Concrete cured in 1% Na_2SO_4

Compressive strength increase of 9.83MPa from 28days to 60days and 3.10MPa from 60days to 90days for 5 % RHA replacement observed. Compressive strength increase of 9.43MPa from 28days to 60days and 4.03MPa from 60days to 90days for 10 % RHA replacement observed. Compressive strength increase of 10.10MPa from 28days to 60days and 2.62MPa from 60days to 90days for 15 % RHA replacement observed. Compressive strength increase of 9.57MPa from 28days to 60days and 3.15MPa from 60days to 90days for 20 % RHA replacement observed. From above observation there was an increase of compressive strength from 28days to 60days and from 60days to 90days. The maximum compressive Strength was 57.18MPa observed at 10% replacement for Exposure of 90days.

3.3.2. Specimens Cured in 3 % Sodium Sulfate Solution

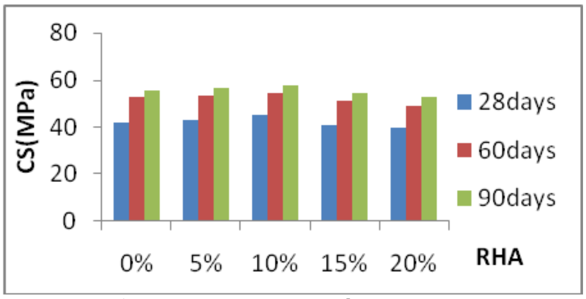

Fig. 6: RHA Concrete cured in 3% Na_2SO_4

Figure 6 surmise that compressive strength of 0%,5%,10%,15% and 20% RHA replaced concrete cubes cured in 3% Sodium Sulfate Concentration. Compressive Strength Increase of 10.60MPa from 28days to 60days and 2.84MPa from 60days to 90days for 0% RHA replacement observed. Compressive strength increase of 10.03MPa from 28days to 60days and 3.04MPa from 60days to 90days for 5 % RHA replacement observed. Compressive strength increase of 9.29MPa from 28days to 60days and 3.37MPa from 60days to 90days for 10 % RHA replacement observed. Compressive strength increase of 10.09MPa from 28days to 60days and 2.47MPa from 60days to 90days for 15 % RHA replacement observed. Compressive strength increase of 9.57MPa from 28days to 60days and 3.84MPa from 60days to 90days for 20 % RHA replacement observed. From above observation there was an increase of compressive strength from 28days to 60days and from 60days to 90days. The maximum compressive Strength was 57.95MPa observed at 10% replacement for Exposure of 90days.

3.3.3. Specimens Cured in 5 % Sodium Sulfate Solution

Figure 7 Surmise that compressive strength of 0%,5%,10%,15% and 20% RHA replaced concrete cubes cured in 5% Sodium Sulfate Concentration. Compressive Strength Increase of 9.44MPa from 28days to 60days and 2.50MPa from 60days to 90days for 0% RHA replacement observed.

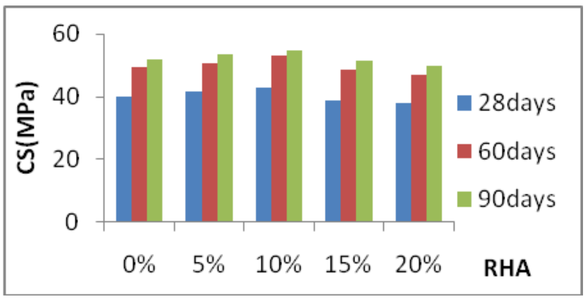

Fig. 7: RHA Concrete cured in 5% Na_2SO_4

Compressive strength increase of 9.07MPa from 28days to 60days and 2.84MPa from 60days to 90days for 5 % RHA replacement observed. Compressive strength increase of 10.01MPa from 28days to 60days and 1.80MPa from 60days to 90days for 10 %

RHA replacement observed. Compressive strength increase of 9.84MPa from 28days to 60days and 2.59MPa from 60days to 90days for 15 % RHA replacement observed. Compressive strength increase of 9.36MPa from 28days to 60days and 2.82MPa from 60days to 90days for 20 % RHA replacement observed. From above observation there was an increase of compressive strength from 28days to 60days and from 60days to 90days. The maximum compressive Strength was 54.84MPa observed at 10% replacement for Exposure of 90 day.

4. Conclusion

Based on the study results, the following conclusion made.1) Rice Husk Ash Concrete specimens exhibit higher compressive strength results in comparisons to concrete cubes without Rice Husk ash when cured in Normal conditions.2) The Compressive strength gain of Rice Husk ash Concrete with age was not affected due to 1%, 3% and 5% of Sulfates (Both Cases of $MgSO_4$ and Na_2SO_4)Solutions Exposure, when Rice Husk Ash content used for cement replacement was less than or equal to 10 %.Above 10% Rice Husk Ash contents reduction in compressive strength, occurred with increased periods of Exposure. 3) Rice Husk ash Concrete Specimens were more sulfate confrontation than specimens without Rice Husk Ash. 4) Magnesium sulfates and sodium Sulfates were the best resistant's to concrete with 10% Rice Husk ash replacement. Hence 10% optimum replacement of Rice Husk ash with cement in concrete can be used in places vulnerable to sulfates without any significant loss of strength.

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