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Experimental Study on Rice Husk Ash for Optimum Level of Replacement of Cement in Concrete

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***Abstract*--The pervious study on rice husk ash suggests that optimum level of replacement of rice husk ash in concrete is 10% of total weight of cement. This paper aims for maximum optimum value within 10% of replacement for better compressive strength and durability. RHA exhibits high pozzolanic characteristics and shows good pozzolanic behavior due to its high silica content. Rice husk ash (RHA) essentially consists of amorphous silica (90% SiO_2), 5% carbon, and 2% K_2O. Rice husk ash has been partially replaced at different percentages (0%, 5%, 6%, 7%, 8%, 9% and 10%) by weight of cement for mixand cured for different curing periods (28 days, 60days, 90 days). This study suggests that at 6% replacement of OPC with RHA Exhibits good compressive strength, because of its high pozzolanic activity. Effect of Sulphuric acid (H_2SO_4) on properties of replaced RHA concrete and compressive strength of cement concrete is taken as study area. The study reviles that the rate of development of compressive strength decreased with increase in concentration of H_2SO_4 at 28days, 60days and 90days.but at 6% replaced RHA shows good resistance to sulphuric acid attack.**

Keywords--Rice husk ash (RHA), compressive strength, durability, sulphuric acid.

I. INTRODUCTION

Cement used in concrete is a mixture of complex compounds. Cement is a major industrial commodity that is manufactured commercially in over 120 countries. Mixed with aggregates and water, cement forms the ubiquitous concrete which is used in the construction of buildings, roads, bridges and other structures. In countries, even where wood is in good supply, concrete also features heavily in the construction of residential buildings. Production of concrete using Portland cement is popular all over the world. This is due to mainly low cost of materials and construction for concrete structures as well as low cost of maintenance. But high amount of energy is required for manufacturing of cement which emits carbon dioxide (CO_2) which is very harmful for the environment [8]. In order to minimize this problem we use the concept of supplementary cementitious material. Some of agricultural and industrial waste ash which was fulfilled the criteria as supplementary cementitious materials. These are rice husk ash, bagasse rice husk wood ash, palm oil fuel ash, fly ash, olive oil ash etc [7], [9].

Rice milling generates a by-product 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).Rice husk ash is obtained by burning rice husk in a controlled manner without causing environmental pollution. When properly burnt it has high SiO_2 content and can be used as a concrete admixture [4]. Rice husk ash is used as cement replacement material in concrete because it exhibits high pozzolanic characteristics and contributes to high strength and high impermeability of concrete [1], [3], [5], [6], [10].

With the addition of RHA weight density of concrete reduces by 72-75%.Thus, RHA concrete can be effectively used as light weight concrete for the construction of structures where the weight of structure is of supreme importance. Thus, the use of RHA in concrete leads to around 8-12% saving in material cost. So, the addition of RHA in concrete helps in making an economical concrete [11]. Under the acid attack also RHA concrete shows better compressive than the normal concrete. [2] Describes the study on acid attack on concrete with rice husk ash as a partial replacement of cement at different percentages (0%, 5%, 10%, 15% and 20%). Strength increases gradually at 5%, 10% and strength decreases gradually at 15% and 20%. The study suggests that up to 10% replacement of OPC with RHA has the potential to be used as partial cement replacement, having good compressive strength. In the present investigation RHA replacement at different percentages (0%, 5%, 6%, 7%, 8%, 9% and 10%) and obtain in which percentage it gives maximum strength because the strength increases in between 5 to 10%.

II. EXPERIMENTAL MATERIALS

a) Rice Husk Ash

Rice husk ash is obtained by burning rice husk in a controlled manner without causing environmental pollution. When properly burnt, it has high SiO_2 content and can be used as a concrete admixture. Rice husk ash exhibits high pozzolanic characteristics and contributes to high strength and high impermeability of Concrete. The physical characteristics of the rice husk are Density=495Kg/m^3, Specific Gravity=2.53, Mean particle size=0.15-0.25 µm, Min specific surface area=220m^2/ kg, Particle shape= Spherical, and Moisture contents (% by weight) = 2.15.

Figure.1 RHA after grinding

b) Cement

The cement used was Ordinary Portland Cement (OPC) of 53 grades. It is made from a mixture of lime stone ($CaCO_3$) and clay, shale ($Al_2O_3.2.SiO_2$) or other alumina silicate. The chemical compositions of OPC are CaO=60-67%; SiO_2=17-25%; Al_2O_3=3.0-8.0%; Fe_2O_3=0.5-6.0%; MgO=0.1-4.0%; Alkalies (K_2O, Na_2O) =0.4-1.3%; SO_3=1.3-3.0%. The initial setting time OPC is 30 minutes (minimum) and final setting time is 600 minutes (maximum).

c) Fine Aggregate

The river sand, passing through 4.75 mm sieve and retained on 600 µm sieve, conforming to Zone II as per IS 383-1970 was used as fine aggregate in the present study. The sand is free from clay, silt and organic impurities. The aggregate was tested for its physical requirements such as gradation, fineness modulus, and specific gravity and bulk modulus in accordance with IS: 2386-1963.

d) Coarse Aggregate

A Machine crushed angular granite metal of 20mm nominal size from the local source is used as coarse aggregate. It is free from impurities such as dust, clay particles and organic matter etc.

e) Water

The water used for the study was obtained from a free flowing stream. The water was clean and free from any visible impurities. The pH value should not be less than 6.

f) Sulphuric acid

Sulphuric acid is a highly corrosive strong mineral acid with the molecular formula H_2SO_4. Sometimes, it is dyed dark brown during production to alert people to its hazards. The historical name of this acid is oil of vitriol. Sulphuric acid is a diprotic acid and shows different properties depending upon its concentration.Sulphuric acid is a very important commodity chemical, and indeed, a nation's Sulphuric acid production is a good indicator of its industrial strength.

III. EXPERIMENTAL PROGRAM

a) Mix Proportions

In the present investigation mix proportioning is done using BIS method for, M_{35} grade concrete. The mix proportions used in this work are 1:1.16:2.73:0.42.

b) Casting of Specimens

Concrete specimens of 100 X 100 X 100mm cubes were casting. After 24 hours the specimens were demoulded and subjected to curing for 28, 60, 90 days in clean fresh water and different percentages of HCL solution.

Figure.2 casting of specimens

c) Testing of Specimens

The cast specimens are tested in compression testing machine as per standard procedures, immediately after they are removed from curing tubs and wiped off the surface water, as per IS 516-1959.

Figure.3 Testing of Specimen

IV. EXPERIMENTAL RESULTS

The following tables shows the compressive strengths of concrete with (0%, 5%, 6%, 7%, 8%, 9% and 10%) weight replacement of cement with RHA cured in normal water and different percentages of H_2SO for 28, 60 and 90 days.

TABLE-1
COMPRESSIVE STRENGTH RESULTS FOR CUBES CURED IN WATER

Sample Designation	**% of RHA**	**Compressive Strength [N/mm^2] (f^1_{cu})**		
		28 days	***60 days***	***90 days***
W1	0	44.80	54.93	57.55
W2	5	47.08	56.89	59.84
W3	6	48.39	58.86	61.80
W4	7	47.25	57.87	60.33
W5	8	46.10	57.22	59.35
W6	9	45.12	55.91	58.36
W7	10	47.41	57.71	60.65

TABLE-2
COMPRESSIVE STRENGTH RESULTS FOR CUBES EXPOSED TO 1% BY VOLUME OF SULPHURIC ACID SOLUTION

Sample Designation	**% of RHA**	**Compressive Strength [N/mm^2] (f_{cu})**		
		28 days	***60 days***	***90 days***
S^{11}	0	42.34	53.30	55.42
S^{12}	5	45.28	55.59	57.71
S^{13}	6	47.57	58.36	60.00
S^{14}	7	45.45	56.89	58.36
S^{15}	8	44.30	55.10	57.22
S^{16}	9	42.83	53.13	55.60
S^{17}	10	45.94	56.40	58.69

TABLE-3
COMPRESSIVE STRENGTH RESULTS FOR CUBES EXPOSED TO 3% BY VOLUME OF SULPHURIC ACID SOLUTION

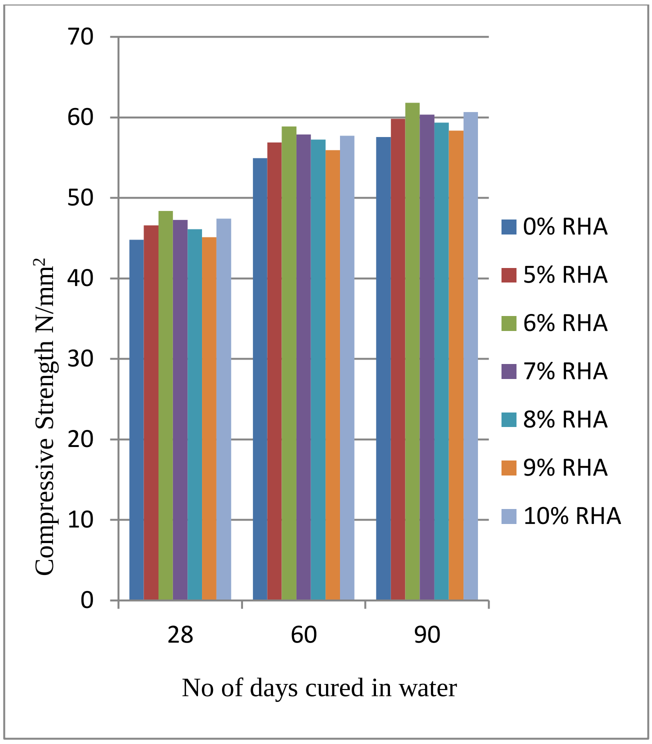
Sample Designation	**% of RHA**	**Compressive Strength [N/mm^2] (f_{cu})**		
		28 days	***60 days***	***90 days***
S^{11}	0	33.68	45.12	53.13
S^{12}	5	36.62	47.57	55.75
S^{13}	6	39024	50.68	58.04
S^{14}	7	37.27	48.23	56.40
S^{15}	8	35.97	46.59	55.42
S^{16}	9	34.82	44.79	53.95
S^{17}	10	37.70	48.39	56.57

TABLE-4
COMPRESSIVE STRENGTH RESULTS FOR CUBES EXPOSED TO 5% BY VOLUME OF SULPHURIC ACID SOLUTION

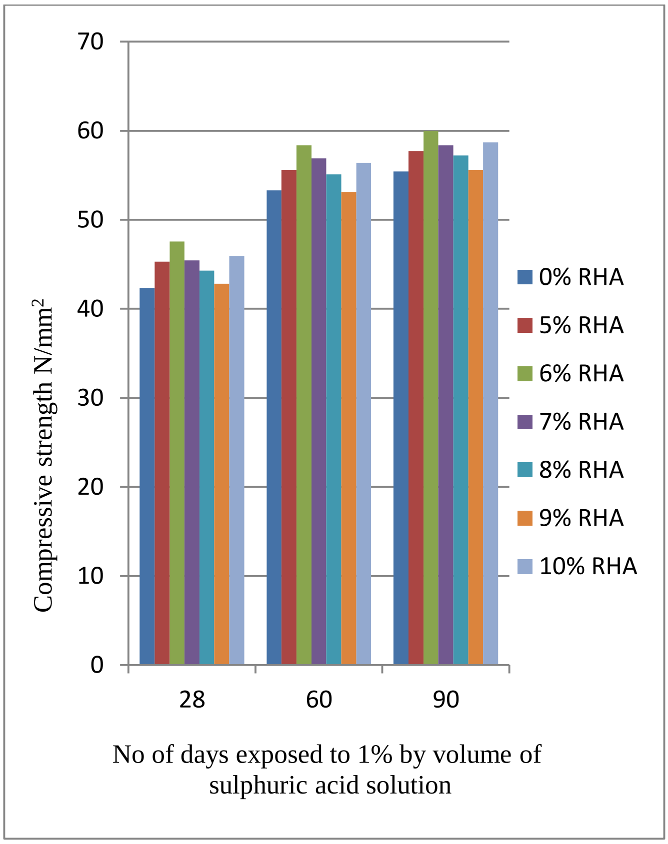
Sample Designation	% of RHA	Compressive Strength [N/mm^2] (f_{cu})		
		28 days	*60 days*	*90 days*
S[11]	0	25.50	31.71	40.54
S[12]	5	27095	33.84	42.67
S[13]	6	30.40	36.29	44.96
S[14]	7	28.93	34.33	43.18
S[15]	8	27.46	33.02	41.69
S[16]	9	25.99	31.06	40.38
S[17]	10	29.43	34.66	43.49

V. DISCUSSIONS

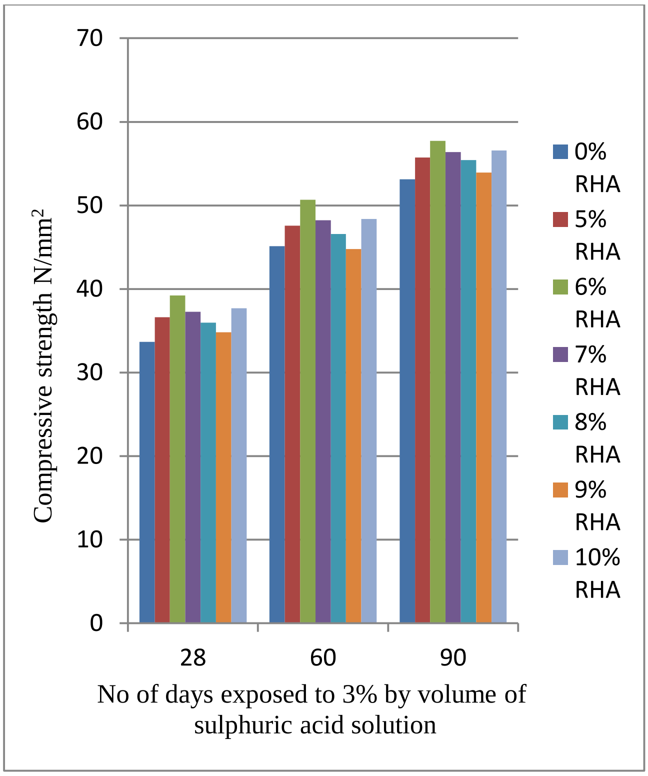
Total 252 cubes were cast of which one fourth were placed in normal water, another one fourth were placed in 1% H_2SO_4solution, another one fourth were placed in 3% H_2SO_4 solution and the last one fourth were placed in 5% H_2SO_4 solution. Four samples from each environment were tested at the age of 28, 60 and 90 days respectively. The resultsare presented graphically below. Graph.1 to 4 represent the compressive strength of concrete specimens with cement replacement level by0%, 5%, 6%, 7%, 8%, 9% and 10% by RHA respectively cured in normal water and indifferent percentages of H_2SO_4 solution. From all graphs it is seen that the compressive strength increases with the age of days. From graph 1, which indicates that at 5% replacement strength increased and it extended to 6% replacement also and then it was observed that at 7%, 8% and 9% replacement strength decreased and again there is increasing the strength in 10% replacement level. Graph 2, 3 and 4 shows compressive strength of specimens cured in 1% H_2SO_4, 3% H_2SO_4 and 5% H_2SO_4solution. Compare to graph.1 compressive strength in all stages decreases in graph 2, 3 and 4 due to acid curing, but we observe that at 5% replacement strength increased and it extended to 6% replacement also and then it was observed that at 7%, 8% and 9% replacement strength decreased and again there is increasing the strength in 10% replacement level. From all graphs it can be concluded that at 6% replacement level compressive is maximum compare to other replacement levels due to pozzolanic activity.



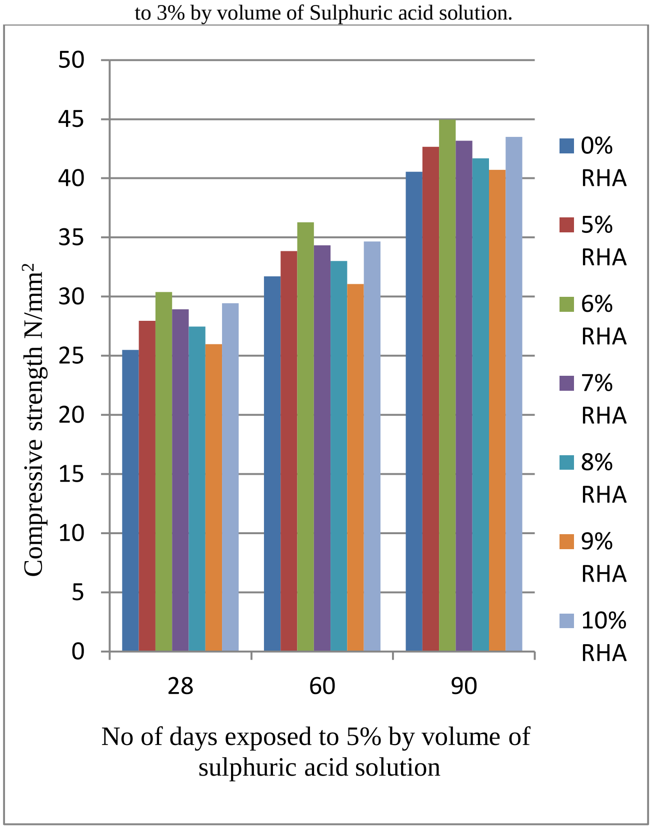
Graph.1 Compressive strength results of Rice Husk ash Concrete cured in normal Water



Graph.2 Compressive strength results of Rice Husk ash Concrete exposed to 1% by volume of Sulphuric acid solution.



Graph.3 Compressive strength results of Rice Husk ash Concrete exposed to 3% by volume of Sulphuric acid solution.



Graph.4 Compressive strength results of Rice Husk ash Concrete exposed to 5% by volume of Sulphuric acid solution.

VI. CONCLUSIONS

After exhaustive discussions of the results, the following conclusions have been derive

a) The compressive strengths of concrete (with 0%, 5%, 6%, 7%, 8%, 9% and 10%, weight replacement of cement with RHA) cured in normal water for 28 days have reached the target mean strength.
b) Comparative study on Rice Husk Ash concrete with various replacement percentages of RHA showed that, a replacement level of 6% RHA in concrete performs and shows better strength than other replacements due to high pozzolanic activity.
c) From results M_{35} grade RHA concrete for H_2SO_4 solution exposure in 28 days, 60 days and 90 days the 6% replacement showed better compressive strengths.
d) The compressive strength decreased with the increase in concentrations of sulphuric acid in curing water.
e) At 6% replacement RHA gives maximum strength and shows good resistance to sulphuric acid attack.
f) Utilization of Rice Husk Ash and its application are used for the development of the construction industry, material science.
g) It is the possible alternative solution of safe disposal of Rice Husk Ash.
h) RHA becomes more economical without compromising concrete strength than the standard concrete. It becomes technically and economically feasible and viable.

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