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Characterization and Application of Rice Husk Ash As Pozzolanic Material In Concrete

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Abstract: *The aim of this study is to investigate the feasibility of using Rice Husk Ash from local Rice mills in Lucknow in concrete. Cement is replaced by Rice Husk Ash in different proportions until 40 percent by weight. Pozzolanic properties of Rice Husk Ash and compressive strength of concrete were investigated. The result shows that Rice Husk Ash has pozzolanic properties. Results also show that concrete with partial cement replacement by Rice Husk Ash has minor strength loss. The results of the investigation confirmed the potential use of this Rice Husk Ash material to produce concrete.*
Keywords: *Rice Husk Ash; Compressive Strength; Pozzolan; Concrete.*

I. Introduction

In concrete the economy, technical aspect of concrete, environmental and energy consumption is important. Sometimes additional materials are used to improve the properties of concrete. Reduction of Portland cement without reducing performance of concrete is very important for huge projects that need a lot of cement. Today, pozzolan and Cementitious materials play an important role in concrete. Wastes of industries and constructions which have pozzolanic or cementitious property, not only can reduce environmental pollution and energy consumption of construction industry, but also make it cheap. According to some authors the best way for the construction industry to become a more sustainable one is by using wastes from other industries as building materials[1-3]. Portland cement clinker production consumes large amounts of energy (850 kcal per kg of clinker) and has a considerable environmental impact. This involves massive quarrying for raw materials (limestone, clay, etc.), as it takes 1.7 tones to produce 1 ton of clinker, as well as the emission of greenhouse and other gases (NOx, SO2, CO2) into the atmosphere. Around 850 kg of CO2 are emitted per ton of clinker produced[4]. Therefore Rice Husk Ash will help in saving energy and environment.

II. Objective

The objective of this research is to find the scope for the use of rice husk ash in luckow division to reduce the amount of cement in concrete for the construction work in lucknow. This is done via material testing of concretes with various percentage of replacement of cement by Rice husk ash collected from lucknow division, Uttar Pradesh.

III. Research Methodology

A partial replacement of cement by mineral admixture such as fly ash, silica fume or blast furnace slag in cementing materials (mortar or concrete) in mixtures would help to overcome these problems and lead to improvement in the workability, strength and durability of cementing materials [5]. This would also lead to additional benefits in terms of reduction in costs, energy saving, promoting ecological balance and conservation of natural resources, etc. Portland cement with pozzolanic admixture is low in C3S (tricalcium silicate), low in C3A (tricalcium aluminate) and low heat of hydration and high long term strength. In a Report[6](Dwivedi, 2011), Lucknow division which comprises of Lucknow, Unnao, Raebareli, Sitapur, Hardoi, Kheri, Shahuji Maharaj Nager is major produces of rice, Total area in which rice production done is 792763000 hectare with a production of 1610409 mt of rice during the year 2010-2011 which is maximum as compared to other divisions in Uttar Pradesh. Rice mills in Lucknow division uses rice husk as a fuel to generate steam for parboiling process. In this experiment rice husk was burnt in an controlled combustion process for about 2 hrs with a burning temperature ranging between 600-800 degrees. The ash abtained was grounded for 2 hours and the colour of the ash was light grey.

IV. Data Analysis

Rice Husk taken from lucknow region was burnt in the gasifier plant in G.S.K. Bharat pvt limited under a controlled burning of 600-800 degree celcius and then the residue ash was ball grinded to a fine powder. After grinding Rice Husk Ash was sieved from 300µ sieve and the portion which passed from the sieve was used in the experiment.

The Ordinary Portland Cement of 43 grade (Jaypee OPC) conforming to IS: 8112-1989 is used. The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 are used. The river sand and crushed sand is used in combination as fine aggregate conforming to the requirements of IS: 383. The physical properties of the aggregates are given in Table below.
Water used in the concrete was taken from the city of Lucknow. In order to obtain a consistency defined by slump values of between 8 and 12 cm a super plasticizer was used.

Property	Fine aggregate	Coarse aggregate
Specific gravity	2.65	2.88
Fineness modules	2.51	7.02
Water absorption in percent	1	0.5

Mix Design: A mix M25 grade was designed as per IS 10262:2009 and the same was used to prepare the test samples.

Data for Mix Proportion: The following data are required for mix proportion of a particular grade of concrete:

- Grade designation.
- Type of cement.
- Maximum nominal size of aggregate.
- Minimum cement content.
- Maximum water cement ratio.
- Workability.
- Exposure condition as per table 4 and 5 of IS 456.
- Max temperature of concrete at the time of placing.
- Method of transporting and placing.
- Early age strength requirements, if required.
- Type of aggregate.
- Maximum cement content.

Target strength of mix proportioning:
Target mean compressive strength f'_{ck} is given by:

$$\mathbf{f'_{ck} = f_{ck} + 1.65s}$$ [7](IS10262, Concrete Mix Design, 2009),3.2

where

f'_{ck}= Target mean compressive strength at 28 days in N/mm^2

f_{ck} = Characteristic compressive strength at 28 days strength in N/mm^2

S = Standard deviation N/mm^2

Concrete mix proportion:

$f'\ ck = f_{ck} + 1.65s$

$= 25+1.65*4$

[7](IS10262, Concrete Mix Design, 2009) clauses 3.2.1.2, A-3 and B-3)

$= 31.60 N/mm^2$

Calculation of water content:

W/C= 0.42

Water content for 25-50 mm slump = **186 liters**
[7](IS10262, Concrete Mix Design, 2009)clause 4.2, A-5 and B-5)

Water content for 120 mm slump = 186+6/120*186

= 195 liters

Calculation of cement content:

W/C = 0.42

Cement content = 195/0.42 = 465 kg.

465>300 (ok) [8](IS456, 2000)table 5

Proportioning of coarse and fine aggregate:

From table 3 of [7]((IS10262, Concrete Mix Design, 2009) table-5) volume of coarse aggregate for 0.5 W/C = 0.62

Present W/C = 0.42

Therefore volume of coarse aggregate need to increase to decrease fine aggregate by 0.08

The coarse aggregate increase by the formula:

+- 0.01 for every +- 0.05 change of W/C ratio

Coarse aggregate for 0.42 W/C ratio = 0.016+0.62 = 0.636

For pump able reduce by 10%

Volume of coarse aggregate = 0.636*0.9 = 0.57

Volume of fine aggregate = 1-0.57 = 0.43

Mix calculation:

a) Volume of concrete = 1 m^3

b) Volume of cement = Mass/sp.gravity*1/1000

= 465/3.15*1/1000

= 0.14 m^3

c) Volume of water = Mass/ sp. gravity* 1/1000

= 195/1000

= 0.195 m^3

d) Volume of all aggregate = 1- (0.14+0.195)

e = 0.665 m^3

e) Mass of coarse aggregate = e*volume of coarse*sp.gravity*1000

= 0.665*0.57*2.88*1000

= 1092 kg

f) Mass of fine aggregate = e*volume of fine*sp.gravity*1000

= 0.665*0.43*2.65*1000

= 758 kg

Mix proportion:

Cement = **465 kg**

Water = 195 **liters**

Fine aggregate = **758 kg**

Coarse aggregate = **1092 kg**

W/C ratio = **0.42**

RATIO = **1:1.63:2.35**

Grade	W/C	% Replaced	Cement (kg)	Rice Husk Ash(RHA) (kg)	FA (kg)	CA (kg)		Water (kg)	Slump (mm)	No. Of cubes
						20mm	12.5mm			
M25	0.42	0%	24.742	0	40.82	16.33	38.102	10.39	120	12
		5%	23.505	1.237	40.82	16.33	38.102	10.39	120	12
		10%	22.268	2.474	40.82	16.33	38.102	10.39	120	12
		15%	21.03	3.711	40.82	16.33	38.102	10.39	110	12
		20%	19.794	4.948	40.82	16.33	38.102	10.39	100	12
		25%	18.556	6.186	40.82	16.33	38.102	10.39	90	12
		30%	17.319	7.423	40.82	16.33	38.102	10.39	80 (0.5)	12
		35%	16.082	8.660	40.82	16.33	38.102	10.39	80 (0.7)	12
		40%	14.845	9.897	40.82	16.33	38.102	10.39	80 (1)	12

(0.5), (0.7), (1) Refers that to maintain the slump of 80-120, 0.5%, 0.7% and 1% superpasticiser was used

V. Experimental Results

Compressive strength of cubes , W/C = 0.42				
	Compressive Strength (MPa) (Ultimate compressive load) /22.5			
	7 Day	28 Day	90 day	180 day
0 % RHA	41.4	51.4	53	56
5 % RHA	42.7	52.4	55.6	56.9
10 % RHA	40.4	50	53.8	55.6
15 % RHA	36.9	47.1	51.1	52.9
20 % RHA	34.7	44.9	48	49.8
25 % RHA	32	43.6	46.2	48.4
30 % RHA	29.8	40.9	42.7	44.9
35 % RHA	27.1	36.4	38.2	40.9
40 % RHA	24.2	34.1	36.3	38.7

Acknowledgment

Test was carried out in RMC plant of L&T Kursi Road, Lucknow. The test specimens were cast in steel cubic moulds 15×15×15 (cm). After about 24 hour, the specimens were removed from moulds. Each specimen was labelled as to the date of casting, mix used and serial number. Concrete Specimen were cured in water until the testing time. Fifteen cube specimens were made from each mixture. Three cubes were tested at the 7, 28, 90, and 180 days to observe the influence of different age strengths of concrete with Rice Husk Ash. A 2000kN capacity compressive testing machine was used to test the specimens.

Thefield test on Rice Husk Ash showed that it is possible to use Rice Husk Ash as a partial replacement upto 40% of cement to produce concrete that achieves desired strength for different grades of concrete(M20, M25, M30). Although compressive strength increased upto 5% replacement, then starts decreasing gradually after replacing cement more than 10% as compared to conventional concrete. The following trends were identified by replacing cement by Rice Husk Ash.

For M20 grade of concrete it was found that around 45-50% increase in strength from 7 days to 28 days, 6-8% increase in strength from 28 days to 90 days and around 5-7% increase in strength from 90days to 180 days

For M25 grade of concrete it was found that around 40-45% increase in strength from 7 days to 28 days, 6-7% increase in strength from 28 days to 90 days and around 6-7% increase in strength from 90days to 180 days

For M30 grade of concrete it was found that around 40-45% increase in strength from 7 days to 28 days, 4-6% increase in strength from 28 days to 90 days and around 3-4% increase in strength from 90days to 180 days.

Economic Analysis

The cost of Ordinary Portland Cement in Lucknow is about Rs320/50kg bag. The cost of cement per meter cube is around Rs 2700 for M20 grade, Rs 3000 for M25 grade and Rs3300 for M30 grade of concrete.

The cost of Rice Husk Ash is around 30paisa/ kg as Rice Husk Ash is locally available material the transportation cost will reduce.

Based on the result of the present study a 40% replacement of Rice Husk Ash is possible in concrete to achieve desired strength. With this level of substitution the price of Rice Husk Ash concrete will reduce up to 40%.

VI. Conclusion

The possibility of using waste Rice Husk Ash as a replacement of cement has been investigated in this experimental study, in this paper that waste Rice Husk Ash can be used until 40 percent as a replacement of cement in concrete. The following conclusions can be derived from the present study:

- Compressive strengths of samples increase upto 5 percent of cement replacement and decreases with increasing the Rice Husk Ash content from 10-40 percent. But results show that concrete with Rice Husk Ash has minor strength loss and Rice Husk Ashexhibit very good pozzolanic reactivity and can be used as cement replacement.
- As there is large production of Rice in Lucknow division so there is availability of Rice Husk Ash. So this will reduce the problem of dumping Rice Husk Ash and as it is a waste material so it will be useful to make concrete economical and eco-friendly.

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