Sustainable concrete using rice husk ash as supplementary material

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Abstract—**Rice husk ash (RHA) is a by-product from the burning of rice husk. The husk of the rice is removed in the farming process before it is sold and consumed. Since it is a waste by product, its disposal is a problem. On the other hand production of cement releases lot of carbon dioxide in atmosphere causing green house effect. Therefore, if RHA is used in concrete as supplementary material can change the properties of concrete. Present Indian standard code does not give the percentage of rice husk that can be substituted in concrete as replacement of cement. Therefore, experiments were carried out using different percentage of RHA i.e 10%,15%,20% were used as replacement of cement and mechanical properties like compressive strength, flexural strength and split tensile strength were found which were than compared with concrete made from ordinary Portland cement. From the studies it was found that 10% of RHA can be used as replacement of cement without affecting the strength.**

Keywords*—Rice Husk Ash, mechanical strength, control co*ncrete

I. Introduction

Rice husk is an agricultural residue obtained from the outer covering of rice grains during milling process. Current rice production in the world is more than 700 million tons. Rice husk constitutes about 20% of the weight of rice. It contains about 50% cellulose, 25–30% lignin, and 15–20% of silica. Due to the pozzolanic reactivity, rice husk ash (RHA) is used as supplementary cementing material in mortar and concrete and has demonstrated significant influence in improving the mechanical and durability properties of mortar and concrete. It has economical and technical advantages to use in concrete.

Based on the available documented literature, it can be concluded that RHA could be used as supplementary cementing material up to a certain level of replacement (about 20-30% of binder) without sacrificing strength of concrete. The particle size of the cement is about 35 microns. There may be formation of void in the concrete mixes, if curing is not done in properly. This reduces the strength and quality of the concrete. **Silpozz** – which is made out of this RHA is finer than cement having very small particle size of 25 microns, so that it fills the interstices in between the cement in the aggregate. That is where the strength and density comes from. And that is why it can reduce the amount of cement in the Concrete mix.

II. Manufacturing of Rice Husk Ash

Rice husk ash is produced by burning the outer shell of the paddy that comes out as a waste product during milling of rice. Since they are bulky disposal of husk present an enormous problem. Each ton of paddy produces about 200kg of husk and this rice husk can be effectively converted through controlled burning.

At around 500ºC a valuable siliceous product that can enhance the durability of concrete in the chemical composition of rice husk ash is obtained. Variations in the burning temperature much above or below will drastically alter the silica content of the ash. It is estimated that one fifth of the five hundred million tons of world annual paddy production is available as rice husks. Only a small quantity of rice husk is used in agricultural field as a fertilizer, or as bedding etc. and stabilization of black cotton soils.

III. Properties of Rice Husk Ash

3.1Physical Properties

Completely burnt rice-husk is grey to white in color, while partially burnt rice husk ash is blackish. The active silica obtained after the heating and grinding presents reduced size of particles and grey coloration due to the lower content carbonaceous material. Rice husk ash is a very fine material. Average particle size of rice-husk ash ranges from 3 to 10 lm. [1]

3.2 Chemical Properties

Rice husk ash is very rich in silica content. Silica content in rice husk ash is generally more than 80%. Typical chemical composition of RHA is given in As per ASTM C 618, the combined proportion of silicon dioxide (SiO_2), aluminium oxide ($A1_2O_3$) and iron oxide (Fe_2O_3) in the ash should be not be less than 70%.[1]

TABLE 1 PHYSICAL PROPERTIES

Physical Properties of Silpozz		
1	Physical state	Solid - Non Hazardous
2	Appearance	Very fine powder
3	Particle size	< 25 microns - mean
4	Color	Grey
5	Odor	Odorless
8	Specific Gravity	2.3

TABLE 2 CHEMICAL COMPOSITION

Chemical Composition of Silpozz		
1	Silica -SiO2	> 88.0 %
2	Carbon	< 2.0 %
3	Moisture	< 2.0 %
4	L.O.I.	< 6.0 %
5	Water Soluble	< 6.0

IV. APPLICATIONS AREAS OF RHA

The particle size of the cement is about 35 microns. There may be formation of void in the concrete mixes, if curing is not done in properly. This reduces the strength and quality of the concrete. Silpozz – which is rich in reactive silica is finer than cement having most particles size of 25 microns and below, so much so that it fills the interstices in between the cement in the aggregate. That is where the strength and density comes from. And that is why it can reduce the amount of cement in the concrete mix besides improving strength and quality of concrete. In concrete they can be applied in high performance concrete, high strength, low permebility concrete, concrete in marine environments, industrial flooring, water tanks and sumps, chemical storage tanks, basements and sewerage pipelines, refractory mixes etc.[2,3]

V.ADVANTAGES USING RICE HUSK ASH

5.1 For Strength:

Silpozz is used in place of silica fumes or micro silica at a much lower cost, without compromising on the quality aspect. Adding Silpozz to the concrete mix even in low replacement will dramatically enhance the workability, strength and impermeability of concrete mixes, while making the concrete durable to chemical attacks, abrasion and reinforcement corrosion, increasing the compressive strength by 10% - 20%. [2,3]

5.2 For water proofing:

Silpozz has excellent water resistance (impermeability) properties and is used in waterproofing compounds to give amazing results. It reduces the water penetration by as much as 60%.

5.3 For Better Concrete in Marine environment:

Adding Silpozz to concrete and paints helps to reduce the chloride ion penetration by as much as 50% into the structure, thus improving life of the building.

5.4 For Lower heat of Hydration:

Adding Silpozz to concrete lowers the heat of hydration by as much as 30% and prevents formation of cracks during casting. [4,5]

VI. MIX DESIGN OF CONCRETE

Mix design was done for M 25 grade of concrete for mild exposure condition. Water cement ratio was taken as 0.45. maximum size of coarse aggregate was 20 mm. after carrying out the mix design as per IS : 10262: 2009. After making necessary field correction of water absorption and free moisture in aggregates, the final proportion of various constituents were calculated for 1 cubic meter of concrete as shown in Table 3.[6]

TABLE 3. MIX PROPORTION FOR CONTROL CONCRETE

Water	Cement	Fine Aggregate	Coarse Aggregate
176	391.11	671.78	1138.22
0.45	1	1.72	2.91

Along with it, three mix of concrete were also cast with 10%, 15% and 20% replacement of cement by rice husk ash.

VII COMPARISON OF MECHANICAL PROPERTIES OF CONCRETE

7.1 Compressive strength

Test for compressive strength were carried out for 7 day and 28 days both for control concrete (i.e. 0 % RHA) and for concrete having 10%, 15% and 20% of RHA as replacement of cement. The compressive was found to be 19.1 MPa for 7 days for concrete made from OPC, while it was 17.2 MPa, 16.3 MPa and 15.7 MPa for 10%, 15% and 20% replacement of cement with RHA. 28 days as seen in Table 4 varied from 30.96 MPa for control concrete to 29.4, 28.7 and 27.5 MPa for cement with 10%, 15% and 20% of RHA .

Table 4 Compressive strength (N/mm^2)

MIX	7 DAYS		28 DAYS	
	19.2		32	
0% RHA	18.7	19.1	30.2	30.96
	19.4		30.7	
	16.9		29.3	
10 % RHA	18.7	17.2	29.1	29.4
	16		29.8	
	14.2		28.5	
15 % RHA	18.7	16.3	28.9	28.7
	16		28.7	
	15.5		27.3	
20 % RHA	15.9	15.7	27.6	27.5
	15.7		27.6	

7.2 Split tensile strength

150 mm diameter and 300 mm height cylinders were casted using ordinary Portland cement and replacement of cement by 120%, 15 % and 20% RHA. It was found that split tensile strength decreased from 2.43 MPa in control concrete to 2.37, 2.14 and1.84 MPa at 7 days. While 28 days strength was 3.19 MPa for control concrete and was 2.71,2.69 and 2.19 MPa for 10%, 15% and 20% replacement of RHA as shown in Table 5.

Table 5 Split Tensile Strength (N/mm^2)

MIX	7 DAYS		28 DAYS	
	2.4		3.06	
0% RHA	2.21	2.43	3.24	3.19
	2.68		3.27	
	2.18		2.54	
10 % RHA	2.54	2.37	2.76	2.71
	2.41		2.83	
	2.54		2.95	
15 % RHA	2.18	2.14	2.51	2.69
	1.7		2.61	
	1.84		1.98	
20 % RHA	1.84	1.84	2.18	2.19
	1.84		2.41	

7.3 Flexural Strength

Beams were casted of 50 mm x 50 mm x 500 mm and were tested in flexural testing machine. Flexural strength as observed in Table 6, was found to be 6.5 MPa for OPC concrete which decreased to 5.2,4.4 and 3.7 MPa for replacement of 10%, 15% and 20% of RHA.

Table 6 Flexural Strength (N/mm^2)

MIX	7 DAYS	28 DAYS	
0% RHA	6.5	7.7	7.9
		8.1	
10 % RHA	5.2	6.6	6.8
		7	
15 % RHA	4.4	6.4	6.6
		6.8	
20 % RHA	3.7	5.2	4.8
		4.4	

8.0 Results and Discussions

8.1 Compressive strength

From Figure 1, we can say that the compressive strength is reducing as the percentage of RHA increases. At 28 days the percentage decrease in compressive strength with increase in RHA is 5.04%, 7.29%, 11.17%.

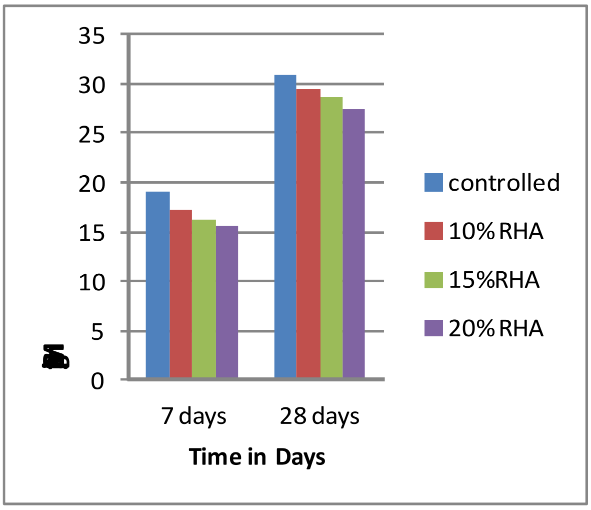

Figure 1 Compressive strength Results

8.2 Split strength

From the Figure 2, we can say that the split tensile strength is reducing as the percentage of RHA increases. At 28 days the percentage decrease in split tensile strength with increase in RHA is 15.05%, 15.67%, 31.34%.

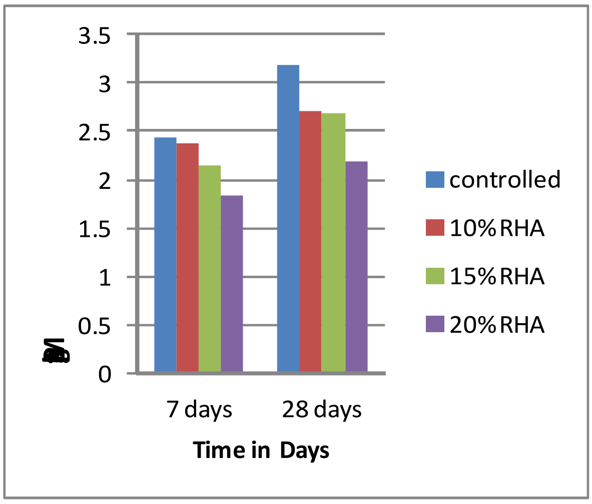

Figure 2 Split Tensile Strength Results

8.3 Flexural strength:

Figure 3, shows that the flexural strength is reducing as the percentage of RHA increases. At 28 days the percentage decrease in flexural strength with increase in RHA is 13.92%, 16.46%, 39.24%.

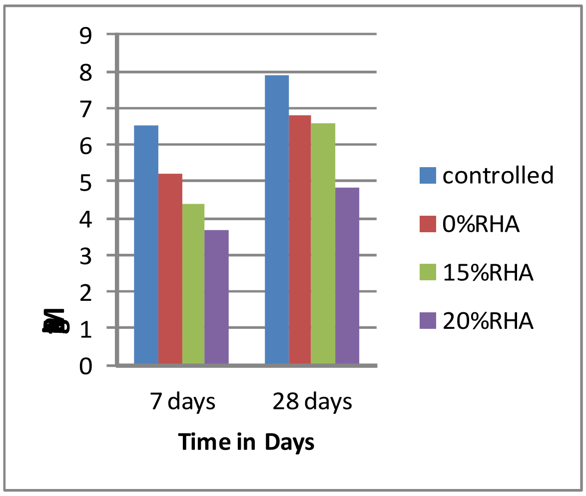

Figure 3 Flexural Strength Results Observations

9. Cost analysis

After getting actual quantities as per mix design cost of ordinary Portland cement concrete and 10 % RHA concrete was done as shown in Table 7 and 8. It can be observed that cost of control concrete is Rs 3127 per cubic meter while that of 10% replacement with RHA is Rs.3074.

Table 7 Cost analysis for controlled concrete

CONTROLLED CONCRETE	QTY.(kg/m3)	RATE(Rs)	
WATER CEMENT RATIO	0.49		
CEMENT	438.13	315 /Bag	2760.22
COARSE AGGREGATE FRACTION I	667.26	631/Cu.M.	156
COARSE AGGREGATE FRACTION II	444.84	812/Cu.M	133.78
FINE AGGREGATE	635.33	248/Cu.M	60.6
WATER	217.28	75/Cu.M	16.3
TOTAL MATERIAL COST			3126.9

Table 8 Cost analysis for 10% RHA

CONCRETE WITH 10% RHA	QTY.(kg/m3)	RATE(Rs)	
WATER CEMENT RATIO	0.53		
CEMENT	406.14	315 /bag of 50 kg	2558.68
RHA	43.81	80/bag of 25 kg	156.19
COARSE AGGREGATE FRACTION I	653.28	631/Cu.M.	152.67
COARSE AGGREGATE FRACTION II	435.52	812/Cu.M	130.98
FINE AGGREGATE	622.02	248/Cu.M	59.33
WATER	216.86	75/Cu.M	16.26
TOTAL MATERIAL COST			3074.11

10. Conclusion

- RHA does not possess these undesired characteristics. Furthermore, RHA has a greater amount of surface area per unit weight than silica fume, helping to increase the overall strength of the mix.
- Because of 10% RHA with great reactivity, a significant increase in the compressive strength of concretes was observed.
- The increase in compressive strength of concretes with residual RHA is better justified by the filler effect (physical) than by the pozzolanic effect (chemical/physical). The increase in compressive strength of concretes with RHA produced by

controlled incineration is mainly due to the pozzolanic effect.

- It can be interpreted that if 10% of RHA is used as replacement of cement, then there is very marginal decrease in compressive, split and flexural strength. If more replacement is done than the strength is greatly compromised.
- The cost of concrete per metre cube decreases with increase in RHA but 10 % replacement of cement gives economical result since strength is also not affected greatly.

Therefore, rice husk ash can be used as substitute for sustainable development.

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