Investigating the Effect of Rice Husk Ash in Concrete as Partial Replacement with Cement

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Abstract

The utilization of agricultural waste materials in construction has garnered significant attention due to environmental and economic benefits. The by-product of rice milling i.e. Rice husk ash (RHA) exhibits pozzolanic properties that can enhance performance of concrete. This study investigates the partial replacement of cement effects with RHA effects on the mechanical and durability properties of concrete. Concrete mixes were prepared with varying RHA content (0%, 5%, 10%, and 15%, by weight of cement), and tests were conducted to assess workability and compressive strength. The results indicate that a 10% replacement level yields optimal improvements in strength without compromising workability, suggesting that RHA can be an effective supplementary cementitious material.

IndexTerms— Rice Husk Ash, RHA, Concrete, Workability, Compressive strength

I. INTRODUCTION

Concrete, the globally most widely used construction material, primarily composed of cement, aggregates (Coarse and fine aggregates), and water. However, the production of cement is energy-intensive and contributes significantly to CO_2 emissions. Incorporating industrial and agricultural by-products as partial replacements for cement can mitigate environmental impacts and improve sustainability.

Rice husk ash (RHA) is an agricultural waste product obtained by burning rice husks. Rich in amorphous silica, RHA exhibits pozzolanic characteristics, making it a potential supplementary cementitious material. Previous studies have shown that RHA can enhance the mechanical properties and durability of concrete when used appropriately. This research aims to evaluate the optimal replacement level of cement with RHA and its effects on concrete properties.

II. MATERIALS AND METHODS

MATERIALS:

Cement: Ordinary Portland Cement (OPC) (IS 12269-1987)
Fine Aggregate: Natural River sand with a fineness modulus of 2.6.
Coarse Aggregate: 20 mm size of Crushed stones.
Rice Husk Ash (RHA): Obtained by controlled burning of rice husks at 600°C for 6 hours, followed by grinding.
Water: Potable water free from impurities.

MIX DESIGN:

Table 1: Mix proportions of Rice Husk Concrete

Amount of Rice husk (in %)	Cement (Kg/m3)	RHA (Kg/m3)	Water (Kg/m3)	Fine aggregate (Kg/m3)	Coarse aggregate (Kg/m3)
0% RHA	1.360	0	153	2.267	5.101
5% RHA	1.292	5	153	2.267	5.101
10% RHA	1.224	10	153	2.267	5.101
15% RHA	1.156	15	153	2.267	5.101

SAMPLE PREPARATION AND TESTING:

Concrete specimens were cast in standard cube (150 mm), cylinder (150 mm × 300 mm), and prism (100 mm × 100 mm × 500 mm) molds. Cube specimens were de-moulded after 24 hours of setting and cured with water in curing tank at 27±2°C for 7, 14, and 28 days.

Figure 1: Cube casting for test

Tests conducted include:
Workability: Slump test (IS 1199-1959)

Figure 2: Slump Cone Testing

Compressive Strength: IS 516-1959

Figure 3: Compressive Strength Testing using CTM

III. RESULTS AND DISCUSSION

WORKABILITY TEST:

Table 2: Slump Values of Concrete Mix

% of RHA	Average slump values (mm)
0%	70
5%	62
10%	58
15%	55

COMPRESSIVE STRENGTH:

Table 3: Compressive Strength of Concrete Mix

Days	No. of Specimen	Percentage of Rice Husk Ash (N/mm^2)			
		0%	5%	10%	15%
7 Days	1	11.55	12.00	12.44	11.11
	2	11.23	12.21	12.5	11.34
	3	11.22	12.23	12.57	11.28
14 Days	1	13.33	14.22	14.67	12.88
	2	13.45	14.35	14.89	12.44
	3	13.25	14.44	14.50	12.30
28 Days	1	26.67	27.56	28.00	26.22
	2	26.10	27.20	28.22	26.77
	3	26.77	27.55	28.23	26.88

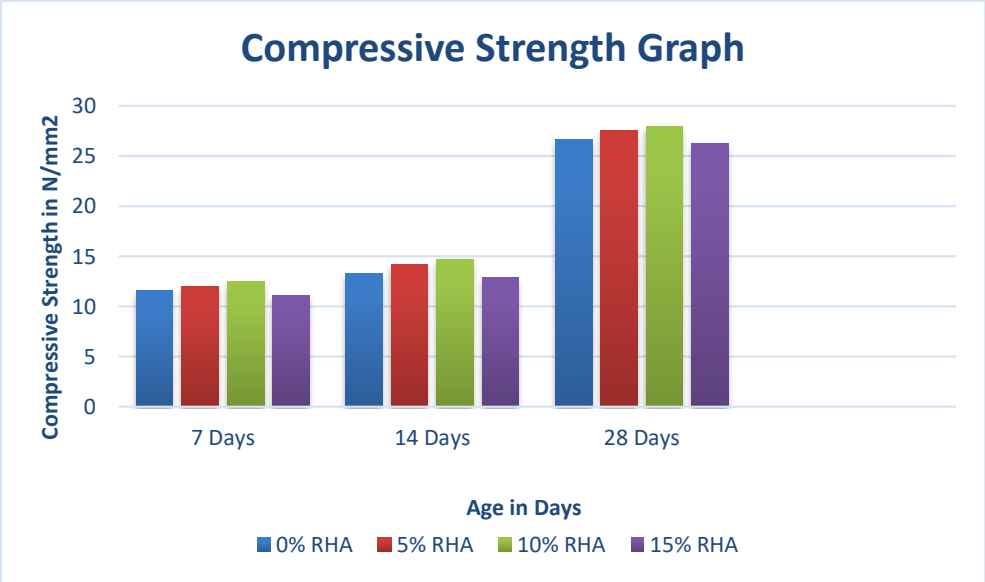

Figure 4: Compressive Strength Graph for various Concrete Mix at 7, 14 and 28 days

In terms of **compressive strength**, mixes containing 5–10% RHA generally exhibit strength values equal to or higher than that of control mixes without RHA. This increase is attributed to the pozzolanic reaction between the amorphous silica in RHA and calcium hydroxide, leading to the formation of additional calcium silicate hydrate (C-S-H), which enhances the concrete matrix. However, replacement levels beyond 15% typically result in reduced compressive strength due to the dilution of cementitious content and lower early-age reactivity.

IV. CONCLUSION

Incorporating Rice Husk Ash as a partial replacement for cement in concrete enhances mechanical properties and durability up to an optimal level of 10%. This approach not only improves performance but also contributes to sustainable construction practices by utilizing agricultural waste and reducing cement consumption.

V. REFERENCES

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