Experimental Investigation on Rice Husk Ash and Coconut Shell Ash as Partial Replacement of Cement in Concrete

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***Abstract*—Cement production contributes significantly to CO_2 emissions, prompting the search for sustainable alternatives. This study evaluates the use of Rice Husk Ash (RHA) and Coconut Shell Ash (CSA) as partial replacements for cement in concrete. Concrete specimens were prepared with 0%, 2%, 4%, 6%, 8%, and 10% replacements by weight of binder. Tests were performed to determine compressive strength, split tensile strength, and workability. The optimal replacement level was found to be 4%, which improved compressive strength by 12–18% and tensile strength by 27–30%. RHA showed better performance than CSA. The results indicate that bio-ash concrete is a viable, eco-friendly alternative in structural applications.**

***Index Terms*—Coconut Shell Ash, Rice Husk Ash, Pozzolanic Materials, Cement Replacement, Compressive Strength, Split Tensile Strength, Sustainable Concrete**

I. INTRODUCTION

Cement is a major contributor to environmental pollution due to its high energy consumption and CO_2 emissions. Each ton of cement produced emits approximately 0.9 tons of CO_2. This research investigates the potential of agricultural waste—RHA and CSA—as partial replacements for cement. Both materials are rich in silica and possess pozzolanic properties that enhance concrete performance.

A. Coconut Shell Ash

CSA is derived from burned coconut shells and contains significant silica content. It enhances durability and reduces reliance on traditional cement production.

B. Rice Husk Ash

RHA is a by-product of rice milling. When burned under controlled conditions, it yields amorphous silica, which reacts with calcium hydroxide to form calcium-silicate-hydrate (C–S–H), improving strength and durability.

II. METHODOLOGY

Concrete mix was designed for M20 grade using IS 10262:2019 guidelines. Mix ratio was 1:2.01:3.38 with a water-cement ratio of 0.47. CSA and RHA were added separately at 2% to 10% replacement levels. Specimens were cast in cubes (150 mm) and cylinders (150 mm × 300 mm) and tested after 7 and 28 days of curing.

III. MATERIALS

- Cement**:** Portland Pozzolana Cement (PPC), specific gravity: 3.15
- Fine Aggregate**:** M-sand, conforming to Zone III, FM: 2.63
- Coarse Aggregate**:** 12.5 mm crushed granite, FM: 6.26
- RHA**:** Burned at 650°C; specific gravity: 2.01; silica content: 87.63%
- CSA**:** Burned coconut shells; specific gravity: 2.07; silica content: 58.68%
- Water**:** Clean, potable, conforming to IS standards
- Superplasticizer**:** Naphthalene-based, as per IS 9103-1999

IV. TESTS CONDUCTED

- Slump Test**:** To measure workability
- Compressive Strength Test**:** Cubes tested at 7 and 28 days
- Split Tensile Strength Test: Cylinders tested at 7 and 28 days

V. RESULTS AND DISCUSSION

A. Workability

Slump decreased with increased ash content.

RHA %	Slump (mm)
0	162
2	145
4	130
6	125
8	120
10	118
CSA %	Slump (mm)
0	162
2	140
4	136
6	129
8	124
10	120

CSA showed a more significant drop in slump than RHA.

B. Compressive Strength

RHA showed maximum compressive strength at **4%** replacement.

RHA %	7-Day (MPa)	28-Day (MPa)
0	17.15	26.54
4	19.38	28.92
10	13.89	23.70
CSA %	7-Day (MPa)	28-Day (MPa)
0	17.15	26.54
4	19.15	26.93
10	13.89	23.70

CSA performed optimally at 4–6%, but not as effectively as RHA.

C. Split Tensile Strength

RHA at 4% showed highest tensile strength.

RHA %	7-Day (MPa)	28-Day (MPa)
0	1.92	2.14
4	2.52	2.48
10	1.67	2.31
CSA %	7-Day (MPa)	28-Day (MPa)

RHA %	7-Day (MPa)	28-Day (MPa)
0	1.91	2.14
4	1.61	2.37
10	1.42	1.93

VI. CONCLUSION

This study confirms that Rice Husk Ash and Coconut Shell Ash are effective supplementary cementitious materials. An optimum replacement level of 4% (especially RHA) enhances mechanical properties and workability while reducing environmental impact. Further research may explore long-term durability and large-scale applications.

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