

Study on Mechanical & Durability Properties of Multi-Component Blended Concrete

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Abstract - Concrete is the most widely used construction material worldwide, second only to water in consumption. The demand for high-performance concrete has led to the incorporation of supplementary cementitious materials and chemical admixtures. This study investigates the mechanical and durability properties of multi-component blended concrete incorporating rice husk ash (RHA) as a partial replacement of cement. Laboratory tests were conducted on cubical, cylindrical, and reinforced specimens to evaluate compressive strength, tensile strength, sulphate resistance, and chloride resistance at 7, 14, and 28 days. Results indicate that RHA enhances strength, reduces permeability, and improves durability, making it a sustainable alternative for adverse environments.

Key Words: Concrete, Admixtures, Rice Husk Ash, Blended Concrete, Durability, Compressive Strength, Sustainability.

1. INTRODUCTION

Concrete is the backbone of modern infrastructure. Its performance depends on the properties of its constituents, mix proportions, and curing methods. Admixtures play a vital role in modifying workability, durability, and strength. Rice husk ash (RHA), a pozzolanic material rich in amorphous silica, has emerged as a sustainable admixture. This paper focuses on the development of multi-component blended concrete using RHA to enhance mechanical and durability properties.

1 A) OBJECTIVES

1. Develop a quaternary blended concrete mix by partially replacing cement with rice husk ash, thereby enhancing performance while promoting sustainability.
2. Investigate the influence of RHA on mechanical properties such as compressive strength and split tensile strength at different curing ages (7, 14, and 28 days), ensuring a comprehensive understanding of strength development over time.
3. Evaluate durability characteristics of RHA-blended concrete, specifically resistance to sulphate attack and chloride penetration, which are critical for structures exposed to aggressive environments such as marine and chemical industries.
4. Optimize the percentage replacement of cement with RHA to identify the most effective proportion that balances strength, durability, and workability without compromising structural integrity.

5. Compare the performance of RHA concrete with conventional concrete, highlighting improvements in strength, microstructural densification, and reduced permeability.
6. Promote environmental sustainability by utilizing agricultural waste (rice husk ash), thereby reducing cement consumption, lowering carbon emissions, and contributing to circular economy practices.
7. Provide experimental validation through laboratory testing of cube, cylinder, and reinforced specimens, ensuring that the findings are practically applicable to real-world construction scenarios.

2. LITERATURE REVIEW

- Zhang et al. (1996) reported that RHA improves compressive strength and modifies hydration products.
- Deepa Nair et al. (2008) highlighted the role of incineration temperature in determining RHA reactivity.
- Jones et al. (1997) demonstrated superior chloride resistance in ternary blended concrete.
- Bagel (1998) showed that slag and silica fume improve pore structure and compressive strength.

These studies confirm the potential of RHA and blended admixtures in enhancing concrete performance.

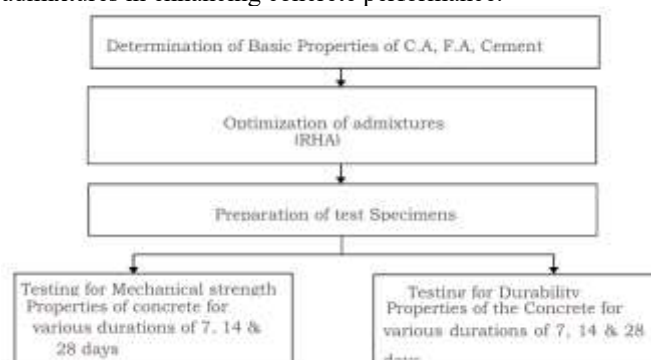


Fig. 1. Methodology flow chart

3. METHODOLOGY

1. Testing basic properties of cement, fine aggregate, and coarse aggregate.
2. Preparing concrete specimens with varying percentages of RHA.

- Conducting mechanical tests (compressive and tensile strength).
- Performing durability tests (sulphate and chloride attack).
- Comparing results with conventional concrete.

4. RESULTS AND DISCUSSION

A. Mechanical Properties

1. Compressive Strength

Concrete cubes (150 mm) were tested at 7, 14, and 28 days.

Table -1: Compressive Strength

Age (days)	Control Concrete (MPa)	RHA Concrete (10%) (MPa)	RHA Concrete (15%) (MPa)
7	22.5	24.8	23.9
14	32.1	35.6	34.2
28	42.8	47.5	45.9

Interpretation: RHA at 10% replacement showed maximum strength gain (approx. 11% higher than control at 28 days).

2. Split Tensile Strength

Cylindrical specimens (150 mm × 300 mm) were tested.

Table -2: Split Tensile Strength

Age (days)	Control Concrete (MPa)	RHA Concrete (10%) (MPa)
7	2.1	2.3
14	2.8	3.0
28	3.4	3.7

Interpretation: RHA improved tensile strength by ~9% at 28 days, indicating better bonding and reduced micro-cracking.

B. Durability Properties

1. Sulphate Attack

Specimens immersed in 5% Na₂SO₄ solution showed reduced weight loss with RHA.

Table -3: Sulphate Attack

Age (days)	Weight Loss (%) Control	Weight Loss (%) RHA (10%)
28	1.8	1.2

Interpretation: RHA reduced sulphate-induced deterioration by ~33%.

2. Chloride Penetration

Rapid Chloride Permeability Test (RCPT) results:

Table -4: Rapid Chloride Permeability Test

Mix Type	Charge Passed (Coulombs)
Control	4200
RHA (10%)	2800

Interpretation: RHA reduced chloride permeability by ~33%, enhancing durability in marine/industrial environments.

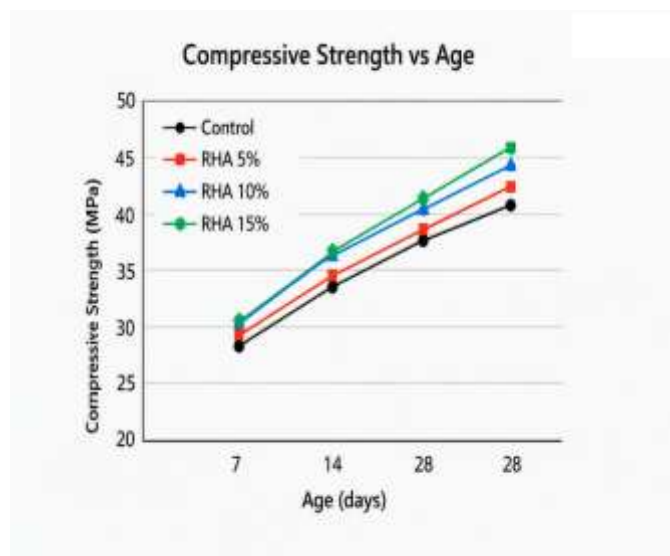


Fig. 2. Compressive strength of concrete mixes at different ages.

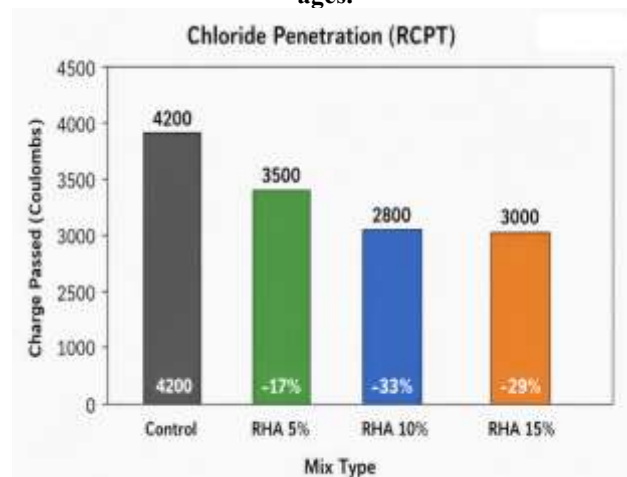


Fig. 3. Split tensile strength of concrete mixes at different ages.

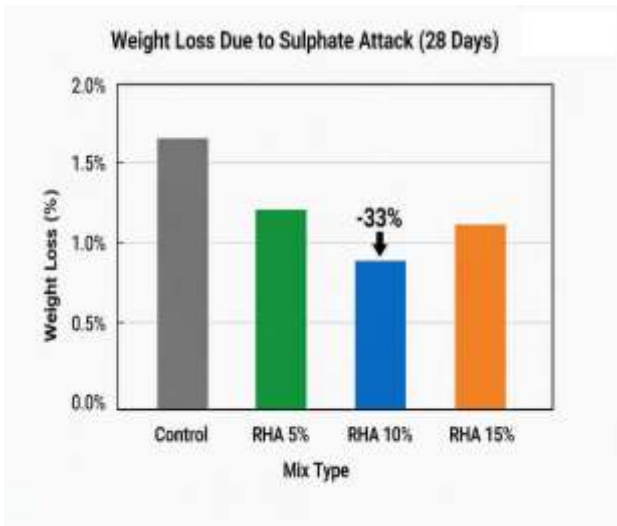


Fig. 4. Weight loss due to sulphate attack after 28 days.



Fig. 7. A view of cast concrete specimens

5. CONCLUSIONS

1. Optimum RHA replacement is 10%, yielding maximum strength and durability.
2. Mechanical properties (compressive and tensile strength) improved significantly.
3. Durability against sulphate and chloride attack enhanced, reducing deterioration risks.
4. RHA utilization promotes sustainability by reducing cement demand and recycling agricultural waste.
5. Multi-component blended concrete with RHA is recommended for chemical industries, marine structures, and sustainable infrastructure projects.

6. FUTURE SCOPE

1. **Long-Term Durability Studies:** Extend testing beyond 28 days to 90, 180, and 365 days to evaluate the long-term performance of RHA concrete under aggressive environments such as marine exposure, industrial effluents, and cyclic wetting-drying conditions.
2. **Microstructural Analysis:** Employ advanced characterization techniques such as Scanning Electron Microscopy (SEM), X-ray Diffraction (XRD), and Fourier Transform Infrared Spectroscopy (FTIR) to study the microstructural changes and hydration products in RHA-blended concrete.
3. **Nano-Technology Integration:** Investigate the synergy between RHA and nano-materials (e.g., nano-silica, nano-alumina) to further refine pore structure, enhance strength, and improve resistance to chemical attack.
4. **Life-Cycle Assessment (LCA):** Conduct environmental impact studies to quantify reductions in carbon footprint, energy consumption, and greenhouse gas emissions when RHA replaces cement in large-scale projects.
5. **Performance in Reinforced Concrete Structures:** Evaluate the effect of RHA on bond strength

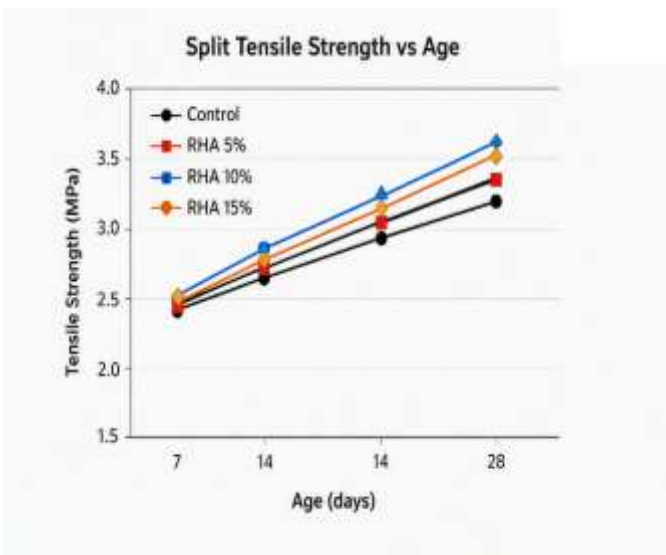


Fig. 5. Chloride penetration results (RCPT).



Fig. 6. Casting of concrete specimens

between concrete and reinforcement, corrosion resistance of steel in chloride-rich environments, and structural performance under load.

6. **Optimization of Mix Design:** Explore machine learning and artificial intelligence-based optimization techniques to determine the most effective blend proportions of RHA with other SCMs such as fly ash, slag, and silica fume.
7. **Field Applications and Pilot Projects:** Implement RHA concrete in real-world construction projects (e.g., pavements, marine structures, industrial flooring) to validate laboratory findings under practical conditions.
8. **Economic Feasibility Studies:** Assess cost savings achieved through reduced cement consumption and utilization of locally available agricultural waste, thereby promoting circular economy practices.
9. **Hybrid Blended Systems:** Investigate quaternary or quinary blends combining RHA with other industrial by-products to achieve tailored performance for specific applications such as high-strength concrete, self-compacting concrete, or lightweight concrete.

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