© April 2025 | IJIRT | Volume 11 Issue 11 | ISSN: 2349-6002

Utilizing Rice Husk Ash (Rha) As A Partial Substitute for Cement in M30 Concrete Mix

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Abstract—**This study examines the behaviour of concrete when Ordinary Portland Cement (OPC) is partially replaced by Rice Husk Ash (RHA) in varying proportions: 0%, 5%, 10%, and 15% by weight. The 0% replacement serves as the control sample. Experimental analyses include the Compacting Factor test for fresh concrete and the Compressive Strength test for 150mm concrete cubes cured in water for periods of 7, 14, and 28 days. Results show that increasing RHA content leads to a reduction in both the Compacting Factor and the compressive strength of concrete. The paper emphasizes the need for further research to determine the viability and optimal usage of RHA as a partial alternative to OPC in concrete formulations.**

I. INTRODUCTION

What is R.H.A. Rice husk ash (RHA) is the ash produced by burning rice husks. It is rich in silica and is used in various applications, including:

• Concrete and cement: Enhances strength and durability.

• Soil amendment: Improves fertility.

• Energy: Used as a renewable energy source.

• Water purification: Removes pollutants.

• Silica extraction: For electronics, ceramics, and cosmetics.

It's a versatile byproduct with several industrial and environmental uses.

Properties of R.H.A. The key properties of Rice Husk Ash (RHA) include: High Silica Content: RHA contains 70-90% silica (SiO_2), which makes it useful for various applications, especially in construction and manufacturing. Fine Particle Size: It has a very fine, powdery texture, which enhances its ability to be mixed with other materials like cement or used in filtration processes. Alkalinity: RHA is alkaline in nature, which contributes to its effectiveness as a soil amendment and in certain chemical processes. Low Bulk Density: Due to its light, fluffy nature, RHA has low bulk density, making it easy to transport and handle. Poisonous Trace Elements: RHA may contain trace amounts of heavy metals, so proper handling and disposal are important. Good Pozzolanic Properties: RHA reacts with lime in the presence of water to form compounds that improve the strength of concrete. Absorbent: It has good adsorption properties, making it effective in applications like water purification. Thermal Stability: RHA can withstand high temperatures, which is important for its use in industrial processes. These properties make RHA a valuable byproduct for multiple industries, including construction, agriculture, and energy production

II. OBJECTIVE

The use of Rice Husk Ash (RHA) as a replacement for cement in concrete has several key objectives, including:

1. Improved Durability: RHA enhances the durability of concrete by reducing the permeability, making it more resistant to water, chemicals, and aggressive environmental conditions.
2. Reduced Carbon Footprint: Replacing cement with RHA helps in lowering CO_2 emissions, as cement production is energy-intensive and contributes significantly to greenhouse gas emissions.
3. Waste Utilization: RHA is a byproduct of rice milling, and its use in concrete provides an environmentally-friendly solution for utilizing agricultural waste, reducing landfill waste.

4. Enhanced Strength: Properly processed RHA can improve the compressive strength of concrete over time by contributing to the pozzolanic reaction, which forms additional cementitious compounds.
5. Cost Reduction: RHA is often cheaper than cement, which can lower the overall cost of concrete production, especially in regions where rice husks are readily available.
6. Improved Workability: RHA can enhance the workability of concrete by improving its flow and ease of handling during mixing and placing.

III. METHODOLOGY

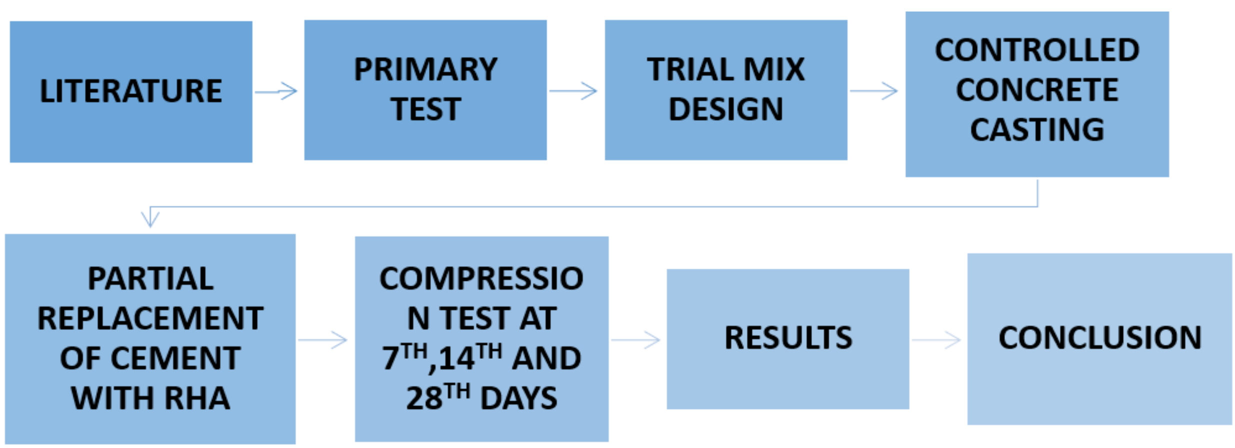
The methodology for replacing cement with rice husk ash (RHA) in concrete involves several steps to ensure a sustainable, high-performance material. Material preparation is the first crucial stage, where rice husks are collected, burned at temperatures between 600-700°C to convert them into ash, and then ground to a fine powder (usually passing through a 45 µm sieve). This process enhances the pozzolanic properties of the ash, allowing it to react with calcium hydroxide (Ca $(OH)_2$) from the cement to form additional calcium silicate hydrate (C-S-H), improving concrete strength and durability.

The mix design includes partial replacement of cement with RHA, typically between 5% and 30% by weight, with a common range being 10-15%. The water-cement ratio may need adjustment due to RHA's higher water absorption. Superplasticizers may also be added to improve workability, especially with higher RHA content.

Once the mix is designed, the materials (cement, RHA, aggregates, and water) are mixed thoroughly, ensuring uniformity. The mixture is then cast into moulds, compacted to remove air voids, and cured under controlled conditions (e.g., submerged in water) for 7, 14, or 28 days.

This methodology promotes sustainable construction by reducing cement consumption and utilizing agricultural waste, contributing to lower environmental impact.

IV. FLOW CHART



V. MIX DESIGN

In concrete mix design, replacing cement with materials like fly ash, slag, or silica fume is a common practice to improve durability and reduce environmental impact. Here's a general approach to designing a concrete mix for M30 grade concrete with 5%, 10%, and 15% replacement of cement by a supplementary material (e.g., fly ash or slag).

Given:

- Concrete Grade: M30 (characteristic strength 30 MPa at 28 days)
- Cement Replacement: 5%, 10%, 15%
- Workability: 25-75 mm (slump)
- Mix Design Method: IS 10262:2019 (Indian Standard for mix design)

SLUMP TEST - procedure to determine workability of fresh concrete by slump test

- Prepare Equipment: Get the slump cone, tamping rod, base plate, measuring tape, scoop, and trowel.

- Collect Concrete Sample: Take a sample of fresh concrete to be tested.
- Position Slump Cone: Place the cone on a flat, non-absorbent surface.
- Fill the Cone:
- Fill the cone in 3 layers, each about 1/3 of the cone's height.
- Tamp each layer with 25 strokes using the tamping rod.
- Level the Surface: Strike off the excess concrete at the top of the cone.
- Lift the Cone: Remove the cone slowly and vertically without disturbing the concrete.
- Measure the Slump: Measure the vertical distance between the original height of the cone and the height of the slumped concrete.
- Interpret Results: The difference is the slump value, indicating the workability of the concrete.

Slump test being performed

Slump height begins checked after removal of mould


Casting of concrete cubes

	Compressive strength (N/mm2)			
Days	0% RHA	5% RHA	10% RHA	15% RHA
7	20	20.3	20.5	21
14	27	27.6	28	27.2
28	30	32.4	33.2	34

COMPRESSIVE STRENGTH - Compressive strength at different curing days

VI. PRO AND CONS

ADVANTAGES OF RHA

1. Environmental Benefits: RHA is a sustainable by-product, reducing waste from rice milling.
2. Rich in Silica: Contains a high level of silica, which makes it valuable in construction materials.
3. Enhanced Concrete Strength: When added to concrete, RHA improves its compressive strength and durability.
4. Soil Fertility: Used as a soil amendment, RHA enhances soil texture and nutrient content.
5. Cost-Effective: It’s a low-cost alternative to expensive industrial materials.

DISADVANTAGES OF RHA

1. High Carbon Content: If not properly processed, RHA retains high carbon levels, which can affect its effectiveness in certain applications.
2. Inconsistent Quality: The composition of RHA can vary depending on rice variety and burning process, leading to inconsistent properties.
3. Handling and Storage: It can be challenging to handle due to its fine, dusty nature, which may pose health risks when inhaled.
4. Limited Availability: In regions with low rice production, RHA may not be available in sufficient quantities.
5. Low Reactivity: In some applications, RHA’s low reactivity compared to other industrial by-products can limit its utility.

VII. CONCLUSION

- Improved Concrete Strength: RHA enhances the compressive strength of concrete by contributing to the formation of a denser microstructure.
- Durability: It increases concrete's resistance to chemical attacks, improving long-term durability.
- High Silica Content: The silica in RHA reacts with lime in cement, forming stronger bonds and improving overall strength.
- Sustainability: Using RHA in construction reduces environmental impact by recycling agricultural waste and lowering CO_2 emissions.
- Processing Dependency: The strength benefits of RHA depend on proper processing, including controlled burning and particle size optimization.

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