# Investigation of The Mechanical Properties of Concrete With And Without the Addition of The Rice Husk Ash As An Additive

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**Abstract -** *The potential of using rice husk ash (RHA) in substitution of some of the cement in M35 grade concrete is investigated in this study. The goal is to preserve or improve concrete's performance while lessening cement's negative environmental effects. RHA was used at weight percentages of 5%, 10%, 15%, and 20% in place of cement. Compressive strength (CS) and flexural (FS) were tested at 7, 14, and 28 days, and workability was assessed using the slump test. Results show that the optimal performance was achieved at 15% RHA replacement, which provided higher compressive (46.5 N/mm²) and flexural strength (4.76 N/mm²) compared to control. However, workability reduced as RHA content increased. This indicates that RHA can effectively enhance strength properties if used in controlled proportions. The study concludes that RHA is a viable supplementary cementitious material in concrete production.*

***Key Words***: Compressive Strength (CS), Flexural Strength (FS), Slump Test (ST), Specific Gravity (SG), Cement Replacement, Sustainable Concrete, Pozzolanic Material

## 1. INTRODUCTION

Concrete is the most widely used building material worldwide, and cement is its main binding agent (Aïtcin, 2000). However, the manufacturing of cement has a major impact on environmental deterioration and CO2 emissions. To cut down on cement usage, there has been an increasing interest in investigating supplemental cementitious materials (SCMs) in recent years. One such promising material is RHA, a by-product of rice milling industries. RHA is rich in silica and possesses pozzolanic properties, making it suitable for use in concrete (Antiohos, Papadakis, & Tsimas, 2014). This study examines how using RHA in different amounts to partially replace cement affects the qualities of concrete both when it is fresh and when it has hardened.

## 2. OBJECTIVES

- To examine how concrete's compressive and flexural strengths are affected when RHA is used in place of some of the cement.
- To assess the workability of RHA-based concrete using the slump test.
- To verify the specific gravity (SG) of cement used in the mixes.

## 3. LITERATURE REVIEW

RHA's high silica content and pozzolanic qualities have led to years of research into its use as an additional cementitious material. Chopra, Siddique, and Kunal (2015) emphasized that finely ground RHA enhances the durability and impermeability of concrete, making it more resistant to chemical attacks. According to Sathawane, Vairagade, and Kene (2013), adding up to 15% RHA in place of cement enhanced concrete's mechanical properties, especially its compressive strength, while lowering bleeding and segregation. Experiments by Bui et al. (2005) showed that RHA helps to improve the pore structure of concrete, which increases its strength and decreases its permeability. Zahedi, Ramezanianpour, and Ramezanianpour (2015) found that incorporating RHA increased flexural strength and reduced chloride permeability, especially when used in proportions less than 20%. These studies support the hypothesis that RHA can be a viable alternative to conventional cement, particularly when used in optimal amounts. However, it is also widely acknowledged that excessive replacement of cement with RHA may lead to a decline in workability and strength, primarily due to high water demanding nature and surface area.

## 4. MATERIALS AND METHODS

### 4.1 MATERIALS

- **Cement:** Ordinary Portland Cement (OPC), specific gravity: 3.15
- **RHA)** Fine powder form
- **Aggregates:** Standard fine and coarse aggregates
- **Water:** Clean potable water used for mixing and curing

### 4.2 CONCRETE MIX DESING

- Concrete grade: M35
- Application of RHAs: 0%, 5%, 10%, 15%, 20% by weight of cement

- Water-cement ratio maintained uniformly
- Five mix designations (Mix1–Mix5) based on RHA percentage

**Table -1:** Mix Design

| Mix Designation | RHA (%) |
|---|---|
| **Mix1** | 0 |
| **Mix2** | 5 |
| **Mix3** | 10 |
| **Mix4** | 15 |
| **Mix5** | 20 |

### 4.3 TESTING PROCEUDRE

The performance of RHA-blended concrete was assessed using a number of common laboratory tests. The slump test, which measures the fresh concrete's compaction and ease of installation, was used to evaluate workability. To see how concrete strength changes over time, cube examples were inspected after seven, fourteen, and thirty-eight days of curing. In order to determine how the concrete will respond to bending strains, FS tests were also conducted on beam specimens at the same curing times. Using a Le Chatelier flask, the study measured the SG of cement by comparing the weight of cement in a given volume to the weight of an equal volume of water. They gave us a clear picture of how fresh and hardened concrete behave at different replacement rates of RHA.

## 5. RESULTS

### 5.1 Specific Gravity Test

In this investigation, the Le Chatelier flask method was employed to evaluate the cement's SG. A comparison was made between the weight of an equivalent volume of water (23.81 g) and the volume displacement of 75 grammes of cement. The specific gravity, as determined by the conventional formula, was 3.15, falling within the typical range for OPC.The value was included in the mix design to help determine the correct amount of each material in every concrete mix.

### 5.2 Slump Test

The workability of fresh concrete for varying RHA replacement levels was assessed using the slump test. With the maximum slump value of 83 mm, the control mix (Mix 1) demonstrated exceptional workability. As the percentage of RHA increased, the slump value decreased, reaching 58 mm for Mix4 (15% RHA). However, Mix5 (20% RHA) showed a slight increase in slump to 63 mm. This variation is attributed to the high porous and fineness nature of RHA, which increases the water demand and thereby reduces workability. Despite the reduction, all mixes maintained acceptable workability for placement and compaction.

**Table -2: Slump Test**

| Mix Designation | Slump Value (mm) |
|---|---|
| **Mix1** | 83 |
| **Mix2** | 74 |
| **Mix3** | 68 |
| **Mix4** | 58 |
| **Mix5** | 63 |

### 5.3 Compressive Strength Test

To evaluate the strength growth over time with different RHA content, CS was measured at 7, 14, and 28 days. According to the data, strength generally improved when RHA was raised by 15%. The maximum 28-day strength of 46.5 $N/mm^2$ was attained by Mix4, which had 15% RHA replacement, outperforming the control mix (Mix1), which had 40.83 $N/mm^2$. This improvement is likely due to the pozzolanic reaction of RHA with calcium hydroxide, leading to additional C–S–H gel formation. Mix5 (20% RHA) showed a slight reduction in strength to 43 $N/mm^2$, suggesting that beyond a certain level, the dilution of cementitious content begins to affect performance negatively.

**Table -2: Compressive Strength Test**

| Mix Designation | 7 Days ($N/mm^2$) | 14 Days ($N/mm^2$) | 28 Days ($N/mm^2$) |
|---|---|---|---|
| **Mix1** | 27.03 | 34.53 | 40.83 |
| **Mix2** | 29.03 | 36.30 | 41.50 |
| **Mix3** | 30.83 | 36.60 | 45.10 |
| **Mix4** | 29.13 | 37.50 | 46.50 |
| **Mix5** | 28.53 | 35.00 | 43.00 |

### 5.4 Flexural Strength Test

The FS of concrete beams was tested at 7, 14, and 28 days to examine how RHA impacts the bending capacity of concrete. Like compressive strength, flexural strength improved with increasing RHA content up to 15%. Mix4 recorded the highest 28-day flexural strength of 4.76 $N/mm^2$, compared to the control mix's 4.47 $N/mm^2$. This indicates that RHA contributes to better matrix densification and enhanced bonding within the concrete. Mix5 showed a slight drop to 4.59 $N/mm^2$, consistent with the trend seen in compressive strength tests.

**Table -3:** Flexural Strength Test

| Mix Designation | 7 Days (N/mm$^2$) | 14 Days (N/mm$^2$) | 28 Days (N/mm$^2$) |
|---|---|---|---|
| **Mix1** | 3.64 | 4.11 | 4.47 |
| **Mix2** | 3.77 | 4.18 | 4.51 |
| **Mix3** | 3.89 | 4.23 | 4.70 |
| **Mix4** | 3.93 | 4.29 | 4.76 |
| **Mix5** | 3.74 | 4.14 | 4.59 |

## 6. CONCLUSION

This study assessed how the properties of M35 grade concrete, whether it was in fresh or hardened state, were affected when RHA was used in part in place of cement. The experimental results allow for the drawing of the following conclusions:

1. In comparison to the control mix, the addition of RHA up to 15% increased both CS and FS. The maximum 28-day CS of 46.5 N/mm$^2$ and FS of 4.76 N/mm$^2$ were demonstrated by the mix containing 15% RHA (Mix4).

2. The increase in mechanical performance is due to the pozzolanic activity of RHA, which promotes the formation of additional C-S-H and densifies the concrete matrix.

3. The high surface area and water absorption properties of RHA were the main causes of the slump test's finding that workability decreased as RHA concentration increased. Nevertheless, the slump values remained within acceptable limits for construction purposes.

4. A slight decrease in strength was observed at 20% RHA replacement, indicating that excessive substitution may dilute the cementitious matrix and negatively affect performance.

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