International Journal of Engineering Trends and Applications (IJETA) – Volume 12, Issue 5, Sep-Oct 2025

RESEARCH ARTICLE OPEN ACCESS

Experimental Investigation on Concrete Performance Using Rice Husk Ash, Silica Fume, and Iron Slag as Partial Cement Replacements

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ABSTRACT

In recent years, climate change and environmental degradation have emerged as critical global challenges. Both government bodies and the industrial sector must adopt eco-friendly policies and sustainable practices to mitigate these issues. It is essential to focus on sustainable construction and waste management approaches that incorporate greenhouse gas reduction strategies, energy-efficient technologies, and the utilization of renewable energy sources. Efficient use and recycling of resources and waste materials can significantly contribute to environmental preservation and sustainability. The optimal utilization of industrial and agricultural waste materials such as blast furnace slag, rice husk ash, glass powder, silica fume, and iron slag in concrete production enhances not only the engineering and economic performance but also the environmental sustainability of construction activities. The use of these waste-based materials as supplementary cementitious components supports the achievement of global sustainable development goals. In this study, an experimental analysis has been conducted to investigate the partial replacement of cement with rice husk ash, silica fume, and iron slag in concrete. The research focuses on evaluating the compressive and flexural strength characteristics of the modified concrete mixtures. The results demonstrate that the inclusion of these industrial by-products can improve the mechanical properties of concrete while reducing its environmental impact, thus offering an eco-efficient alternative for sustainable construction.

Keywords — Cement, concrete, Rice Hunk Ash, Silica Fume, Eco-friendly, Compressive Strength, Flexural Strength.

1. INTRODUCTION

Concrete production requires a substantial amount of natural resources such as fuel, sand, and aggregates. To address the depletion of these resources and reduce environmental impacts, researchers have increasingly focused on utilizing various waste materials and industrial by-products as potential alternatives in the construction industry [1–2]. The incorporation of by-products such as waste glass, fly ash, plastic, slag, and microbeads into concrete not only conserves natural resources but also aligns with the broader goal of achieving sustainable development in construction practices [3–4].

Sustainable construction materials are those that can be reused, recycled, and repurposed to meet future demands while minimizing environmental damage. These materials help reduce the emission of harmful gases such as carbon dioxide (CO_2) and other greenhouse gases, which are major contributors to global warming [5]. Moreover, such eco-friendly materials are thermally efficient, require less fuel and energy for processing, and exhibit lower toxicity compared to conventional construction materials. Their recyclability, reduced emissions, and economic viability make them a promising choice for sustainable construction applications [6].

In this context, the use of rice husk ash (RHA) in concrete presents a viable and scientific approach to promoting sustainability in construction. Rice husk is an agricultural by-product that is often disposed of by open burning, resulting in significant environmental pollution and wastage of a potentially valuable resource. Its improper disposal not only causes air and land pollution but also involves high costs without generating any economic return. Utilizing RHA as a partial replacement for cement can effectively reduce the environmental burden while simultaneously lowering the overall cost of concrete production and enhancing its mechanical properties [7].

This study focuses on the investigation of rice husk ash and lime as partial cement substitutes to determine their effect on the compressive strength of concrete. Experimental analysis has been conducted to identify the optimum water-cement ratio and mix proportion that yield desirable strength characteristics. The results suggest that incorporating rice husk ash contributes to improved durability, strength, and sustainability, making it a promising material for eco-efficient concrete production.

2. RICE HUSK ASH

Rice husk debris (RHA) fillers are gotten from rice husks, which are typically seen as agrarian waste and an environmental risk. Rice husk, when expended in outside the rice plant, yields two sorts of flotsam and jetsam that can fill in as fillers in plastics materials. The rice paddy preparing adventures give the outcome rice husk. As a result of the extending pace of environmental defilement and the idea of practicality factor have made utilizing rice husk. The clarifications for the use of rice husk as a possibility for concrete in strong gathering are explained in the going with zones. To have a fitting idea on the introduction of rice husk in concrete, a point by point concentrate on its properties must be finished. Around 100 million tons of rice paddy make reactions are gotten the world over. They have a low mass thickness of 90 to 150kg/m^3. This results in a more vital estimation of dry volume. The rice husk itself has an unforgiving surface which is harsh in nature. These are therefore impenetrable to normal defilement. This would achieve unseemly expulsion issues. Among all dares to reuse this thing, cement, and strong gathering ventures are the ones who can use rice husk in a prevalent way.

Rice Husk Ash is an agricultural waste obtained from milling of rice. This is usually being thrown away to the landfill without further use, thus contribute to environmental pollution. Rice Husk Ash is a by-product from the burning of Rice Husk under controlled temperature and burning time. In the present investigation Rice Husk Ash was partially replaced in Portland cement at various percentages to study compressive strengths and split tensile strengths. The physical properties and chemical composition of rice husk ash [8].

Table 1. Physical Properties of Rice Husk Ash [8]

S. No.	Property	Test Result
1	Density	495 kg/m^3
2	Specific Gravity	2.53
3	Mean particle size	0.15-0.25μm
4	Colour	Grey
5	Min specific surface area	220m^2/kg
6	Particle shape	Spherical
7	Moisture contents (% by weights)	2.15

3. SIGNIFICATION OF THE WORK

Now a day mostly construction structure based on concrete so its demands increasing gradually, the use of rice hush ash, silica fume & iron slag as a partial replacement with cement leads to a great results in achieve new goals. Recent research find that concrete made by using rice hush ash are capable to gives good compressive strength and thermal insulation property [9-10]. The use of rice hush ash as greatly enhance the weight of concrete and helps in making light weight concrete. The major aim of this study is to achieve a good environment policies to reduce the disposal and burning of rice hush ash directly into the environment so it help in reducing greenhouse concentration.

In this study the waste materials used are in the form of rice hush ash, silica fume & iron slag is added in partial in cement and it is collected directly from the agricultural filed. Than it is burnt to find ash of rice husk and sieved from 90 micron sieve to achieve fineness similar to cement and others material also sieved from 90 micron sieve to achieve fineness similar to cement.

4. EXPERIMENT WORK AND RESULT

The controlled burning and grinding of rice husk ash (RHA) have been utilized to optimize its use as a pozzolanic material in concrete. Incorporating RHA offers several advantages, including improved strength and durability properties, as well as environmental benefits such as waste material disposal and reduced carbon dioxide emissions. However, there has been limited research on the use of RHA as a supplementary material in cement and concrete production.

For instance, a recently published paper explored the production of RHA by burning rice husk in a drum incinerator. The study investigated the effect of particle size on the strength of RHA blended gap-graded Portland cement concrete. Given the scarcity of research in this area, the current study aims to examine the compressive strength of concrete containing residual RHA generated from burning rice husk pellets, as well as RHA obtained after grinding the residual RHA. The study specifically focuses on analyzing the impact of partially replacing cement with different percentages of ground RHA on the compressive strength of concrete. By conducting this research, a better understanding of the potential benefits and effectiveness of incorporating RHA in concrete production can be gained.

Compressive Strength

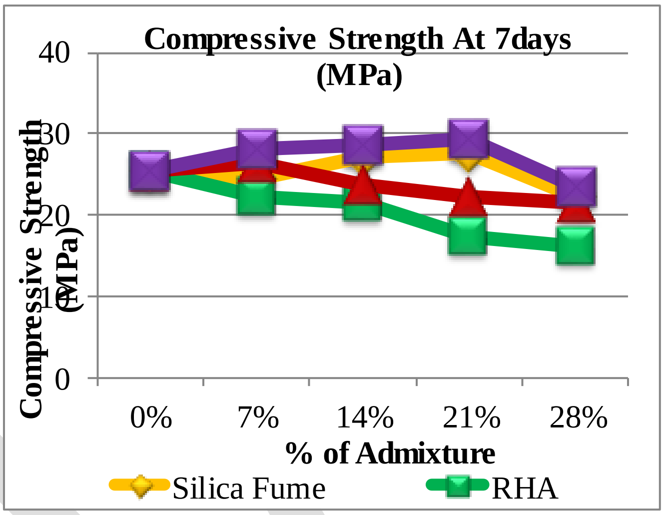

Fig. 1: Compressive strength of concrete after 7 days with varied percentages of mineral additive in place of cement

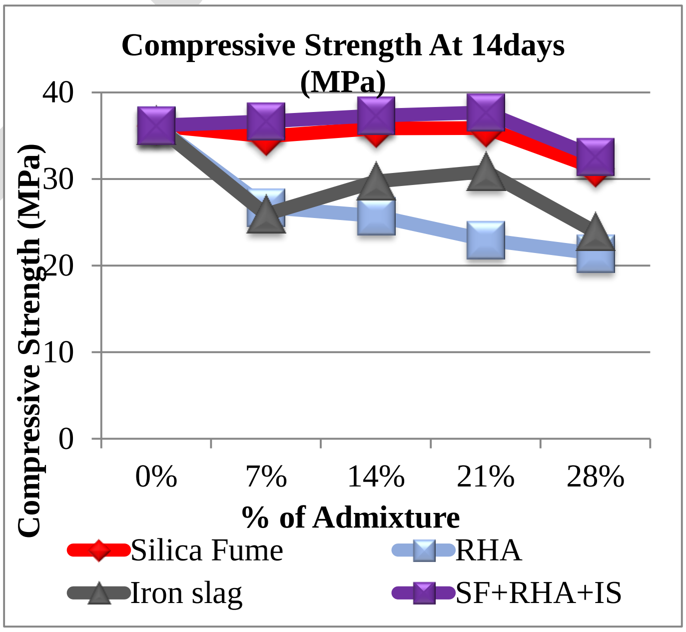

Fig. 2: Compressive strength of concrete after 14 days with varied percentages of mineral additive in place of cement

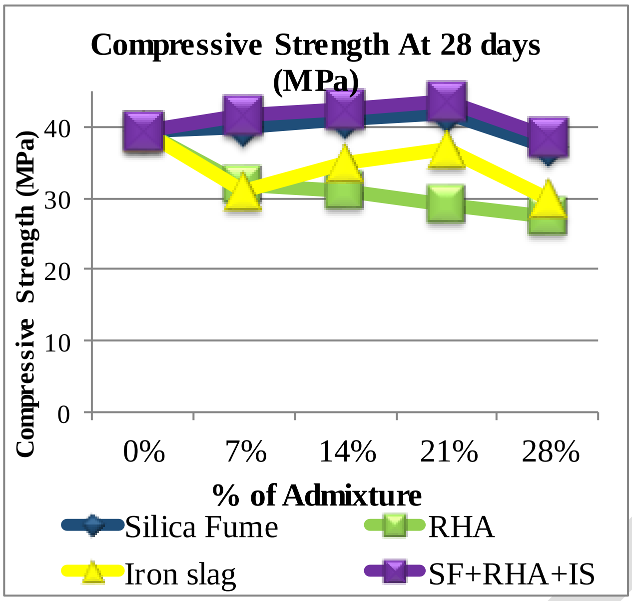

Fig. 3: Compressive strength of concrete after 28 days with varied percentages of mineral additive in place of cement

In Figure 1, 2 and 3 showed the compressive strength at 7, 14 and 28days with varied percentage of replacement of rice husk ash (RHA), silica fume, iron slag.

Flexural Strength

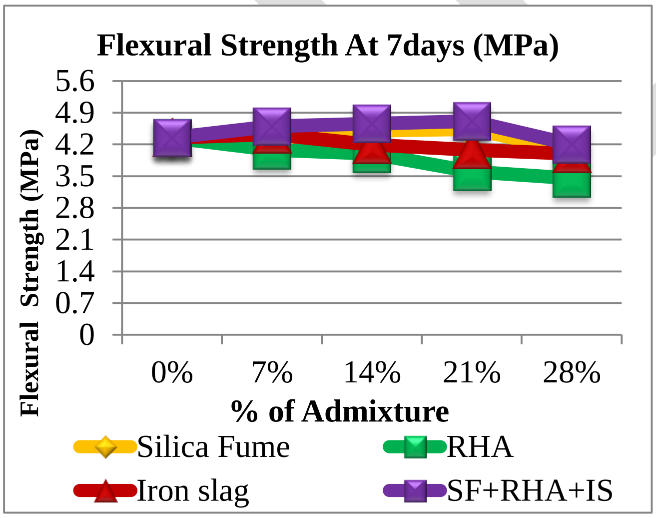

Fig. 4: Flexural strength of concrete after 7 days with varied percentages of mineral additive in place of cement

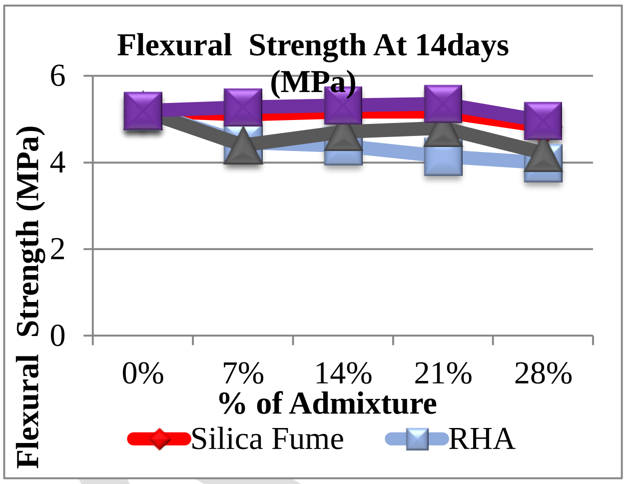

Fig. 5: Flexural Strength of Concrete after 14 Days with Various% of Mineral Admixture in Place of Cement

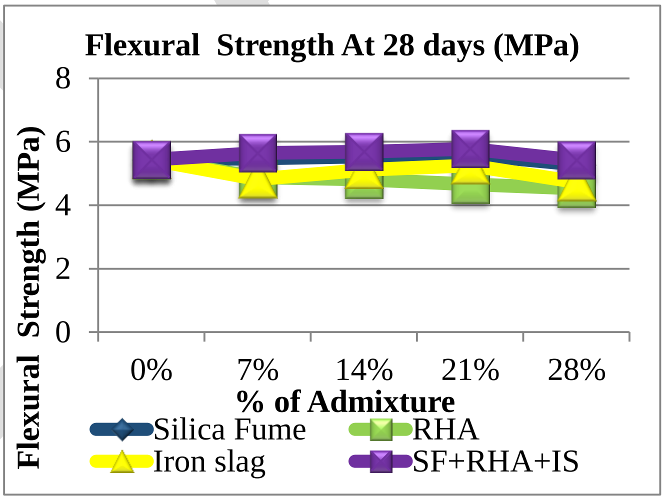

Fig. 6: Flexural strength of concrete after 28 days with various percentages of mineral additives in place of cement

In Figure 4, 5 and 6 showed the flexural strength at 7, 14 and 28days with varied percentage of replacement of rice husk ash (RHA), silica fume, iron slag.

5. CONCLUSIONS

Compressive Strength

- At 7 days, maximum compressive strength is 29.4 MPA until 21% combine addition, at which point compressive strength starts to decline due to combined addition of variable% of (SF+IS+RHA) when replacement of cement occurs.

- Compressive strength resulting from the combined addition of increasing percentages of (SF+IS+RHA) as cement replacement occurs at 14 days reaches a high of 37.67 MPA up until the combined addition of 21%, at which point compressive strength starts to decline.
- At 28 days, the maximum compressive strength is 43.8 MPA up to a combined addition of different percentages of (SF+IS+RHA) when cement replacement occurs. After that, the compressive strength starts to decline

Flexural Strength

- Flexural strength reaches a high of 4.718 MPA at 7 days due to the combined addition of varied percentages of (SF+IS+RHA) when cement replacement occurs, but starts to decline at 21% combination addition.
- Flexural strength reaches its peak at 14 days due to the combined addition of varied percentages of (SF+IS+RHA) when cement replacement takes place, and it remains there until 21% of the combined addition, at which point it begins to decline
- Flexural strength reaches its peak at 28 days due to the combined addition of varied percentages of (SF+IS+RHA) when cement replacement takes place, and it remains there until 21% of the combined addition, at which point it begins to decline.

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