EVOLUTION OF CONCRETE INCORPORATING RICE HUSK ASH

Abstract

Concrete, as its name implies, is an eco-friendly solution that contributes to environmental preservation by utilizing industrial byproducts, such as rice husk ash, to create concrete structures that conserve resources. This study investigates the characteristics of rice husk ash when employed as a partial substitute for Portland pozzolana cement within concrete compositions. Substitution ratios of 0% to 30% by weight of rice husk ash for Portland pozzolana cement were considered. Compressive strength tests were conducted on 150mm hardened concrete cubes after 7 and 28 days of water curing. The introduction of rice husk ash to Portland cement notably enhances the concrete's strength. The research further examines the impact of varying proportions of rice husk ash on the physical and mechanical traits of the concrete, evaluated through compressive strength, Young's modulus, and flexural strength measurements. These findings were juxtaposed with those of a control sample to authenticate the feasibility and efficacy of incorporating rice husk ash into the concrete mixture.

Keywords: Concrete, Compressive Strength, Rice Husk Ash.

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I. INTRODUCTION

Throughout the 20th century, there has been a notable rise in the utilization of mineral admixtures within the cement and concrete sectors, a trend that is projected to persist and intensify. The growing requirement for cement and concrete is being fulfilled through the practice of partial cement replacement. This approach not only addresses the escalating demand but also holds the potential for substantial energy and cost savings. The incorporation of industrial byproducts as admixtures in concrete has been recognized for its capacity to substantially enhance workability and durability, offering significant benefits to the construction industry.

Employing by-products presents an environmentally conscious approach to managing substantial volumes of materials that would otherwise contaminate soil, water, and air. The current global cement production rate, standing at around 1.2 billion tons per year, is anticipated to experience rapid growth, reaching approximately 3 billion tons per year by 2011. The majority of this heightened demand for cement will be satisfied through the utilization of supplementary cementing materials. This strategic shift is essential, given that each ton of Portland cement clinker manufacturing is linked to a commensurate release of CO_2 emissions, thus underscoring the imperative for sustainable alternatives.

Rice husk, an agricultural residue, constitutes approximately one-fifth of the 500 million tons of rice produced globally each year. Through controlled combustion of rice husks under specific temperature and atmospheric conditions, a remarkably reactive rice husk ash is obtained. Research has demonstrated that even minor amounts of inert filler have historically been acceptable as substitutes for cement. This significance is amplified when the fillers possess pozzolanic properties, as they not only confer technical benefits to the resulting concrete but also enable substantial reduction in cement usage.

The utilization of pozzolana in concrete offers a multitude of advantages. Enhanced workability is achieved at minimal replacement levels, and when employing pozzolana with low carbon content. Additional benefits include diminished bleeding and segregation tendencies, reduced heat generation during hydration, as well as decreased creep and shrinkage tendencies within the concrete structure.

Rice husk ash emerges as a by-product resulting from the incineration of rice husks, a phenomenon particularly prevalent in East and Southeast Asia due to the prolific rice cultivation in these regions. The fertile land and tropical climate provide ideal conditions for rice cultivation, which is extensively harnessed by countries in this Asian vicinity. During the farming process, the rice husks are separated from the rice before the latter is marketed and consumed. The practice of burning these rice husks in kilns has proven advantageous for creating diverse products. Subsequently, the rice husk ash finds application as a substitute or additive in cement. This comprehensive utilization of the entire rice product underscores an efficient and environmentally friendly approach. In this article, we delve into the conventional processes involved in burning rice husks and highlight the benefits associated with incorporating the resulting ash into cement. This endeavor primarily aims to foster structural advancements, particularly in the East and Southeast Asian regions where rice production and its subsequent utilization are pivotal.

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The aim of this study is to utilize locally sourced rice husk ash (RHA) to replace cement in concrete at elevated ratios, while achieving comparable compressive strength to that of traditional cement concrete.

II. MATERIALS USED

The materials used for making high volume RHA concrete specimens are cement, fine aggregate, coarse aggregate, RHA.

1. **Cement:** The cement employed in this study is of PPC 53 grade, in adherence to the standard specifications obtained from the local market, which align with IS 12269-2009 guidelines and presented in Table 1.

Table 1: Physical Properties of Cement

Sl. No.	Description	Values	Remarks
1	Consistency	34%	Tested results are satisfactory
2	Initial setting time	68minutes	
3	Final setting time	392 minutes	
4.	Specific gravity	3.10	
5.	Fineness of Cement	3%	

2. **Coarse Aggregate:** Aggregate of typical granite that has been fractured into pieces larger than 12 mm. Utilised was natural granite aggregate with a fineness module of 3.70, and a density of 1600 kg/m^3. Water absorption was found to be 0.5% and specific gravity to be 2.70.

3. **Fine Aggregate:** The natural fine aggregate has a specific gravity of 2.50, a fineness modulus of 2.60, density of 1700 kg/m^3 and Zone – II satisfying IS 383:2016.

4. **Water:** The casting of the concrete specimens was done using regular tap water.

5. **Rice Husk Ash:** Rice husk, commonly referred to as rice hull, constitutes the outermost layer of the paddy grain and is separated from the brown rice during rice milling. The process of burning rice husk yields the RHA. The RHA utilized in this research was sourced from a local rice mill in Cuddalore. To ensure consistent chemical composition, samples were exclusively obtained from a single batch of ash disposal for the entire duration of the project. The ash underwent grinding to achieve the desired level of fineness and was subsequently sieved through a 600 µm sieve to eliminate any impurities or larger particles. Table 2 represents the chemical composition of RHA

Table 2: Represents the Chemical Composition of RHA

S.No.	Oxides	Percentage by Weight
1	SiO_2	94.30
2	Al_2O_3	0.233
3	Fe_2O_3	0.126
4	CaO	0.612

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5	Mgo	0.432
6	Na_2O	0.033
7	K_2O	2.39

RHA represents the inorganic residue derived from lignite subsequent to its combustion in boilers. Its composition primarily comprises elements like silica, alumina, and calcium oxide, among others. A notable characteristic of the RHA employed in producing high-volume RHA concrete is its CaO content, exceeding 10%. The RHA possesses a dark grey hue, and its fineness is measured at 387.5 kg/m³. The specific gravity of the RHA measures at [specific gravity value]. To maintain the consistency of RHA properties, a singular source of RHA was exclusively used, preventing significant alterations.

III. EXPERIMENTAL INVESTIGATION

During the initial stage of this investigation, we analyze the strength under compression of various grades of cement mortar. This is accomplished by introducing varying proportions of Rice Husk Ash (RHA), ranging from 0% to 30%, as a partial substitute for cement. In the subsequent phase, the RHA specimens undergo a refinement process where particles smaller than 150 microns are removed through screening. The concrete utilized for the experiments adheres to the M30 grade standard outlined in IS 10262, and its performance is assessed after being cured for 28 days. Subsequently, we compare the strength characteristics of the concrete samples containing RHA substitution with those of conventional concrete.

In the basic mix the water, cement and aggregate ratio are 1: 2.01 : 3.25 for M30 Grade concrete. In the first mix 10% of RHA is added to the concrete, in the second mix 20% of RHA is added to the concrete and in the third mix 30% of RHA is added to the concrete. The mix proportioning specifications are detailed in Table 3.

Table 3: Proportion of Mix Ingredients (For $1m^3$ of Concrete)

Rice Hush Ask (%)	Cement (Kg)	Fin Aggregate (Kg)	Coarse Aggregate (Kg)	Rice Husk Ash (Kg)
0	1.39	2.92	4.59	-
10	1.25	2.92	4.59	0.139
20	1.112	2.92	4.59	0.278
30	0.973	2.92	4.49	0.417

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IV. SPECIMEN PREPARATION

The specimens of reinforced concrete with RHA, varying percentages of RHA (ranging from 0% to 30%) are incorporated into separate concrete mixes based on volume fractions. The sand used is thoroughly cleaned to eliminate any inorganic impurities, and only the sand particles that passed through a 2.36mm sieve and were retained on a 150-micron sieve are utilized.

For every mix, cubes measuring 150x150x150mm, cylinders with dimensions of 150mm in diameter and 300mm in height, as well as small beams measuring 100x100x500mm, are prepared. All these specimens are manufactured and subsequently subjected to curing in water for durations of 7 and 28 days, following the guidelines outlined in the Indian standard 10262. Additionally, slump tests are conducted and their results recorded for each concrete mix. Within 24 hours of being cast, the cubes, beams, and cylinders are removed from their molds and then placed in a water tank for the curing process.

V. RESULTS AND DISCUSSION

The compressive strength outcomes of standard cubes adhere to the conservative approach outlined in the Indian standard method. This approach yields notably conservative results for the compressive strength of both concrete grades due to the comparatively higher cement content used in the aggregate/cement ratio and the water/cement ratio, when contrasted with more progressive methods employed by other countries. Cubes measuring 150 mm were cast, integrating varying percentages of rice husk ash as partial replacements for cement. All specimens underwent a 24-hour hardening phase and were subsequently subjected to a 28-day curing period. Following this, the samples were extracted from water, cleaned, and subjected to testing.

The presented data reveals a clear trend: as the percentage of cement replacement by RHA increases, particularly beyond 50-60%, the compressive strength decreases in relation to the anticipated values. It's important to note that high-calcium dry RHA was sourced from the local rice mill lignite corporation in all instances. The aggregate's mass constituted approximately 70-80% of the total mixture mass. The replacement of cement with RHA was carried out at levels of 10%, 20%, and 30%.

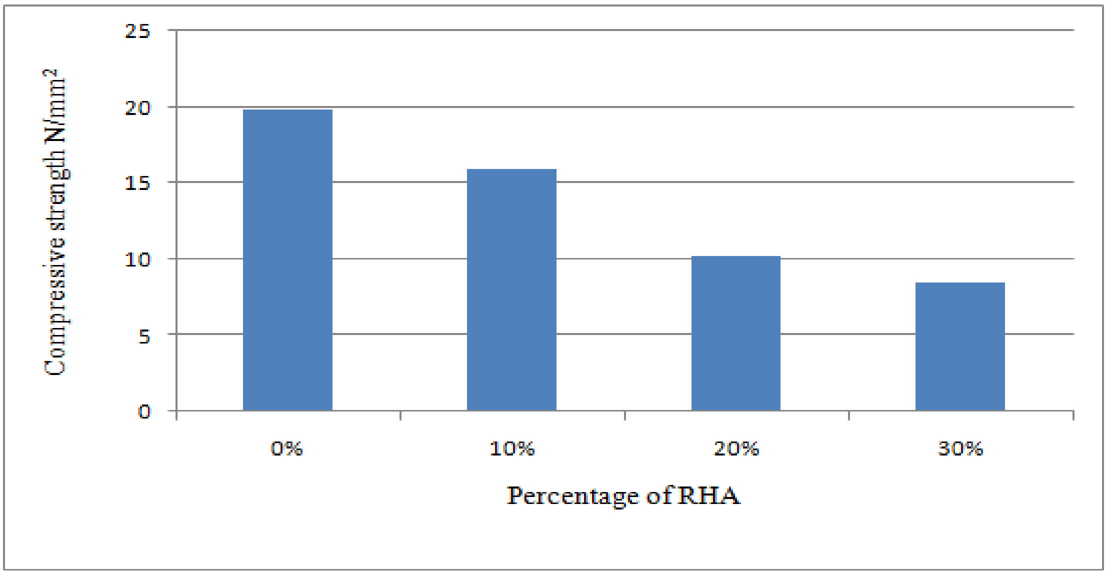

Figure 1: Compressive Strength Vs Percentage of RHA at 7 Days

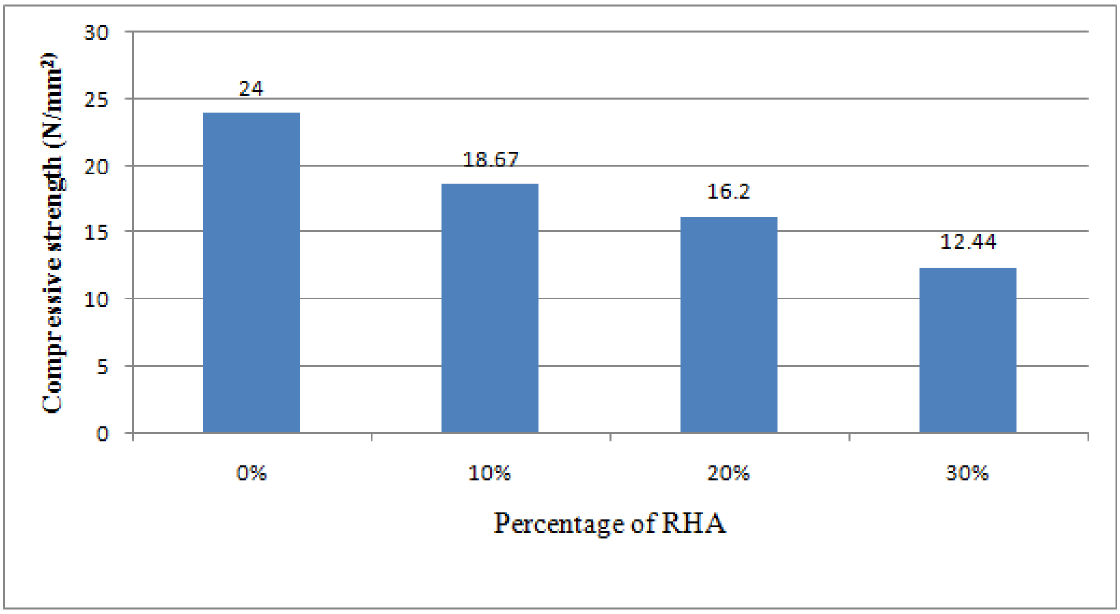

Figure 2: Compressive Strength Vs Percentage of RHA at 28 Days

VI. CONCLUSION

With the addition of RHA weight density of concrete reduces by 72-25%. Thus, the use of RHA in concrete leads to around 8-12% saving in material cost. So, the addition of RHA in concrete helps in making an economical concrete. The compressive strength will increase with the addition of RHA. Thus, concrete containing RHA can be effectively used in places where the concrete can come in contact with water or moisture. RHA has the potential to act as an admixture, which increase the strength workability and pozzolanic properties

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