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INVESTIGATION OF THE PERFORMANCE OF RICE HUSK ASH IN M20-GRADE CONCRETE

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ABSTRACT

The world's leading cause of environmental degradation today is global warming, caused by releasing carbon dioxide into the atmosphere. Most of these CO_2 emissions come from vehicle use. The large cement industry in almost every country in the world produces a lot of carbon dioxide, making it the second largest source of environmental pollution due to the production of fine silicate cement products. Therefore, other materials are being introduced to replace ordinary Portland cement in concrete making. Rice husk ash has pozzolanic properties and was used as an additive in Cement, and its properties were examined. This study investigates the performance of residual rice flour (RHA) on M20-grade Concrete. Variable levels of 0% {Control}, 5%, 10%, 15%, and 20% of RHA were rigorously studied concerning the Indian standard model for composite samples. M20 grade concrete measuring 150mm x 150mm x 15mm was poured by replacing the Cement with RHA. As a control, cubes were cured at room temperature for 7 and 28 days. Strength (compression, flexural, and splitting tensile) and performance (water tightness rate and duration) tests were carried out. Test results have shown that the performance and strength of RHA {replacement} is slightly better than regular Concrete and meets the limits set and accepted by the standard. Some important conclusions were drawn based on the results of the research experiment.
Keywords: *Rice husk ash, compressive strength, flexural strength, split tensile strength, mix design.*

1.0 INTRODUCTION

1.1 Background to the study

Concrete proved to be second to none in the construction industry globally, and it has all it takes to withstand the effects of loads. The product is used because of its durability, strength, versatility, and reflectivity. It does not rust, burn, or even rot, making it an incredibly long-lasting option for domestic and commercial settings. However, the chief actor in producing Concrete is the binder, ordinary Portland cement, which binds the other components to produce conventional Concrete. Cement production exhibits a lot of carbon dioxide. The emission of this toxic element can result in global warming and become hazardous to the environment. To minimize this challenge, an alternative binder that does not require combustion in its production can be an option.

Cement is one of the most used building materials. Its production contributes 8–10% of the emissions of greenhouse gasses worldwide [1]. It is essential to replace Cement with biomass. Rice husk ash is an important material, a by-product obtained from agriculture. Due to the increasing number of rice husks daily in the environment, we require large landfill areas. To overcome this issue, rice husks in Concrete have been introduced to develop an eco-friendly concrete material for construction. The rice husk ash is an eco-friendly material [2]. Concrete replacement of Cement will help increase the mechanical & durability values depending upon the grade consideration [3]. RHA is an old product that is growing in India. Vast amounts of rice husk are available worldwide [4]. RHA has a high amorphous silica content, which makes it an ideal Pozzolan or cement replacement [5]. The quality of RHA relates to the amorphous SiO_2 content, which depends on the time, the temperature, and the environment of thermal treatment [6]. Changes in compressive strength, corrosion, and porosity from replacing OPC with RHA have been investigated by several researchers for over two decades. The experimental investigation was conducted on M20 grade concrete mix using cement replacement as 0%, 5%, 10%, 15%, 20%, and 25%.

The increase in the strength of Concrete depends upon the concrete mix. For determining the compressive strength, 150 mm × 150 mm × 150 mm size cube molds are used. To determine the split tensile strength, a 150 mm diameter 300 mm length cylindrical mold is tested, and to choose the flexural strength, the 150 mm × 15 mm × 700 mm beam mold is used to determine the flexural strength of Concrete. Strength is a significant property of hardened Concrete. As we know, Concrete is strong in compressive and weak in tensile [7]. The strength values are increased using the proper mix and various cementitious materials. Cementitious materials such as GGBS, Metakaoline, silica fume, and other materials can help to improve the strength values [8]. In the work, the Rice husk ash material is used to prepare the concrete mixture for the M20 grade concrete mix [9]. Using Rice husk ash decreases the cracking effect of Concrete due to the proper binding action between materials and rice husk ash.

From the intensified research into locally available products and reduction in cost, partial replacement of Ordinary Portland Cement with rice husk ash is proven effective and fulfills the requirements. Incorporating waste products such as rice husk ash as a partial replacement for Cement can reduce the cost of Concrete since the production of Cement is expensive. Using waste products is an environmentally friendly method of disposing of large quantities of waste that would contaminate the surroundings [10].

1.2 **Significant of the study**

The research will be significant to builders and engineers in deciding what percentage of RHA should be used in Concrete, as this will enhance their know-how and trust in it. The cost implications of continuous OPC use will be drastically minimized, which may eventually affect the mass production of OPC and, hence, the reduction in the emission of CO_2 resulting in global warming.

1.3 Aim of the study

This investigation focuses on using RHA to partially replace OPC in producing M20-grade Concrete.

1.4 Objectives

The principal objectives are mainly as per the following:

i. To study different strength properties (compressive strength, flexural strength, and split tensile strength) of Rice husk ash concrete with age compared to Control Concrete.

ii. To ascertain the designs of concrete mixes using a varying gradation of rice husk ash as a replacement for Cement.

iii. To determine the optimum level of replacement of rice husk ash with ordinary Portland cement.

2 - MATERIALS AND METHODS

2.1 Preamble

This chapter describes the works on partially replacing concrete elements with rice husk ash {RHA} in M20 grade concrete production. It also exhibits the suitability of rice husk ash {RHA} to replace Cement in M20 concrete partially. At the same time, the optimum percentage of Cement was established that could be replaced by rice husk ash {RHA} in concrete production. The optimum cement replacement refers to the maximum amount of Cement that can be partially replaced by rice husk ash {RHA} without compromising the Concrete's safety, integrity, and intended function. Laboratory experiments were used to achieve the aim of the study.

2.2 Mix Variables

The variables considered are (i) Concrete without rice husk (Control), (ii) Concrete with 5% of cement content replaced by rice husk, (iii) Concrete with 10% of cement content replaced by rice husk, (iv) Concrete with 15% of cement content replaced by rice husk and {v} Concrete with 20% of cement content replaced by rice husk ash.

2.3 Materials

i) Cement: Cement can be described as a material with adhesive and cohesive properties, making it capable of bonding mineral fragments into a compact whole and solid in water. For construction purposes, Cement is restricted to the bonding material used with aggregates, bricks, building blocks, etc. This type of Cement usually comprises lime, clay, and magnesium compounds. The Cement used in this experiment is M53 grade cement because it has a compressive strength of 53 megapascals (MPa) after 28 days of Curing, which is usually required for high-strength Concrete. This grade of Cement is known for its superior strength and durability properties, thus making it suitable for any structural purposes.

ii) Aggregates: Aggregates are hard, inert filler materials mixed with binding materials like Cement, lime, or mud in the preparation of Mortar or Concrete. Aggregates occupy 70 – 75% of the total volume of a concrete mass. Therefore, the properties of Concrete are, to a large extent, dependent on the properties of the aggregates. The aggregate used is local aggregates (Gravel and pit sand for coarse and fine aggregate, respectively).

iii) Rice husk ash: Rice husk contains organic matter and 20% inorganic matter. Rice husk ash (RHA) is obtained by burning rice husk. The most crucial feature of RHA that determines its pozzolanic performance is the content of the amorphous phase. Rice bran is finished during blending and sorting operations to remove and preserve the rice in the castings. Hand threshing is beating small grains by hand 6 to 8 times on a hard object (stone, metal, or roller). If the rice is harvested when it is fully ripe and dry, it will separate easily, and small pieces will form around it.

iv) Water: Potable water is suitable as mixing water for cement concrete since its chemical composition is known and well-regulated. Drinking water is primarily used to mix water for Concrete. The water used for the research work was obtained locally, which fulfills the requirement provided by Indian Standard. The water was clean and free from any visible impurities. Water is being supplied, partially deliberating the proportionate ratio.

2.4 Mix Design: Indian standard method of mix design for conventional Concrete was referred for the replacement levels of 0% {Control}, 5%, 10%, 15%, and 20% of the RHA and studied critically. The mix design procedure adapted to obtain M20 grade concrete is per IS-456:2000 and IS-10262:2019

2.4.1 Calculated mix proportion for trial

Final mix of M20 grade concrete as per IS 10262 code

Cement = **358.47 kg/m3**,

Fine aggregates = **736.90 kg/m3**,

Coarse aggregates = **1176.88 kg/m3**,

Water = **197.16 l/m3**

Divide these values of aggregates and water with that of Cement **(358.47).**
We have the final mix proportion as **1:2.055:3.283 at 0.55**
As per the above Calculation, the final mix ratio of M20-grade Concrete is obtained.

Table 2.1 Concrete mix proportioning per m^3

W/C ratio	Cement	Fine aggregate	Coarse aggregate
	358.47kg	736.90kg	1176.88kg
0.55	1	2.056	3.283

Table 2.2 Mix proportion for different % of Rice Husk Ash and OPC

Replacement of OPC by RHA (%)	Cement (kg/m^3)	Rice Husk Ash (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	Water (kg/m^3)
0	358.47	0.00	736.90	1176.88	197.1
5	340.55	17.92	736.90	1176.88	197.1
10	322.62	35.88	736.90	1176.88	197.1
15	304.70	53.77	736.90	1176.88	197.1
20	286.78	71.70	736.90	1176.88	197.1

3- RESULTS AND DISCUSSIONS

3.1 Test Results of Strengths of Concrete Cubes Specimens

Experimental results have been tabulated and presented graphically. Cement was partially replaced with RHA at 5%, 10%, 15 %, and 20 % by weight and tested for compressive strength after 7 & 28 days as per Indian Standards. The results of hardened Concrete with partial replacement of Rice husk ash are not just compared, but critically evaluated against conventional concretes. Strength properties (compressive strength, split tensile strength, and flexural strength) were meticulously measured to assess the strength parameters related to varying percentages of Rice Husk Ash, making these results of utmost importance.

The compressive strength (C.S.) test was performed on standard cubes of size 150X150X150 mm, using a compression testing machine about I.S.: 516 -1959. The compressive strength was then found for 7 and 28 days, respectively.

The Split Tensile Strength (STS) of Concrete at 7 and 28 days was performed as per the standard, using a universal compression testing machine.

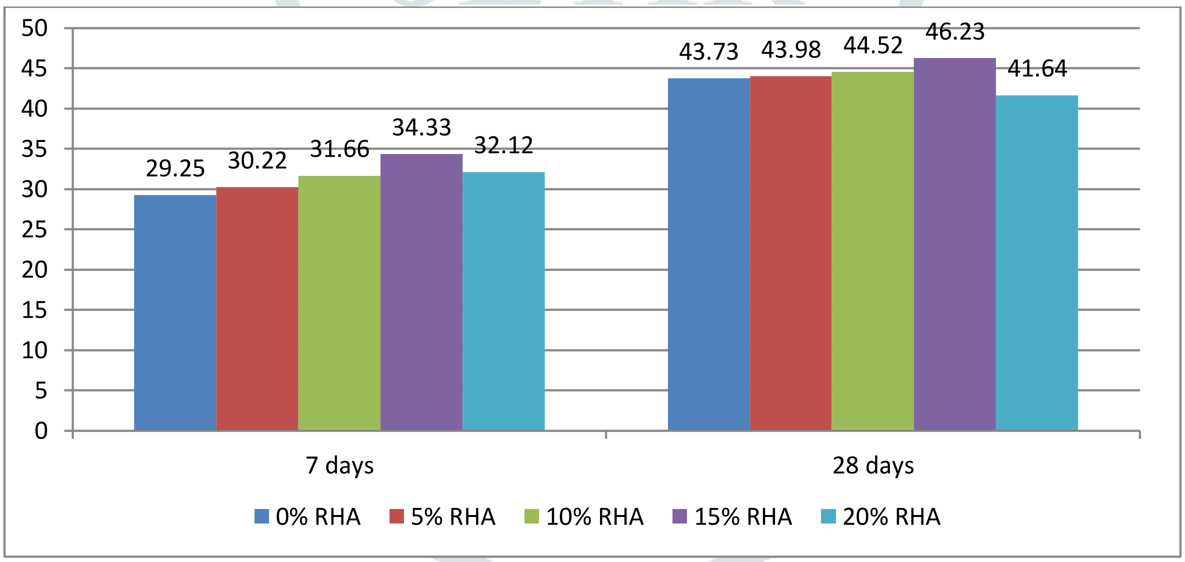
The Flexural Tensile Strength (FTS) was performed on beams of size 100×100×500mm after 28 days of Curing. The test was done per I.S.: 516-1959.

3.1.1 Compressive strength test result

Tables 4.1 and Fig.4.1 described the results obtained on the compressive strength of Concrete at 7 and 28 days for the control concrete and Concrete produced with 5%, 10%, 15%, and 20% rice husk ash replacement.

Table **3.1** Results of the compressive strength test

Specimen number	% Ordinary Portland Cement	% Rice Husk Ash	Compressive strength (N/mm2)	
			7 days	28 days
M0	100%	0%	29.25	43.73
M1	95%	5%	30.22	43.98
M2	90%	10%	31.66	44.52
M3	85%	15%	34.33	46.23
M4	80%	20%	32.12	41.64



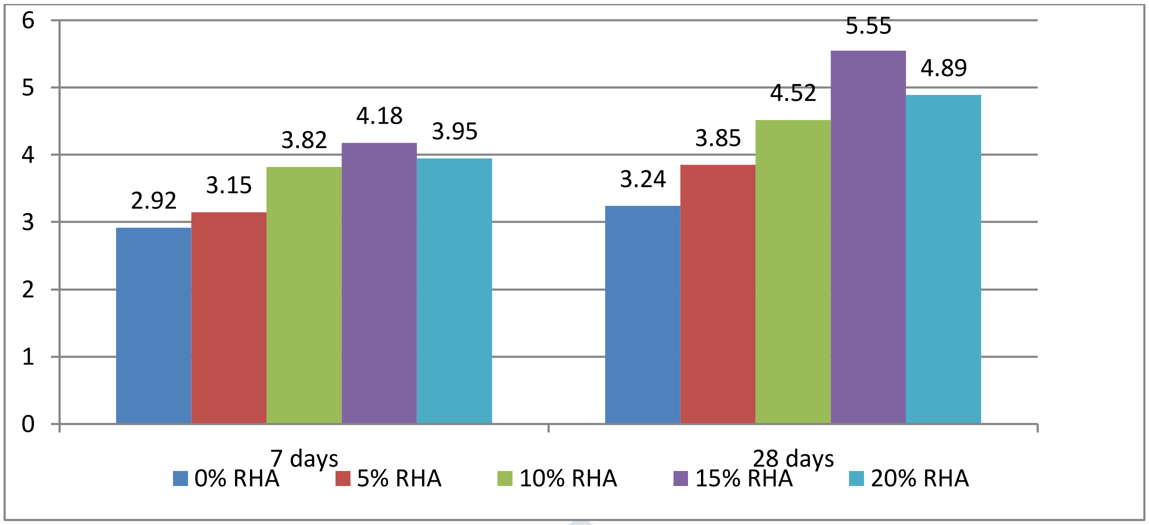
Graph 3.1 Overall results of compressive strength test

3.1.2 Flexural strength test

Table 2 and Fig. 2 below present the test for the flexural strength of a concrete specimen conforming to I.S.: 516-1959. The results in the table and the figure are for the control concrete and Concrete produced with rice husk ash replacement of 5, 10, 15, and 20% at a 7—and 28-day curing period.

Table 3.2 Results of Flexural Strength Test

Specimen number	% Ordinary Portland Cement	% Rice Husk Ash	Flexural strength (N/mm2)	
			Seven days	28 days
M0	**100%**	**0%**	**2.92**	**3.24**
M1	**95%**	**5%**	**3.15**	**3.85**
M2	**90%**	**10%**	**3.82**	**4.52**
M3	**85%**	**15%**	**4.18**	**5.55**
M4	**80%**	**20%**	**3.95**	**4.89**



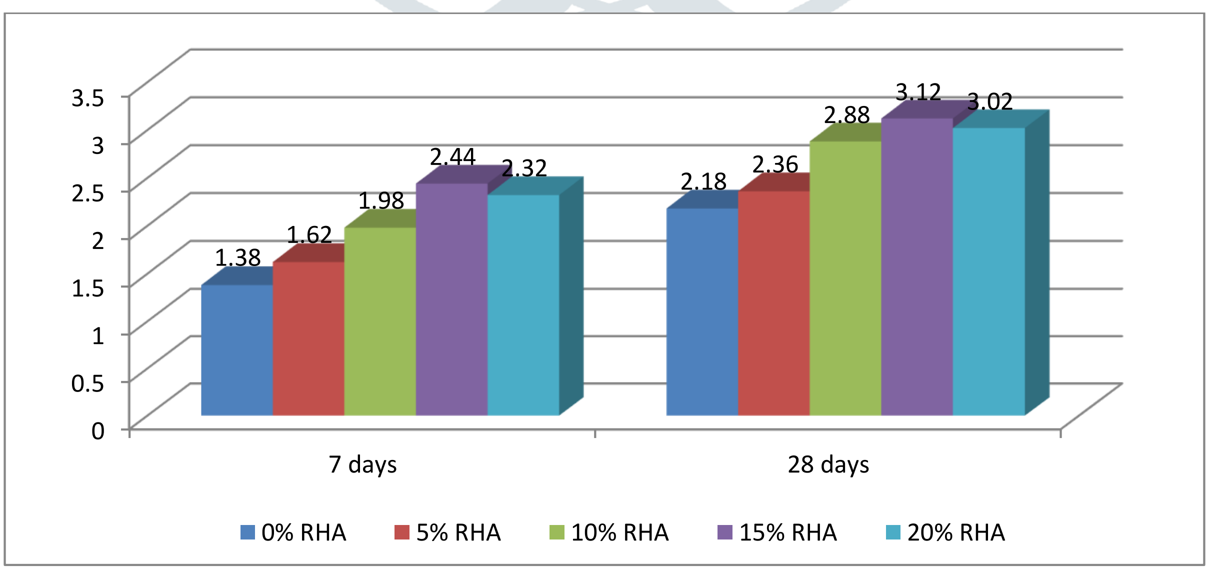
Graph 3.2 Overall results of the Flexural Strength test

3.1.3 Split tensile strength results

The test was carried out according to IS 516-1959. The split tensile strength of concrete specimens for control concrete and Concrete replaced with rice husk ash at 5%, 10%, 15%, and 20% at 7 and 20 days curing time are presented in Table 3 and Fig.3, respectively.

Table 3.3
Results of Split Tensile Strength Test

Specimen number	% Ordinary Portland Cement	% Rice Husk Ash	Split tensile strength (N/mm2)	
			Seven days	28 days
M0	**100%**	**0%**	**1.38**	**2.18**
M1	**95%**	**5%**	**1.62**	**2.36**
M2	**90%**	**10%**	**1.98**	**2.88**
M3	**85%**	**15%**	**2.44**	**3.12**
M4	**80%**	**20%**	**2.32**	**3.02**



Graph 3.3 Overall Results of the Split Tensile Strength Test

4 - DISCUSSION OF RESULTS

4.1 Compressive strength

The improvement of compressive strength from a period of 7 to 28 days for control mix and mixes with varying percentages of RHA is presented in Table 3.1 and Fig. 3.1. The results indicate that the 28 days strength increases from 43.23 MPa to 46.23 MPa with incorporation of 15% RHA. This enhancement of compressive strength of Concrete with RHA was attributed to the increase in pozzolanic action when RHA was added to Concrete. However, for other variations in RHA, there was a reduction in the compressive strength of Concrete after a curing period of 28 days at 20%.

4.2 Flexural strength

The change in flexural strength for different percentages of RHA is represented in Fig. 3.2. Maximum Flexural Strength was reached at 15% addition of RHA, which recorded 5.55MPa after 28 days of Curing. The interfacial transition zone of Concrete becomes more robust because of the pozzolanic products given out by RHA that help improve the bonding between cement mortar and aggregate. Flexural strength percentage variation concerning 0% RHA for different RHA replacements is reported in Table 3.2. As the percentage replacement of Rice husk ash increased, there was also a gradual increase in the flexural strength of Rice husk ash concrete up to 15% replacement, then decreased to 20%.

4.3 Split tensile strength

Table 3.3 and Figure 3.3 show variations of split tensile strength with RHA percentage. After 28 days of Curing, the split tensile strength of the Concrete increased from 2.18 MPa to 3.12 MPa, and the RHA percentage increased to 15%. The improvement in split tensile strength may be due to the improvement of the transition zone of the interface (ITZ) from the silica content present in RHA. However, a decrease in strength was observed when 20% RHA was used. As the rice husk ash content increases, the splitting tensile strength of rice husk ash concrete also gradually increases, reaching about 15% and then decreasing.

5. CONCLUSION

Based on the findings, the following conclusions can be drawn:-

1. Rice husk ash's strength properties have been proven suitable for producing M20 class concrete; its strength is 46.23MPa, and that of Control concrete is 43.23MPa.

2. The ideal amount of rice husk ash to obtain M20 concrete quality is 15%, and the curing time is 28 days. The same percentage applies to compressive, bending, and split tensile strength.

Future Studies:

i) This quest is based on gem level M20. However, the high level of the stone will be investigated further. The work can now be extended to a higher concrete level.

ii) Replace ordinary Portland cement with 5%, 10%, 15%, and 20% rice husk ash to obtain the best proportions to make M20-grade Concrete. The study can now be expanded to cover more of the RHA.

iii) This study evaluated the effect of RHA on compressive strength, bending strength, and splitting tensile strength. The current research can include the durability (operational, chemical, etc.) of M20-grade Concrete using RHA.

iv) It should find and develop other new, low-cost, and domestic materials that can be used as mineral resources.

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