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Experimental Study On Partially Replacement Of Cement By Using Ricehusk Ash

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Abstract: This study investigates the potential of rice husk ash (RHA) as a sustainable partial replacement for cement in concrete. By substituting cement with RHA at varying proportions of 5%, 10%, and 15%. Rapid increase in construction activities has resulted in shortage of conventional construction materials. In the present scenario, the high cost of conventional building materials is a major factor affecting housing delivery in the world.This has necessitated research into alternative materials of construction .The effective housing techniques deal with reduction in cost of construction as well as providing strength to buildings. Mainly gravel, sand and cement are used in the preparation of conventional concrete. While the use of agricultural by-product i.e. rice husk as a partial replacement with the conventional fine aggregates is expected to serve the purpose of encouraging housing developers in building construction. Rice husk is produced in about 100 million tons per annum in India. Twenty kg of rice husk are obtained from 100 kg of rice. It contains organic substances and 20% inorganic material Ash from rice is obtained as a result of combustion of rice husk at suitable temperature. Proper utilization of it aims to save the environment ,encourages the Government to find solutions regarding disposal to landfills of waste materials ,and provides new knowledge to the contractors and developers on how to improve the construction industry by using rice husk, to sustain good product performance and to meet recycling goals .The rice husk ash concrete aims to prepare light weight structural concrete which may reduce considerably the self load of structures and permits large precast units to be handled .The main objective is therefore to encourage the use of these 'seemingly' waste products as construction materials in low cost housing.

Index Terms **- Partial cement replacement, rice husk ash, sustainable concrete, eco-friendly construction, cementitious materials, compressive strength, and waste utilization.**

I. INTRODUCTION

Concrete is one of the most used construction materials due to its strength and durability. However, while producing cement which is a major part of concrete, contributes greatly to the emissions of carbon dioxide and other greenhouse gases which is a threat to environment [1]. For this very reason it is a need of the day to find a substitute material which can replace cement partially while keeping the performance of concrete unchanged [2]. It will be a very practical and economical solution for the reduction of carbon dioxide in environment if the cement in concrete can be replaced with any cementitious material which can be found from any agricultural by products or any waste materials from industry [3]. It is observed that agricultural by-products when used as a partial replacement of concrete, enhance the strength of concrete and simultaneously increase the sustainability properties as the total costs reduces and improving environmental protection [4]. Rice husk is an agricultural by-product which can be found in all the rice producing countries around the world. It is generally not fit for human consumption and not as the nutritional value is very low it is not recommended for animal feed also [5]. Along with that the natural degradation of rice husks is very low because its surface is uneven and abrasive and having high silica content, making it a potential pollution material [6]. Rice husk ash (RHA) can be utilised for partial replacement of cement with a color range of white, grey, and black in relation to raw material source, mode of incineration, and duration and temperature of burning [7]. For this reason, in this study rice husk ash is used as a partial replacement of cement. Several studies are made with different percentage of RHA starting from 10% replacement to 15% replacement and Compression Strength were carried out after 7 days. This study investigates utilization of RHA as a substitute for cement in the manufacture of concrete blocks to increase sustainability and stability.

2. OBJECTIVE OF THE STUDY

- To examine the possibility of replacing cement in concrete samples partially with rice husk ash (RHA).
- To find out the effects of RHA on the stability, compressive strength of concrete sample in an effort to discover environmentally friendly solutions that retain or enhance the functionality of conventional concrete.
- To use rice husk ash as a partial replacement for cement and utilize a waste material to save environment.

3.MATERIALS AND METHODS

3.1 Materials used and their properties

- Portland Pozzolanic Cement (PPC)
- Coarse and Fine aggregate
- Rice Husk Ash
- Water

3.1.1 Portland Pozzolanic Cement

- Portland pozzolanic cement (PPC) is a blended cement that includes a mixture of Portland cement and pozzolanic materials, such as fly ash, volcanic ash, or silica fume. The addition of pozzolans enhances the cement's strength, durability, and resistance to chemical attacks, making it suitable for sustainable construction and long-lasting concrete structures.

TABLE 1- PHYSICAL PROPERTIES OF CEMENT

PROPERTIES OF CEMENT	VALUES
Fineness Test	5%
Consistency Test	31%
Initial setting time	35 Minutes
Final setting time	600 Minutes

3.1.2 Coarse and Fine Aggregate

3.1.2.1 Coarse Aggregate: Coarse aggregates are larger particles, typically gravel or crushed stone, that range in size from 4.75 mm to about 50 mm. They provide strength and stability to concrete and form the bulk of the concrete mix.

3.1.2.2 Fine Aggregate: Fine aggregates are smaller particles, usually sand or crushed stone, that pass through a 4.75 mm sieve. They fill voids between coarse aggregates, improve workability, and contribute to the overall strength of the concrete mix.

TABLE 2-PROPERTIES OF COARSE AGGREGATE

PROPERTIES OF COARSE AGGREGATE	VALUES
Specific Gravity	2.82
Water Absorption	4.5%

TABLE 2- PROPERTIES OF FINE AGGREGATE

3.1.3 Rice Husk Ash

Rice husk ash is a by-product of burning rice husks, which are the hard protective coverings of rice grains. RHA is rich in silica (SiO_2), making it a valuable pozzolanic material. When finely ground, it can be used as a supplementary cementitious material in concrete, enhancing strength, durability, and resistance to chemical attacks while promoting sustainable construction by recycling agricultural waste.

TABLE 3- PROPERTIES OF RICE HUSK ASH

PROPERTIES OF RICE HUSK ASH	VALUES
Specific Gravity	2.14
Consistency Test	37%
Initial Setting Time	44 MINUTES

3.1.4 WATER

Water in concrete is a key ingredient that initiates the chemical reaction with cement, known as hydration, which allows concrete to harden and gain strength. The water-cement ratio amount of water relative to cement—affects concrete's workability, strength, and durability. Proper water content is essential; too much water weakens the concrete, while too little makes it difficult to mix and place.

3.2 MIX DESIGN

I. STIPULATIONS FOR PROPORTIONING

Grade Designation	= M25
Cement	= PPC
Coarse aggregate size	= 20mm
Minimum cement content	= 300 kg/m^3
Maximum cement content	= 450 kg/m^3
Maximum water cement ratio	= 0.45
Slump	= 100mm
Exposure	= Severe

I. TEST DATA

Specific gravity of cement	= 3.16
Specific gravity of fine aggregate	= 2.53
Specific gravity of coarse aggregate	= 2.82
Specific gravity of rice husk ash	= 1.0
Specific gravity of water	= 2.14

1. TARGET STRENGTH FOR MIX PROPORTIONING

f'ck = fck + 1.65 S

f'ck = 25 + 1.65 x 4 (From Table 2, standard deviation, S = 4 N/mm^2)

f'ck = 31.6 N/mm^2

2. APPROXIMATE AIR CONTENT

From Table 3, the approximate amount of entrapped air to be expected in normal (non-air-entrained) concrete is 1.0 percent for 20 mm nominal maximum size of aggregate.

3. SELECTION OF WATER-CEMENT RATIO

the free water-cement ratio required for the target strength of 31.6 N/mm^2 is 0.45 .

Water Cement Ratio is 0.45.

4. SELECTION OF WATER CONTENT

From Table 4, water content = 186 kg (for 50 mm slump) for 20 mm aggregate. Estimated water content for 100 mm slump

= 186 +((6/100) x 186) =197.16 kg/m^3 ~ 198 kg/m^3

5. CALCULATION OF CEMENT CONTENT

Water-cement ratio = 0.45

Cement content = 198 / 0.45 = 440 kg/m^3

From Table 5 of IS 456, minimum cement content for 'severe' exposure condition = 300kg/m^3 >440 kg/m3> 450 kg/m3, hence, O.K.

6. PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGETE CONTENT

From Table 5, the proportionate volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone II) for water-cement ratio of 0.50 = 0.62.

In the present case water-cement ratio is 0.45 . Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. Table 5 for a water-cement/water cementitious materials ratio of 0.5, which may be suitably adjusted for other ratios, the proportion of volume of coarse aggregates to that of total aggregates is increased at the rate of 0.01 for every decrease in water-cement/cementitious materials ratio by 0.05 and decreased at the rate of 0.01 for every increase in water cement ratio by 0.05.

Volume of CA = 0.62 + 0.01 = 0.63 (w/c = 0.45)

Volume of FA = 1 – 0.63 = 0.37

7. **CALCULATION FOR RICEHUSK ASH**

RHA = Percentage Of Rice husk Ash x Cement Content

For 5%

RHA = 5% x 440 = 22 kg/m^3

Effective Cement Content = 440 – 22 = 418 kg/m^3

For 10%

RHA = 10% x 440 = 44 kg/m^3

Effective Cement Content = 440 – 44 = 396 kg/m^3

For 15%

RHA = 15% x 440 = 66 kg/m^3

Effective Cement Content = 440 – 66 = 374 kg/m^3

8. **MIX CALCULATION**

a) Total volume = 1 m3

b) Volume of entrapped air in wet concrete = 0.01 m3

c) Volume of Cement = Mass / Specific Gravity x 1000

5% = 418 / 3.16 x 1000 = 0.132 m ^3

10% = 396 / 3.16 x 1000 = 0.125 m^3

15% = 374 / 3.16 x 1000 = 0.118 m^3

d) Volume of RHA = Mass / Specific Gravity x 1000

5% = 22 / 2.14 x 1000 = 0.0102 m^3

10% = 44 / 2.14 x 1000 = 0.0205 m^3

15% = 66 / 2.14 x 1000 = 0.0308 m^3

e) Volume of water = Mass of water / Specific Gravity of Water x 1 / 1000

= 198 / 1 x 1 / 1000 = 0.198 m^3

f) Volume of Aggregate = 1 – (Volume of Cement + Volume of RHA + Volume of Water)

5% = 1 – (0.132 + 0.0102 + 0.198) = 0.6598 m^3

5% = 1 – (0.125 + 0.0205 + 0.198) = 0.6562 m^3

5% = 1 – (0.118 + 0.0308 + 0.198) = 0.6532 m^3

h) Mass of Coarse Aggregate = Volume x Specific Gravity x 1000

5% = 0.6598 x 0.63 x 2.82 x 1000 = 1172.20 kg

10%= 0.6562 x 0.63 x 2.82 x 1000 = 1165.80 kg

15%= 0.6532 x 0.63 x 2.82 x 1000 = 1160.47 kg

g) Mass of Fine Aggregate = Volume x Specific Gravity x 1000

5% = 0.6598 x 0.37 x 2.53 x 1000 = 617.63 kg

10%= 0.6562 x 0.37 x 2.52 x 1000 = 614.26 kg

15%= 0.6532 x 0.37 x 2.53 x 1000 = 611.46 kg

9. FINAL MIX PROPORTIONS:

For 5% RHA:

Cement	418kg
RHA	22kg
Water	198kg
Fine Aggregate	617.63kg
Coarse Aggregate	1172.20kg

C	RHA	FA	CA
1	**0.05**	**1.47**	**2.80**

For 10% RHA:

Cement	= 396 kg
RHA	= 44 kg
Water	= 198 kg
Fine Aggregate	= 614.26 kg
Coarse Aggregate	= 1165.80 kg

C	RHA	FA	CA
1	**0.11**	**1.55**	**2.94**

For 15% RHA:

Cement	= 374 kg
RHA	= 66 kg
Water	= 198 kg
Fine Aggregate	= 611.46 kg
Coarse Aggregate	= 1160.47 kg

C	RHA	FA	CA
1	**0.17**	**1.63**	**3.10**

MIX PROPORTIONS FOR 3 CUBES:

TABLE 4 – MIX PROPORTIONS FOR 3 CUBES IN DIFFERENT PERCENTAGES OF RHA

Mix	W/C	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	RHA (kg)
5%	0.45	1.410	2.0	3.9	0.007425
10%	0.45	1.3365	2.0	3.9	0.1485
15%	0.45	1.26225	2.0	3.9	0.222

4. RESULT

4.1 COMPRESSIVE STRENGTH

The compression test was done on the 150*150*150mm cube specimen after curing for 7 days. All the moulds were tested using CTM of 2000KN capacity, which undergoes a uniform loading rate until failure occurs. The final loading in failure was also taken for the estimation of compressive strength.

TABLE 5 – COMPRESSIVE STRENGTH TEST

S.NO	REPLACEMENT%	COMPRESSIVE STRENGTH N/mm^2 (7^{th} day)
1.	0%	18.12
2.	5%	16.43
3.	10%	13.73
4.	15%	9.87

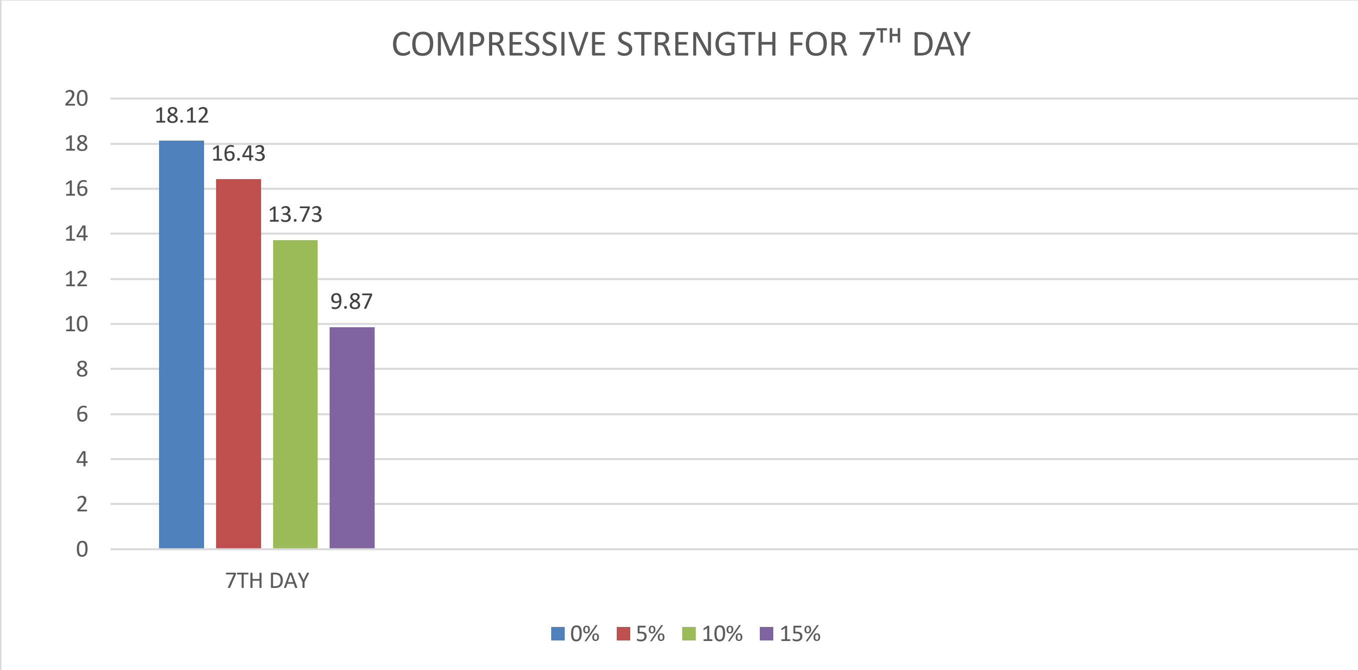

FIGURE 1 – COMPRESSIVE STRENGTH OF CONCRETE

5. CONCLUSION

Conclusion from the test performed and the analysis of the result following conclusions seem to be valid with rice husk ash act to the utilization of Rice Husk Ash. The results indicate a clear trend: as the percentage of RHA replacement increases, the compressive strength of the concrete decreases. This suggests that while a small amount of RHA (5%) can be used without significantly compromising strength, higher percentages (10% and 15%) lead to noticeable reductions in compressive strength. Therefore, for optimal performance, the replacement of cement with RHA should be limited to lower percentages.

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