

Experimental Study on Characteristic Strength of Mortar and Concrete by Partial Replacement of Cement with Rice Husk Ash

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ABSTRACT: This research was experimentally carried out to investigate the effects of introducing Rice Husk Ash (RHA) as a Partial Replacement of Portland Slag Cement (PSC) on the physical and Structural Properties of mortar and Concrete. Compressive strength of cement, compressive strength of concrete, split tensile strength and flexural strength of concrete with 0% (R₀), 5% (R₅), 10% (R₁₀), 15% (R₁₅) and 20% (R₂₀) partial replacement of PSC with RHA has been conducted. The compressive strength of mortar (cement + RHA) decreases gradually as the amount of RHA increases. Slump value decreases as the partial replacement of PSC with RHA increases in the concrete mix. The compressive strength, split tensile strength and flexural strength of concrete decreases by increasing the percentage of partial replacement of PSC with RHA in the concrete mix.

KEYWORDS: RHA , PSC, R₀, R₅, R₁₀, R₁₅ and R₂₀.

I. INTRODUCTION

Concrete is the most widely used construction material for various types of structures due to its structural stability and strength. All the materials required for producing such huge quantities of concrete comes from the earth's crust. Thus, it depletes its resources every year creating ecological strains. On the other hand, human activities on earth produce solid waste in considerable quantities of over 2500 MT per year including industrial waste, agricultural waste and waste from rural and urban societies. Recent technological development has shown that these materials are valuable as organic and inorganic resources and can produce various useful products. Amongst the solid wastes, the most prominent ones are fly ash, blast furnace slag, rice husk ash, silica fume and demolished construction materials. Rice plant is one of the plants that absorbs silica from the soil and assimilates it into its structure during the growth. Rice husk is the outer covering of the grain of rice plant. Rice husk is produced in millions of tons per year as a waste material in agricultural and industrial processes. It constitutes about 20% of the weight of rice..

II. EXPERIMENTAL SETUP AND INVESTIGATION

In this present work, a comprehensive experimental schedule is being formulated to achieve the objective and scopes of the present investigation. The whole experimental work is classified into the following steps:-

II. PREPARATION OF RICE HUSK ASH FROM RICE HUSK

The rice husk was obtained from KISHORE RICE MILL, SL-2, Saharpura, Dhanbad. The obtained rice husk was then burnt under controlled condition at the temperature of 500°C to make rice husk ash.

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II.II TESTS OF MATERIALS

The tests of RHA, Cement and aggregates are discussed below –

Physical and Mechanical Properties of cement

Properties	Results	Standard Limits (IS: 455)
Consistency	34%	–
Soundness	Expansion 3.5 mm	<10mm
Initial setting time (min)	90 minutes	>30 min
Final setting time	285 minutes	<600 min
Specific gravity	3.11	–
Fineness	4.0% (Retain on 90 micron sieve)	<10%
Compressive strength	N/mm ²	N/mm ²
1. 3days	20.00	>16
2. 7days	31.00	>22
3. 28 days	38.00	>33

Physical properties of RHA

S.NO.	TEST	RESULT
1	Fineness (By 90 micron sieve)	2%
2	Bulk density	505 kg/m ³
3	Specific gravity	2.07

Tests of Coarse Aggregate

S. No.	Test	Coarse Aggregate
1	Unit weight	1.87 gm/cc
2	Moisture content	0 %
3	Water absorption	0.2 %
4	Specific gravity	3.0
5	Fineness modulus	7.92
6	Crushing value	23.43 %
7	Impact value	16.0 %
8	Abrasion value	17.50 %
9	Elongation index	9.30%
10	Flakiness index	8.5 %

Tests of Fine Aggregate

S. No.	Test	Fine Aggregate
1	Zone	III
2	Moisture content	0.20%
3	Specific gravity	2.55
4	Unit weight	1.62gm/cc
5	Fineness Modulus	2.21
6	Water Absorption	1.37%

II.III TESTS OF CONCRETE

In the present thesis the test on concrete was performed on fresh as well as on hardened stage.

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II.III.ITEST ON FRESH CONCRETE

II.III.II WORKABILITY (SLUMP)

The properties of fresh concrete are assessed by workability in terms of slump value. To check the slump value of fresh concrete in the range of 25-50 mm, the slump cone test is conducted on all concrete mixes. The slump cone specified by BIS (IS: 7320-1974) is used to measure the slump of fresh concrete.



Fig: A typical arrangement for the measurement of slump

II.III.ITESTS OF HARDENED CONCRETE

II.III.II.I DESTRUCTIVE TEST OF HARDENED CONCRETE

II.III.II.I.I COMPRESSIVE STRENGTH

The compressive strength is determined using 2000 kN compression testing machine in accordance with BIS (IS: 516-1959) after 7 and 28 days of curing on cube specimen.

II.III.II.I.II SPLIT TENSILE STRENGTH

The split tensile strength of concrete was determined after 7 days and 28 days of curing on cylindrical specimens of 150 mm diameter x 300 mm height using 1000 kN compression testing machine as per the procedure given in BIS (IS: 5816-1999).

II.III.II.I.III FLEXURAL STRENGTH

This test was performed in accordance with BIS (IS: 516-1959) on prisms of size 100 x 100 x 500 mm after 7 & 28 days of water curing using 200 kN universal testing machine.



Fig : A typical arrangement for the measurement of flexural strength

III. RESULTS AND DISCUSSION

III.1 COMPRESSIVE STRENGTH OF MORTAR (CEMENT + RHA)

The value of compressive strength found for different percentage of replacement of PSC with RHA is present in table below and also its variation is shown in graph.

Compressive strength of mortar (cement + RHA)

Mortar	Compressive strength (N/mm ²)			Percentage decrease w.r.t. R ₀ (28 days)	Remarks
	3 days	7 days	28 days		
R ₀	20	31	38	0%	
R ₅	22.33	26.66	35	7.89%	R ₁₀ is 14.92% less than R ₀ and it is close to the permissible value i.e. 33 N/mm ² after 28 days.
R ₁₀	16.66	23.33	32.33	14.92%	
R ₁₅	13.66	21.66	26.33	30.71%	
R ₂₀	11	17.33	20	47.36%	

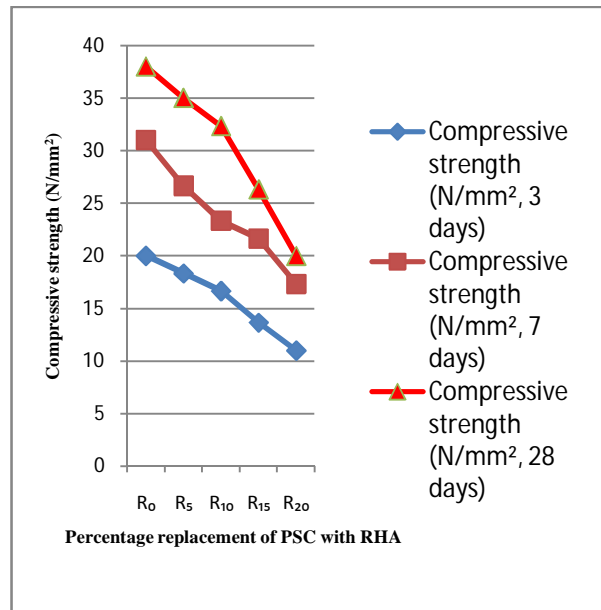


Fig : a typical graph compressive strength and percentage replacement of PSC and RHA

From table and graph above, it is found that the compressive strength of partially replaced PSC with RHA decreases at 3, 7 and 28 days as the amount of RHA increases in mortar (cement + RHA). However, up to 10% replacement gives the result close to the permissible value i.e. 33 N/mm². For 10% partial replacement, compressive strength decreases by 14.92% and for 20%, it decreases by 47.36% w.r.t. normal compressive strength after 28 days.

III.2 SLUMP TEST

The slump value obtained for R₀, R₅, R₁₀, R₁₅ and R₂₀ are given in table below and also its variation is shown in bar chart-

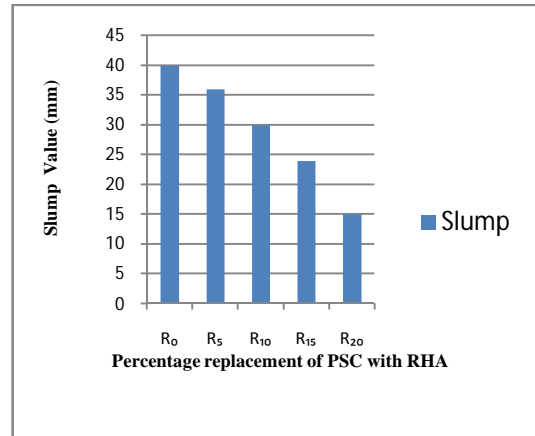
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Slump value of different concrete mix (cement + RHA)

Concrete Mix	Slump (mm)	Percentage decrease w.r.t. R_0
R_0	40	0%
R_5	36	10%
R_{10}	30	25%
R_{15}	24	40%
R_{20}	15	62.5%

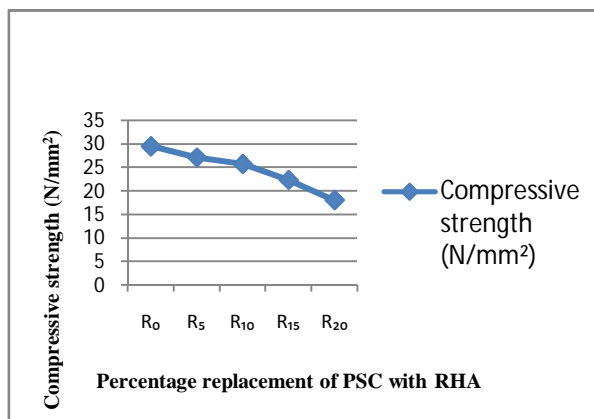


Slump value of different concrete mix (cement + RHA)

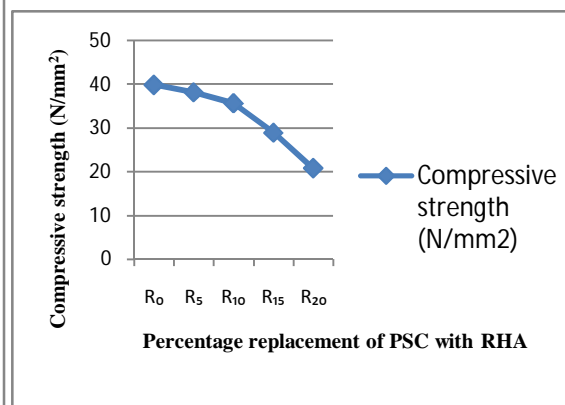
From table and bar chart above, it is concluded that up to 10% partial replacement the degree of workability is low and above 10% replacement the degree of workability is very low. For 10% partial replacement, slump decreases by 25% and for 20% replacement, it decreases by 62.5% w.r.t. normal slump.

III.III COMPRESSIVE STRENGTH TEST

The values of compressive strength of R_0 , R_5 , R_{10} , R_{15} and R_{20} for 7 and 28 days are shown in graphs below-



Compressive strength at 7 days



Compressive strength at 28 days

It is observed that the compressive strength for different percentage of partial replacement of PSC with RHA decreases gradually after 7 days as the amount of RHA increases in the concrete mix. For 10% partial replacement, compressive strength decreases by 12.79% and for 20% replacement, it decreases by 38.84% w.r.t. compressive strength of normal concrete after 7 days.

Again for compressive strength at 28 days it is concluded that the compressive strength decreases as the partial replacement of PSC with RHA increases in the concrete mix. For 10% partial replacement, compressive strength decreases by 10.57% and for 20% replacement, it decreases by 47.87% w.r.t. compressive strength of normal concrete after 28 days. Replacement up to 10% shows the values of compressive strength close to the target strength. Hence for compressive strength, 10% replacement may be allowed.

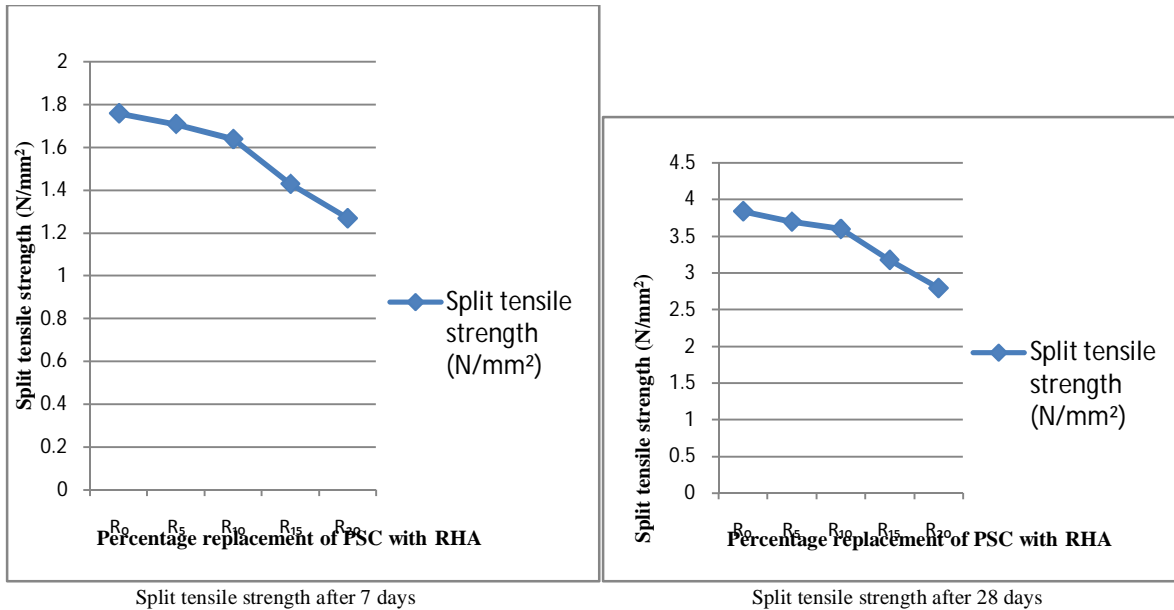
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III.IV. SPLIT TENSILE STRENGTH TEST

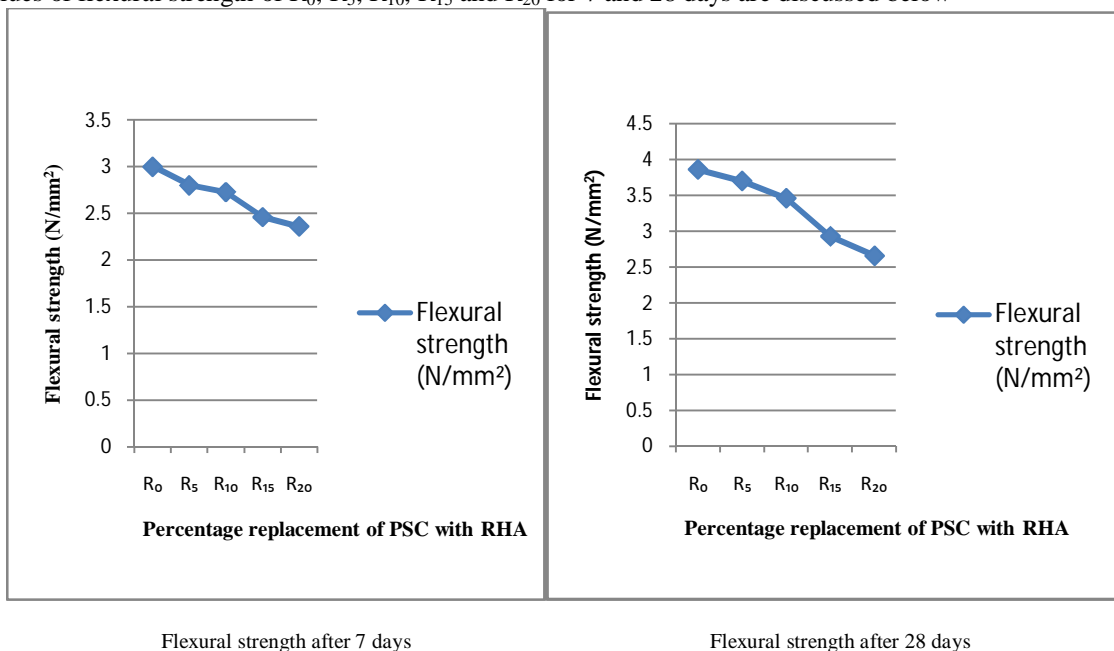
The values of split tensile strength of R₀, R₅, R₁₀, R₁₅ and R₂₀ for 7 and 28 days are discussed below-



There is very small decrease in split tensile strength up to 10% replacement of PSC with RHA. So it may be concluded that 10% replacement may be allowed for the case of split tensile strength.

III.V FLEXURAL STRENGTH TEST

The values of flexural strength of R₀, R₅, R₁₀, R₁₅ and R₂₀ for 7 and 28 days are discussed below-



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There is very small decrease in flexural strength up to 10% partial replacement of PSC with RHA. So it may be concluded that 10% replacement may be allowed for the case of flexure strength.

IV. CONCLUSION

The work presented in this thesis is concluded as follows-

1. The compressive strength of mortar (cement + RHA) decreases gradually as the amount of RHA increases. For 10% partial replacement, compressive strength (mortar) decreases by 14.92% and for 20%, it decreases by 47.36% w.r.t. normal compressive strength (mortar) after 28 days.
2. Slump value decreases as the partial replacement of PSC with RHA increases in the concrete mix.
3. For 10% partial replacement, slump value decreases by 25% and for 20% replacement, it decreases by 62.5% w.r.t. normal slump value.
4. The compressive strength of concrete decreases as the partial replacement of PSC with RHA increases in the concrete mix. For 10% partial replacement, compressive strength decreases by 10.57% and for 20%, it decreases by 47.87% w.r.t. compressive strength of normal concrete after 28 days.
5. For 10% partial replacement, split tensile strength decreases by 6.25% and for 20%, it decreases by 27.08% w.r.t. split tensile strength of normal concrete after 28 days.
6. There is very small decrease in split tensile strength up to 10% replacement of PSC with RHA.
7. For 10% partial replacement, flexural strength decreases by 10.36% and for 20% replacement, it decreases by 31.08% w.r.t. flexural strength of normal concrete after 28 days. There is very small decrease in flexural strength up to 10% partial replacement of PSC with RHA.
8. Finally, it may be concluded from this thesis that there may be 10% partial replacement of PSC with RHA for both mortar and concrete.

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