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A Study on Performance of Concrete by Partial Replacement of Cement with Rice Husk Ash and Silica Fume

S Sundararaman and S Azhagarsamy

Department of Civil Engineering, Mailam Engineering College, Mailam, Villupuram District, Tamil Nadu, India
hodcivil@mailamengg.com

ABSTRACT

Fast depleting natural resources, huge consumption of energy, and environmental hazards involved in the production of cement has inspired for searching the substitution by other material with similar material, especially in developing countries. Cement is widely noted to be most expensive constituents of concrete. The objective of is study is to investigate the mechanical properties of concrete with different replacement levels of ordinary Portland cement by rice husk ash and silica fume. The cement has been replaced by rice husk ash (RHA) accordingly in the range of 5%, 10%, 15%, 20% and 25% by weight of cement and 10% of silica fume in common for M-20 mix. The compressive strength at 3 days, 7days and 28 days have been obtained with normal curing condition. A maximum increase in compressive strength of 32.2Mpa with 10% of RHA replacement and silica fume of approximately 10% was observed. The compressive strengths of concrete is reduced as the percentage of RHA replacement is increased beyond 10%.

Key words: Rice husk ash, silica fume, cementitious material, Compressive Strength, split strength

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INTRODUCTION

Concrete is one of the most widely used construction materials, because of its good durability to cost ratio. Cement is widely noted to be most expensive constituents of concrete. The need to reduce the high cost of Ordinary Portland Cement in order to provide accommodation for the populace has intensified research into the use of some locally available materials that could be used as partial replacement for Ordinary Portland Cement [1]. The use of RHA in concrete leads to around 8-12% saving in material cost [9]. Rice husk is produced in millions of tons per year as a waste material in agricultural and industrial processes. It can contribute about 20% of its weight to Rice Husk [2]. Rice husk ash (RHA), an agricultural waste, is classified as "a highly active pozzolan" because it contains a very high amount of amorphous silica and a large surface area [11]. It is estimated that 1,000kg of rice grain produce 200kg of rice husk; after rice husk is burnt, about 20 percent of the rice husk or 40 Kg would become RHA Rice husk ash (RHA) is a general term describing all types of ash produced from burning rice husk [12]. In practice, the type of ash obtained varies considerably according to the burning technique. At 550°C – 800°C amorphous ash is formed and at temperatures greater than this, crystalline ash is formed [3]. The pozzolanic and cementitious reaction associated with RHA reduces the free lime present in the cement paste, decreases the permeability of the system, improves overall resistance to CO_2 attack and enhances resistance to corrosion of steel in concrete. The content of silica in the ash is about 92-97% [10]. The partial replacement of cement by RHA will result in lower energy consumption associated with the production of cement [4]. RHA has two roles in concrete manufacture as a substitute for cement, reducing the cost and weight of concrete in the production of low cost building blocks.

MATERIALS AND EXPERIMENTAL METHODOLOGY

Cement

The Ordinary Portland cement of 53-grade was used in this study conforming to IS: 12269-1987 [5] as shown in Table 1.

Fine Aggregates

The river sand is used as fine aggregate conforming to the requirements of IS: 383-1970 [6] as shown in Table 2.

Coarse Aggregate
Coarse aggregate obtained from local quarry units has been used for this study conforming to IS: 383-1970 [6] as shown in Table 3.

Rice Husk Ash
Rice Husk Ash used in the present experimental study was obtained from Tindivanam, Tamilnadu. Specifications and Physical Properties of this RHA are as shown in Table 4.

Silica Fume
The specific gravity of silica fume is 2.2. It consists of 0.1 to 1 micron sized fine, smooth spherical glassy particles with fineness of 20m²/gm conforming to ASTM C1240-1999 standards [16].

Water
The water used for experiments was potable water conforming as per IS: 456-2000 [14].

Table -1 Properties of Cement (OPC 53 grade)

Physical Properties of Cement	Result
Specific gravity	3.15
Standard consistency (%)	31%
Initial setting time (min)	35 min
Final setting time (min)	178 min

Table -2 Physical Properties of Fine Aggregates

Property	Fine aggregate
Specific gravity	2.7
Fineness modulus	2.71
Water absorption (%)	1.20%
Bulk Density (gm/cc)	1753

Table -3 Physical Properties of Coarse Aggregates

Property	Coarse aggregate
Specific gravity	2.64
Fineness modulus	6.816
Water absorption (%)	0.75%
Bulk Density (gm/cc)	1741

Table 4 Physical Properties of RHA

Particulars	properties
Colour	Gray
Specific gravity	2.33

Table -5 Details of Mix Proportions of Concrete

Cement Replacement % of RHA	W/C ratio	Cement	Coarse Aggregate	Fine Aggregate	Cement Replacement by RHA	Cement Replacement by silica fume
0	0.40	492.5	1021.74	781.73	0	0
5	0.40	467.87	1021.74	781.73	24.62	2.46
10	0.40	443.25	1021.74	781.73	49.25	4.92
15	0.40	418.62	1021.74	781.73	73.87	7.38
20	0.40	394.00	1021.74	781.73	98.5	9.85
25	0.40	369.375	1021.74	781.73	123.12	12.31

Table -6 Compressive Strength with Various Percentages of RHA

Rice Husk Ash Replacement (%)	Compressive Strength (N/mm2)		
	3 days	7 days	28 days
0	14.44	20.2	30.3
5	12.7	19.2	31.5
10	14.7	21.8	34.2
15	8.88	17.7	23
20	7.2	15.2	20.2
25	6.2	9.6	16.4

Table -7 Split Tensile Strength with Various Percentages of RHA

Rice Husk Ash Replacement (%)	Split tensile Strength (N/mm2)		
	3 days	7 days	28 days
0	1.34	2.67	3.91
5	0.94	2.19	3.12
10	1.06	2.34	3.32
15	0.85	1.89	2.83
20	0.82	1.82	2.78
25	0.67	1.49	2.22

EXPERIMENTAL PROCEDURE

M20 grade concrete mixes of different RHA levels (5% to 25% by weight replacement of cement and silica fume of 10% with w/c ratio of 0.40 (IS 10262-2009) were prepared. The mixes were designated in accordance with IS: 10262-2009 [7]. The weight of each material for the above grade of M20 cement mix is tabulated in Table 5. The workability of fresh concrete is determined by slump test confirming to IS: 456-2000 [14]. It was found that the replacement by 10% RHA for cement showed a better slump value when compared to other value of percentage of RHA as shown in Fig.1. A total of 45 concrete cubes and 45 concrete cylinders were casted for the different percentages of replacement of cement [8]. The specimens were demoulded after 24 hours and curing was done for different age of testing. They were tested for their strength properties on 3, 7, 28th day confirming to IS: 516-1959 [15].

Workability Test

It is used to determine the workability of fresh concrete. The apparatus used for slump test are: slump cone and tamping rod.

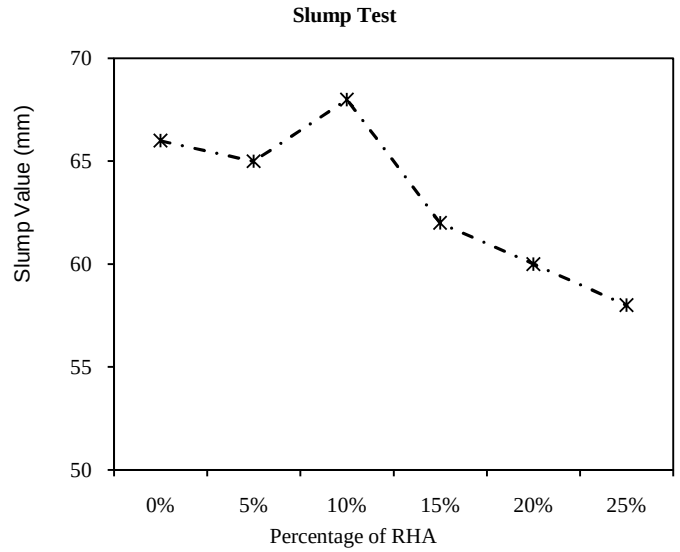

Fig.1 Slump test for various % of RHA

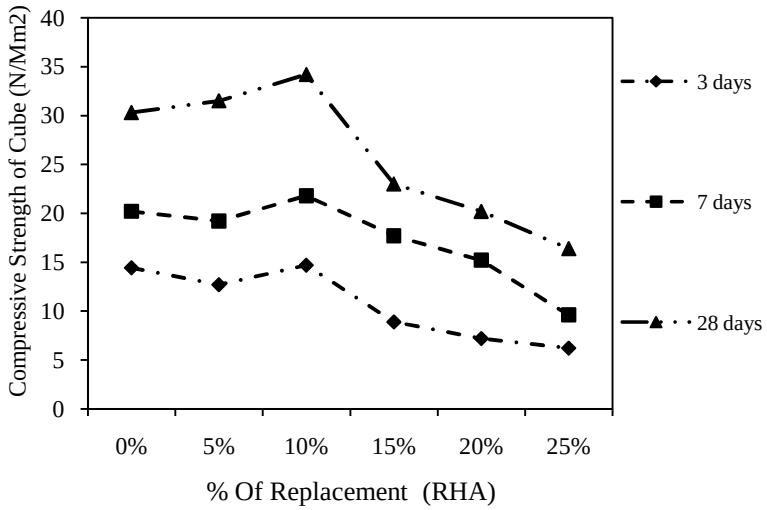

Fig. 2 Comparison of Compressive Strength of Cubes on 3, 7 and 28 Days

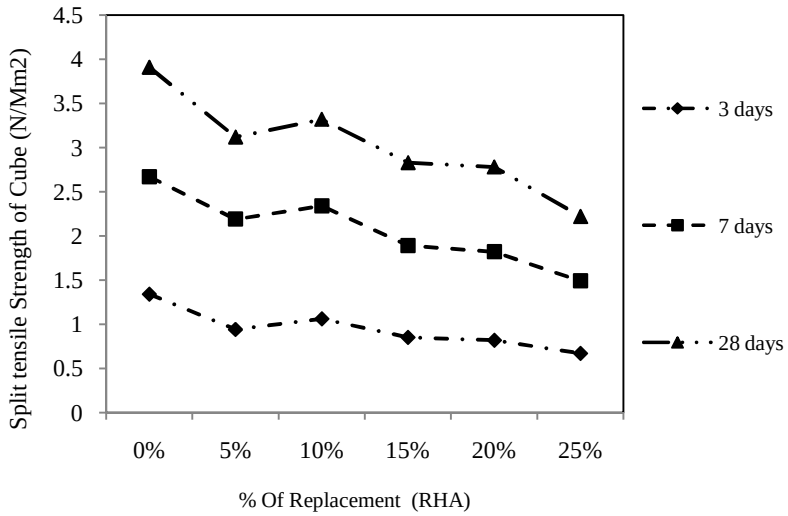

Fig. 3 Comparison of Compressive Strength of Cubes on 3, 7 and 28 Days

RESULTS AND DISCUSSION

- The compressive and tensile strength of M20 grade concrete mix for different percentage RHA for replacement of cement as shown in Table 6 and Table 7. The results for various percentages are discussed below.
- The compressive strength showed an increase trend at the end of 3, 7 and 28 days with 13%, 12% and 9.3% respectively for 10% of RHA.
- With the increase of RHA from 10% to 25% the compressive strength showed a drastic decling strength of 57%, 55% and 52% at the end of 3, 7 and 28 days respectively as shown in Fig 2.
- The split tensile strength showed an increase trend at the end of 3, 7 and 28 days with 11%, 6.4% and 6% respectively for 10% of RHA.
- With the increase of RHA from 10% to 25% the compressive strength showed a drastic decling strength of 36.7%, 36.3% and 33.1% at the end of 3, 7 and 28 days respectively as shown in Fig 2.

CONCLUSION

From the above discussion the following conclusion can be drawn -

- For M20 grade of concrete, the compressive strength and split tensile strength increases with 10% of silica fume and 10% of RHA.
- Above 10% of RHA, the compressive strength and split tensile strength found to decrease and hence it is concluded that only 10% of RHA can allowed achieving the desired compressive strength of concrete.
- Hence the optimum % for the additions of RHA in cement can be 10% [13].

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