

Assessment of Characteristic Strength of Concrete Using Fly Ash and Rice Husk Ash

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ABSTRACT: This paper deals with the potential use of Rice Husk Ash (RHA) and Fly Ash (FA) in combined proportion as a cementitious material in concrete. Experimental investigation was done to study the effect on strength of the concrete prepared by 30% replacement of OPC-43 by Fly Ash (FA) and Rice Husk Ash (RHA) in combined proportion. Initial replacement was started from 30% FA and 0% RHA together in concrete by weight of cement, with the gradual increase of RHA by 3% and simultaneously gradual decrease of FA by 3%. Last proportion was taken 15% Fly Ash and 15% RHA by weight of cement in concrete. Among different concrete mix consists of SCMs (FA and RHA), optimum replacement for OPC-43 was reported as 24% FA and 6% RHA by weight of cement, for the strength of concrete. Compressive strength, split tensile strength and flexural strength of optimum mix proportion has strength value only varies within 10% from the strength value of normal concrete. Thus result shows the possibility of use of such concrete in construction.

KEYWORDS: Concrete, Strength, OPC-43, SCM (Supplementary cementing material), Fly Ash, Rice Husk Ash etc.

I. INTRODUCTION

Over the past years, there has been an increasing number of papers on the use and utilization of industrial, agricultural and thermoelectric plants residue in the production of concrete. Different materials with pozzolanic properties such as fly ash, silica fume, blast-furnace slag and rice husk ash have played an important role in the production of concrete. Substantial energy saving, reducing environmental ill-effects and cost savings can result when above mentioned by-products/waste are used as a partial replacement for the energy intensive Portland cement. Among the different existing residues and by-products, the possibility of using rice husk ash in the production of concrete is very important for India as it is the second largest paddy cultivating country in the world.

The milling of rice produces rice husk, which is a waste material. Rice husk is generated on average at a 20% rate by weight of the rice that is processed. The burning of the husks produces ash at an average of 18% by weight of the husk (D. V. Ready 2006). Prior to 1970, RHA was usually produced by uncontrolled combustion, and the also produced was generally crystalline and had poor pozzolanic properties. In 1973, Mehta published the first of several papers describing the effect of pyroprocessing parameters on the pozzolanic reactivity of RHA (Bouzoubaa, 2001). The use of RHA will contribute not only to the production of concrete of a higher quality and lower cost, but also the reduction of carbon dioxide (CO₂) emissions from the production of cement. The burning of Rice husk at temperatures of 550°C – 800°C, amorphous silica is formed which is desirable in concrete, but at higher temperatures crystalline silica is produced, also at lower temperature carbon content increases, which are not desirable. The silica content at above mentioned temperature is between 90%- 96%. The melting point of rice husk ash is 1440°C.

Fly Ash is finely divided produced by coal-fired power station. In India, coal continues to be used as a major source of fuel for power generation of about 59% of total, which result in generation of huge quantity of ash every year. This quantity is estimated to reach about 225 million tonnes by the year 2017 and present value is about 163 million tonnes (S N Ganguly, Director, NTPC limited 2015). Fly Ash is the most widely used pozzolanic material all over the world. This is not only due to its great global availability (over 600 million tonnes annually) and low cost, but also due to the fact that is clearly the most tested and best quality-controlled SCM being utilized in the construction sector.

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II. LITERATURE REVIEW

Hwang and Chandra (1996) have suggested that the particle size of RHA in the 10–75 μm range exhibits satisfactory pozzolanic behavior. RHA processed with higher burning temperature with some crystalline silica, reactive RHA could be obtained by fine grinding (Rodriguez-Camacho, 2002; Mehta, 1977; Zhang and Malhotra, 1996). The properly burnt and ground rice husk can be used as a mineral admixture in cement production (IS 3812 part-1, Ganesan et al., 2008; Chindaprasirt et al, 2008), High amounts (up to 30%) of RHA could be blended with cement without adversely affecting the strength and permeability of concrete (Chatveera and Lertwattanaruk, 2009). For durability, RHA often improves the concrete's resistance to deterioration from sulfates and chlorides, and also lowers the temperature of fresh concrete (Huang et al., 2005; Gastaldini et al., 2007).

Fly Ash provides relatively slow rate of reaction [M.D.A. Thomas et al, 1999], it generally provides improved workability [M.D.A. Thomas et al, 1999; S N Ganguly 2015], higher later-age strength [N. Bouzoubaa et al, 1999; V.G. Papadakis, 2000] and superior resistance towards aggressive media [R.K. Dhir et al, 1999; S. Antiohos et al, 2003] when it is added in cement and concrete. Looking into fly ash as a resource material, Ministry of environment and forests, Government of India, brought its Gazette notification dated 14-09-199, 27-08-2003 and 03-11-2009 and has made mandatory for construction agencies to use fly ash and fly ash based product in building construction, road embankment, mine filling, land filling etc.

III. EXPERIMENTAL SETUP AND PLANNING

A. GENERAL

The whole experimental work is classified into the following steps:-

- 1) Collection of the Materials. 2) Tests of Materials. 3) Selection of Mix Design. 4) Tests of Normal Concrete, and 5) Tests of (FLY ASH+RICE HUSK ASH) Concrete.

B. MATERIALS AND METHODS

Cement: - Ordinary portland cement of 43 grade, conforming to IS: 8112-1989 was used in the entire experimental work.

Table 3.1 Properties of cement (OPC 43 Grade)

Properties	Results	Standard Limits (IS:8112-1989)
Consistency	25%	—
Initial setting time	95 minutes	>30 minutes
Final setting time	252 minutes	<600 minutes
Soundness	Expansion 1.29mm	<10mm
Specific gravity	3.132	—
Fineness	06% Retain on 90 micron sieve	<10%
Compressive strength	In N/mm^2	In N/mm^2
• 3days	24.33	>23
• 7days	34.00	>33
• 28 days	46.50	>43

Natural fine aggregate (Damodar river sand) and **Natural coarse aggregate** (Baliyapur, Jharkhand) was procured locally. The **Fly Ash** was collected from Bokaro Thermal power plant (Jharkhand, India), the **Rice Husk Ash** was collected from burdwan rice mill (West Bengal, India) and **Potable water** was used for mixing and curing of concrete.

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Table 3.2 Physical properties of pozzolanic material

Sl. No.	Parameters	Fly Ash	Rice Husk Ash
1	Specific gravity	2.1	2.12
2	Fineness	4%	2%
3	Unit weight	0.750 gm/cc	0.766 gm/cc
4	Moisture content	0.35%	0.70%

C. SELECTION OF MIX DESIGN

Three different mix designs M_1 , M_2 and M_3 were prepared for three different water-cement ratios to get M25 as per IS: 10262-2009. The most appropriate mix design was selected on the basis of slump value and compressive strength. The target mean strength was 31.6 MPa for the normal concrete, and the normal concrete consists of 398 kg/m³ OPC-43 grade cement, 680 kg/m³ fine aggregate and 1168 kg/m³ coarse aggregate. The water cement ratio was 0.48 for selected mix design.

D. MIXING, CASTING AND CURING

Cement, fine aggregate and coarse aggregate were properly mixed together in ratio 1:1.71:2.93 by weight, before water was added and was properly mixed together to achieve homogenous material. The total mixing time was 5 minutes; the samples were then casted and left for 24 hrs before demoulding. Cube (150 mm x 150 mm x 150 mm), Beam (100 mm x 100 mm x 500 mm) and Cylinder (150 mm ϕ x 300mm) moulds were used for casting. Compaction of concrete in the moulds was done in three layers. The concrete cubes were cured in the curing tank for 7, 28, and 90 days for compression test but prism and cylinder specimens were cured for 7 days and 28 days before testing for flexural and split tensile strength respectively.

IV. EXPERIMENTAL RESULTS

A. GENERAL

This chapter deals with the results of the tests performed for this project work. The results of green concrete and hardened concrete are discussed with the help of tables and graphs. Test was started with normal concrete of M25 grade thereafter; replacing 30 % cement by RHA and FA in next each mix proportion.

Table 4.1 Nomenclature

S	Normal Concrete
S ₁	Concrete Consists of 30% FA and 0% RHA, by weight of Cement
S ₂	Concrete Consists of 27% FA and 3% RHA, by weight of Cement
S ₃	Concrete Consists of 24% FA and 6% RHA, by weight of Cement
S ₄	Concrete Consists of 21% FA and 9% RHA, by weight of Cement
S ₅	Concrete Consists of 18% FA and 12% RHA, by weight of Cement
S ₆	Concrete Consists of 15% FA and 15% RHA, by weight of Cement

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B. TESTS ON FRESH CONCRETE

WORKABILITY OF FRESH CONCRETE: - The slumped concrete takes various shapes and according to the profile of slumped concrete, the slump is termed as true slump, shear slump or collapses slump. If a shear or collapse slump is obtained, a fresh sample should be obtained so as to repeat the test. A collapse slump means that the mix is too wet or workability of mix is high, in this particular case slump test is not appropriate. Only a true slump is of any use in the test. The slump values obtained for concrete mix proportion are tabulated below in table no.4.2.

Table 4.2 Slump value of different concrete mix

Mix designation	Slump (mm)	% Change w.r.t. normal concrete (S)
S	75	-
S ₁	90	+20.00
S ₂	86	+14.67
S ₃	79	+5.33
S ₄	69	-8.00
S ₅	63	-16.00
S ₆	53	-29.33

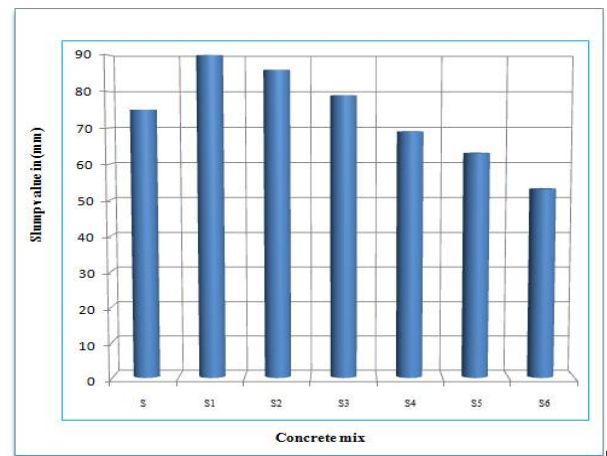


Fig 4.1 Slump value of different concrete mix

C. HARDENED CONCRETE TESTING

The principal properties of hardened concrete which are of practical importance are those concerning its strength; stress-strain characteristics; shrinkage and creep deformations; response to temperature variation; permeability and durability. Of these, the strength of concrete assumes a greater importance because the strength is related to the structure of hardened cement paste and gives an overall picture of the quality of concrete.

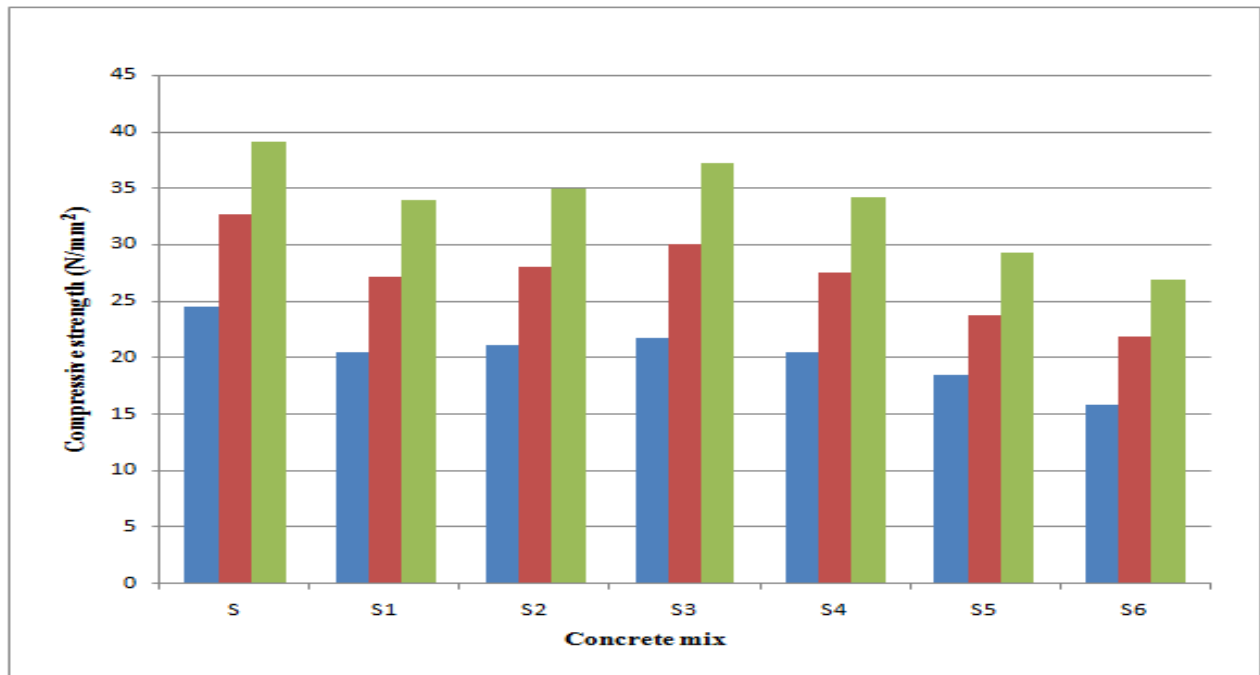
Table 4.3 Compressive strength of cubes

Mix Strength	S	S ₁	S ₂	S ₃	S ₄	S ₅	S ₆
7 days strength (in N/mm ²)	25.42	20.48	21.11	21.70	20.44	18.44	15.78
28 days strength (in N/mm ²)	32.67	27.18	28.00	30.00	25.76	23.78	21.85
90 days strength (in N/mm ²)	39.11	34.00	34.89	37.18	34.15	29.32	26.89

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From table 4.3 it may be concluded that

- Addition of fly ash and rice husk ash in the OPC-43 shows there is lesser early days compressive strength development to the concrete mix.
- The addition of RHA in OPC-43 as partial replacement, improves the compressive strength of concrete up to 6% .Thereafter addition of RHA to the concrete shows negative impact on compressive strength at all the age of concrete.
- At all the age of the concrete mix, optimum replacement of cement is reported as 24% FA and 6% RHA for compressive strength of concrete.

Table 4.4 Split tensile test results

Mix Strength	S	S ₁	S ₂	S ₃	S ₄	S ₅	S ₆
7 days strength(in N/mm ²)	2.26	1.84	1.91	1.98	1.63	1.49	1.27
28 days strength(in N/mm ²)	3.67	3.12	3.26	3.33	2.92	2.41	2.06

From above table it may be concluded as-

- With the inclusion of fly ash only as 30% OPC-43 replacement in the concrete, split tensile strength of concrete decreases by 18.60% after 7 days and 15.00% after 28 days w.r.t. normal concrete.
- From mix S₁ to S₃, rate of improvement of split tensile strength is slower as compared to rate of loss of split tensile strength between mixes S₃ to S₆.
- For the mix S₃, split tensile strength decreases by 12.40% after 7 days w.r.t. normal concrete.
- For the mix S₃, split tensile strength decreases by 9.26% at 28 days w.r.t. normal concrete.

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Table 4.5 Flexural strength test results

Mix Strength	S	S ₁	S ₂	S ₃	S ₄	S ₅	S ₆
7 days strength(in N/mm ²)	3.92	3.00	3.17	3.60	3.00	2.80	2.53
28 days strength(in N/mm ²)	5.06	4.06	4.20	4.80	3.93	3.70	3.27

From above table it may be concluded as-

- With the inclusion of fly ash only as 30% OPC-43 replacement in the concrete, flexural strength of concrete decreases by 23.50% after 7 days and 19.80% after 28 days w.r.t. normal concrete.
- Addition of rice husk ash and decreasing in initial percentage of fly ash shows gradual increase in flexural strength of concrete over S₁ up to the mix S₃.
- From mixes S₁ to S₃ rate of improvement of flexural strength is slower as compared to rate of loss of flexural strength between mixes S₃ to S₆.
- For the mix S₃ flexural strength decreases by 8.16% after 7 days w.r.t. normal concrete. For the mix S₃ flexural strength decreases by 5.10% after 28 days w.r.t. normal concrete.

V. CONCLUSION

The analysis of results indicates that there is a possibility of partial replacement of ORDINARY PORTLAND CEMENT with combination of FLY ASH and RICE HUSK ASH.

The present work may be concluded as follows-

- 1) Replacement of OPC-43 by Fly Ash increases the workability of concrete while Rice Husk Ash decreases the workability of concrete.
- 2) The optimum replacement of OPC-43 by 30% using Fly Ash & Rice Husk Ash, for strength of concrete was found to be 24% Fly Ash & 6% Rice Husk Ash by weight of cement.
- 3) The use of Fly Ash and Rice Husk Ash in the OPC-43 shows there is slower rate of strength development in early days.
- 4) Compressive strength, split tensile strength and flexural strength of optimum mix proportion has strength value only varies within 10% from the strength value of normal concrete.
- 5) Fly Ash and Rice Husk Ash in combine proportion as partial replacement to OPC-43 by 30% will Minimize the costs of construction as it is cheaply available.

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