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A Study on the Effect of Fly Ash and Rice Husk Ash on Strength Parameters of Pavement Quality Concrete

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ABSTRACT: Concrete pavements have high strength, durability, better serviceability and overall economy in the long run. The shove nowadays is to produce thinner and green pavement sections of better quality, which can carry the heavy loads. The present study was undertaken to investigate the effect of partial replacement of cement with fly ash and rice husk ash on compressive strength and flexural strength of concrete mix. Cement was partially replaced by fly ash at three different levels of replacement i.e. 10%, 20% and 30% and same with rice husk ash as well as with combined replacements of fly ash and rice husk ash. Tests were performed after 28 days of curing of concrete. Cubes and beams were prepared for determining compressive strength and flexural strength of concrete with different water-cement ratio as 0.30, 0.35 and 0.40 for min required flexural strengths 5.5 N/mm^2 5 N/mm^2 4.5N/mm^2 respectively. Super-plasticizer was used in all the mixes at 1% level by weight of cementitious material. It is found that it is possible to achieve savings in cement by replacing it with FA and RHA.

I. INTRODUCTION

Concrete usage around the world is second only to water. Ordinary Portland cement (OPC) is conventionally used as the prime binder to produce concrete. A concrete pavement is a structure comprising of a layer of Ordinary Portland Cement Concrete which is usually supported by a sub-base layer on the sub-grade. Concrete pavements may be either unreinforced (plain) or reinforced depending on how the designer prefers to control shrinkage cracking, which will occur in the pavements. The beneficial attributes of concrete pavements are it has Long lasting – 40 year Design Life, Saving natural resources. Pavement maintenance costs are up to 10 times cheaper than the same for flexible pavements, can be constructed over poor sub-grades, Greener process, Resistant to abrasion from turning actions., Concrete pavements have clean appearance, High abrasion durability, High sustainability rating through use of local materials, Use of waste products like fly-ash and slag, Concrete is generally less slippery in wet weather.

The characteristic flexural strength of concrete shall not be less than 4.5 MPa (M 40 Grade). Target mean flexural strength for mix design shall be more than 4.5 MPa + 1.65*s, where s is standard deviation of flexural strength derived by conducting test on minimum 30 beams. While designing the mix in the laboratory, correlation between flexural and compressive strengths of concrete shall be established on the basis of at least thirty tests on samples. However, quality control in the field shall be exercised on the basis of flexural strength. The water content shall be the minimum required to provide the agreed workability for full compaction of the concrete to the required density and the maximum free water cement ratio shall be 0.45 when only OPC is used and 0.50 when blended cement (Portland Pozzolans Cement or Portland Slag Cement or OPC blended with fly ash or Ground Granulated Blast Furnace Slag at site) is used.

II. MATERIALS AND METHODS

The work presented in this paper reports an investigation on the behaviour of concrete produced from partial replacement of cement with RHA and FA. The physical and chemical properties of RHA, FA and OPC were first investigated. The effects of RHA and FA on concrete properties were studied by means of the mechanical properties of concrete i.e. compressive strength and flexural strength.

A. Cement

The cement used was Ordinary Portland cement (43 Grade) with a specific gravity of 3.15. Initial and final setting time of the cement was 75 min and 250 min, respectively, conforming to I.S-8112- 1989.

Table 1: Chemical properties of cement (OPC), Fly ash and Rice husk ash.

Materials	SiO2 (Silica)	Al2O3 (Alumina)	Fe2O3 (iron oxide)	CaO (calcium oxide)	Mgo (Magnisium oxide)	LOI (Loss on ignition)	K2O (Potassium oxide)	Na2O3 (Sodium oxide	SO3 (Sulphur tri oxide)
Cement	19.69	5.52	3.69	62.90	2.52	0.94	0.89	0.24	2.73
Fly ash	46.8	23.7	13.2	1.2	1	6.9	0.82	0.95	1.72
Rice husk ash	92.1	0.51	0.40	0.55	0.08	_	1.53	_	0.12

Table 2: Properties of OPC 43 Grade Concrete.

Sr. No.	Characteristics	Values Obtained Experimentally	Values Specified By IS 8112:1989
1.	Specific Gravity	3.15	-
2.	Standard Consistency	26.5%	-
3.	Initial Setting Time, minutes	75	30 minutes (minimum)
4.	Final Setting Time, minutes	250	600 minutes (maximum)
5.	Compressive Strength 3 days 7 days 28 days	28.2 N/mm^2 37.5 N/mm^2 48.2 N/mm^2	23 N/mm^2 33 N/mm^2 43 N/mm^2

B. Rice Husk Ash

Completely burnt rice husk ash was brought from rice mills from Sirsa. The Specific gravity of rice husk ash is 1.99 and bulk density is 105.9 kg/m^3 RHA, produced after burning of Rice husk (RH) has high reactivity and pozzolanic property. IS 456- 2000 [10].

C. Fly Ash

Fly ash used in the study was obtained from Rajiv Gandhi Thermal Power Plant, Khedar, Hissar, India. Fly ash is one of the residues generated in the combustion of coal. Fly ash is generally captured from the chimneys of power generation facilities, whereas bottom ash is, as the name suggests, removed from the bottom of the furnace.

In the past, fly ash was generally released into the atmosphere via the smoke stack, but pollution control equipment mandated in recent decades now require that it be captured prior to release. It is generally stored on site at most US electric power generation facilities. Depending upon the source and makeup of the coal being burned, the components of the fly ash produced vary considerably, but all fly ash includes substantial amounts of silica (silicon dioxide, SiO2) (both amorphous and crystalline) and lime (calcium oxide, (CaO). Fly ash is commonly used to supplement Portland cement in concrete production, where it can bring both technological and economic benefits.

D. Aggregate

Good quality river sand was used as a fine aggregate. The fineness modulus, specific gravity bulk density and water absorption are 2.52, 2.65,1300 kg/m3 and 0.80%. Coarse aggregate passing through 20mm and retained 10mm sieve was used. Its specific gravity and water absorption was 2.65 and 0.33%.

Table 3: Physical properties of rice husk ash.

Physical property	Value
Colour	gray with slight black
Bulk density	105.9 kg/m^3
Specific gravity	1.99
Fineness	2775 cm^2/gm
Avg. particle size	150.47µm
Mesopores	78%
Heating value	9.68 MJ/kg

Table 4: Physical properties of fly ash.

Physical property	Value
Colour	Whitish gray
Bulk density	1120 kg/m^3
Specific gravity	2.10
Fineness	2840 cm^2/gm

E. Chemical Admixture

The main purpose to used superplasticiser was to maintain the workability of concrete. As we Specific surface area of RHA is high and it needed more water quantity .superplasticiser constant w/c by partial replacement of cement combination of FA and RHA. The superplasticiser "GLENIUM™ B233" procured from SIKA India Pvt. Limited was used to maintain the workability of fresh concrete. The dosage of Super plasticizer was 1% to 1.5% by weight of cement of the binder content of concrete. The super plasticizer benefits in increasing the workability without increasing the w/c ratio**.**

III. EXPERIMENTAL PROGRAM

Experimental programme comprises of test on cement, concrete with partial replacement of cement with RHA and FA.

A. Mixture Proportioning

The mix proportion was done as per the IS 10262-1982[11]. The target mean strength was 48.25 MPa (M40) for the OPC control mixture,. The water/cement ratio was kept constant as 0.40, 0.35 and 0.30. [16]

Table 5: Mix Design of Pavement Quality Concrete.

Mean Target Flexural Strength (MPa)	Max. Size Of Aggregate (mm)	Mix proportions (C:FA:CA-I:CA-II)	W/C ratio	Materials for 1 m3 in (kg)				
				Water	Cement	F.A	C.A-I (20mm)	C.A-II (10 mm)
4.5	20	1 : 1.95:2.05:0.88	0.4	154	385	751	788	338
5	20	1 : 1.902:1.997:0.86	0.35	140	400	761	798.84	342.36
5.5	20	1 : 1.884:1.978:0.85	0.3	124	415	772	811.1	347.62

IV. EXPERIMENTAL METHODOLOGY

A. Compressive Strength Test

Test specimens of size 150mm x 150mm x 150mm were prepared for testing the compressive strength. In this study, the mix was done manually. The interior surface of the moulds and the base plate were highly oiled before concrete was placed. The moulds were filled with different proportions of cement, Rice Husk Ash and Fly Ash. Vibration was given to the moulds using table vibrator. After 24 hours the specimens were removed from the moulds and placed in clean fresh water at for 28 days curing.. The load was applied axially without shock till the specimen was crushed. Test results of compressive strength test at the age of 28 days these cubes were tested on digital compression testing machine as per I.S. 516-1959[17].

B. Flexural Strength Test.

Test specimens of beam size 150 mm 150 mm 700 mm were prepared for testing the flexural strength of unreinforced beams. The beam moulds conform to IS: 10086-1982. Test specimens shall be placed in clean fresh water at a temperature of 24^0-34^0c for 28 hours before testing. The specimens shall be tested immediately on removal from the water while they are still in the wet condition. The Flexure test was performed on two point loading system.

V. EXPERIMENTAL RESULTS

A. Results of Compressive Strength

Table 6: Results of Compressive strength with different % of FA+RHA.

	w/c=0.40		W/C = 0.35		W/C = 0.30	
	7th day	28th day	7 days	28days	7th day	28th day
0%FA	39.27	53.02	40.04	56.87	46.5	61.67
10%FA	37.83	48.95	37.87	49.78	42.46	53.26
20%FA	34.62	46.08	35.15	48.2	44.45	53.02
30%FA	29.31	42.39	32.86	42.82	32.86	46.23
10%RHA	22.77	32.6	24.24	33.74	26.75	41.84
20%RHA	19.65	30.03	21.56	31.67	23.46	32.41
30%RHA	16.60	26.51	19.3	26.84	21.36	27.09
10%FA + 10%RHA	21.03	32.34	23.98	34.98	30.52	44.68
20%FA + 10%RHA	16.50	27.52	20.87	32.25	26.01	39.61
10%FA + 20%RHA	16.06	25.91	18.26	30.44	22.25	35.99

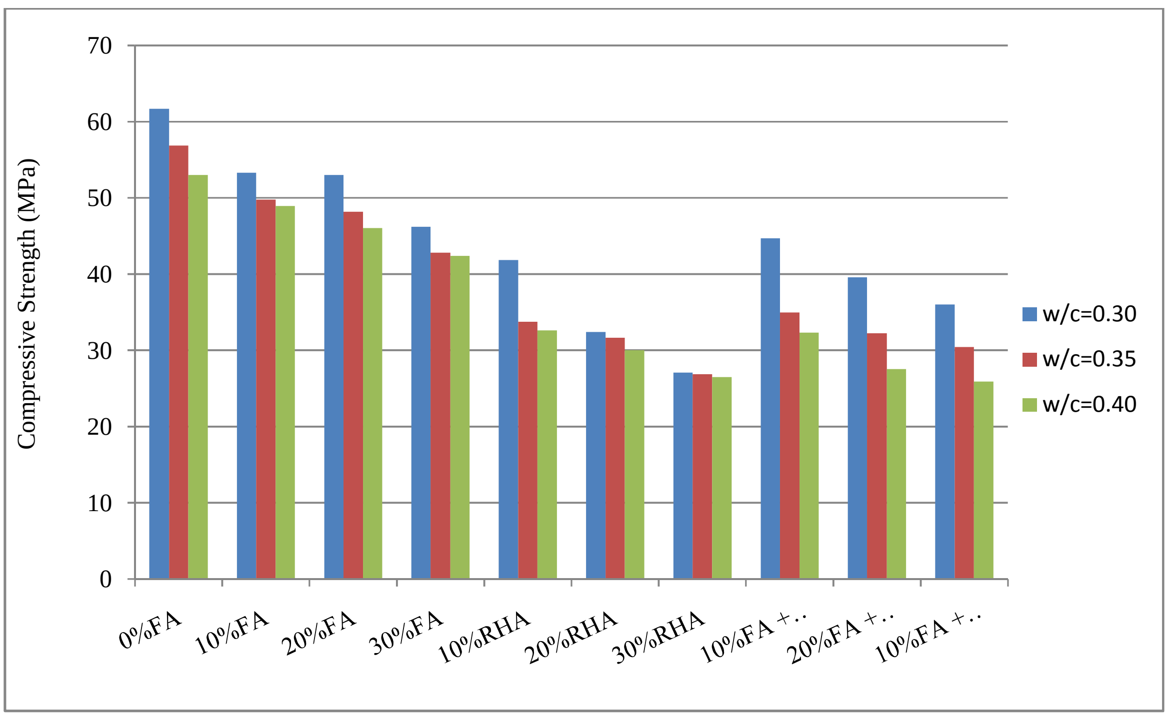

Fig. 1. 7-day and 28-day compressive strengths for all water cement ratios.

Figure 1 indicates the comparison of results of compressive strength using cube specimen of M40 grade of concrete for different percentage of cement, RHA and FA. Target strength of M40 concrete was 48.25 Mpa, it was observed that compressive strength obtained at combination of 20% FA at all water cement ratio which was less than strength of control concrete but greater than target strength .and at 10%FA+10% in w/c= 0.3 showed higher compressive strengths than minimum required as per MoRT & H specifications.

A. Results of Flexural Strength on Beams (As per IS: 516 1959)

Table 7: Results of flexural strength with different % of FA+RHA.

	w/c=0.30	w/c=0.40	w/c=0.35
Minimum rec.	5.5	4.5	5
0%FA	6.37	5.9	5.38
10%FA	6.21	5.84	5.16
20%FA	5.89	5.51	5.01
30%FA	5.33	5.29	4.56
10%RHA	5.02	4.84	4.4
20%RHA	4.2	3.97	3.42
30%RHA	3.59	3.38	3.07
10%FA + 10%RHA	4.02	3.93	3.53
20%FA + 10%RHA	3.87	3.73	3.37
10%FA + 20%RHA	3.56	3.42	3.02

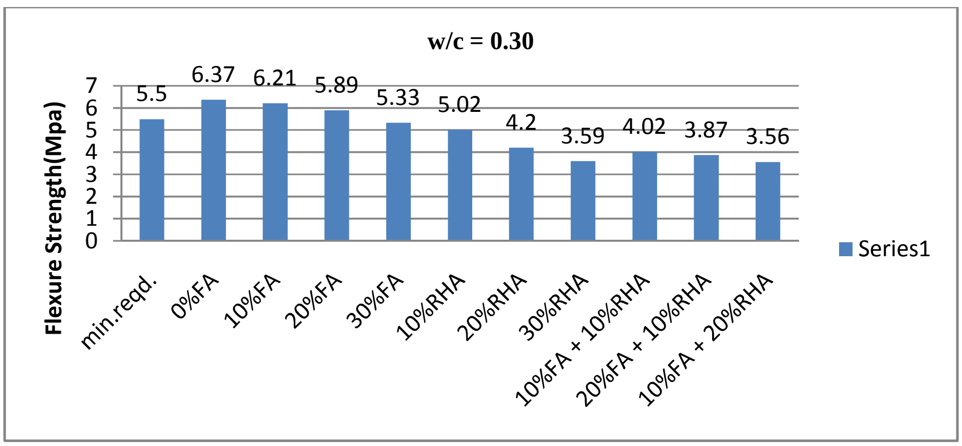

Fig. 2. Results of flexural strength with different % of FA+RHA.

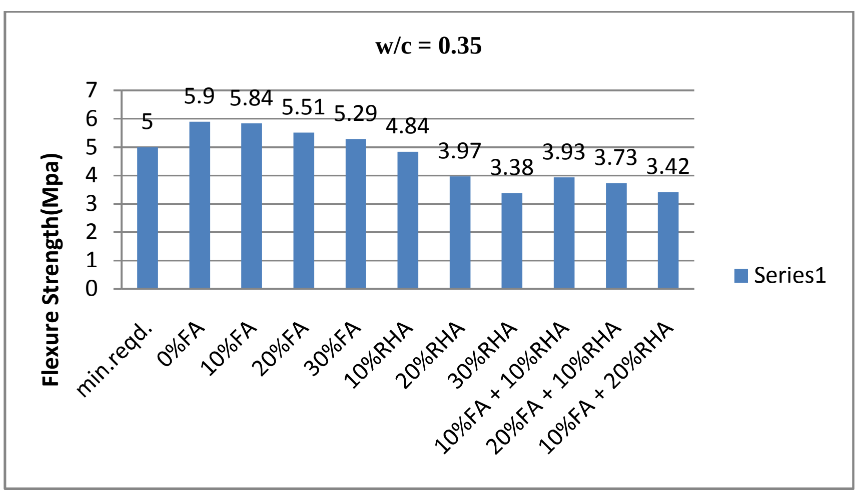

Fig. 3. Results of flexural strength with different % of FA+RHA.

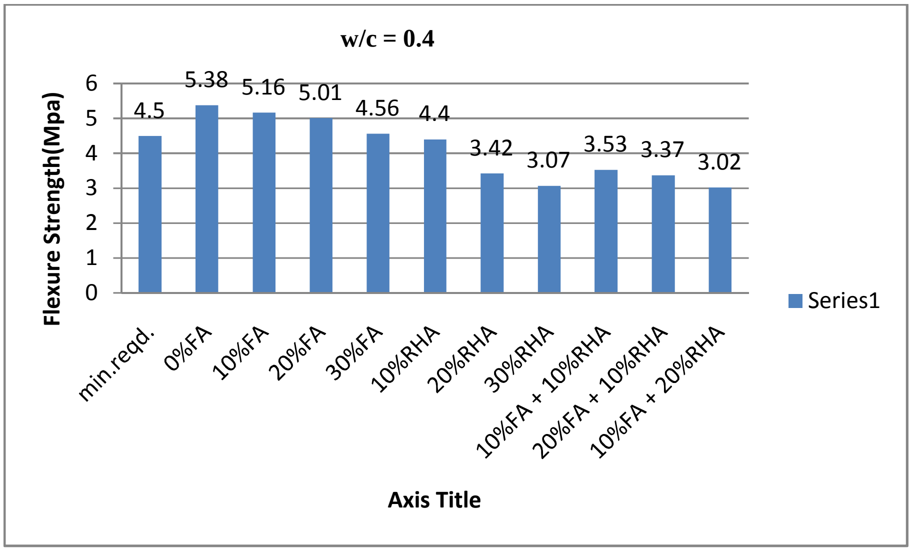

Fig. 4. Results of flexural strength with different % of FA+RHA.

Fig. 2, 3 & 4 indicates the comparison of results of flexural tensile strength using beam specimens of M40 grade of concrete. Beams were tested after 28 days of curing for Flexural Strength. It was observed that Fly ash up to 20% replacement for all the water-cement ratios showed higher flexural strengths than minimum required flexural strengths as per PQC design standards.

CONCLUSIONS

Fly ash and Rice husk ash is found to be better-quality to other supplementary materials like slag, and silica fume. RHA used in this study is efficient as a pozzolanic material; it is reach in amorphous silica. Due to less specific gravity of RHA which leads to reduction in mass per unit volume, thus adding it reduces the dead load on the structure and it helps in reducing the environment pollution during the disposal of excess Fly ash and Rice husk ash. Cement is costly material, so the partial replacements of these materials by Rice husk ash and Fly Ash reduces the cost of concrete. Based on the results presented above, the following conclusions can be drawn:-

(i) Concrete mix with up to 30% percent replacement of cement with fly ash for all water-cement ratios have higher compressive strengths than minimum required as per MoRT & H specifications.

(ii) Concrete mixes with 10% replacement of rice husk ash in w/c= 0.3 have higher compressive strengths than minimum required as per MoRT & H specifications.

(iii) Concrete mixes with combined replacement of 10% each of fly ash and rice husk ash in w/c= 0.3 showed higher compressive strengths than minimum required as per MoRT & H specifications.

(iv) The mixes containing only fly ash could achieve 85 to 95% of the control strength, whereas, the mixes containing only 30% rice husk as replacement achieved only 55% of the target controlled strength.

(v) Fly ash up to 20% replacement for all the water-cement ratios showed higher flexural strengths than minimum required flexural strengths as per PQC design standards. Thus, 20% cement replacement by fly ash can be used in designing pavement quality concrete mixes with significant saving in cost.

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