Improvement of Mechanical Properties of Concrete with Rice Husk Ash

Daddan Khan Bangwar, Manthar Ali Keerio

Abstract— The research article relates to properties of Rice Husk Ash (RHA) manufactured by burning of locally available rice husk and its potential use as a cementitious material in concrete. RHA was extracted from burning of rice husk using a simple technique developed in the laboratory. The chemical characterization was carried out with the help of the Energy Dispersive Spectrometry (EDS) to check the silica content and X-ray Diffraction (XRD) analysis was done to authenticate the existence of amorphous silica in the ash. To establish the suitable proportion of RHA for part cement replacement, the concrete mixtures with 0 to 15% cement replacement with RHA were cast and their compressive strength were found out. A noteworthy enhancement in the compressive strength of mix at 10% cement replacement with RHA as compared to control mix has been noticed and workability remained within the required range.

Index Terms— Rice husk ash, supplementary cementing material, compressive strength, Amorphous, silica, concrete

1 Introduction

Researchers from the all over the world are endeavoring to to utilize waste materials produced from the different sources in the construction industry so as to get rid of the wastes which are detrimental for environment.

World rice consumption in 2014/15 is presently planned at 500.5 million tones [1] and the trend is surging as the population of world and utilization of rice rises as a food. The rice husk, an agricultural waste, is the byproduct produced an average of 20% during the milling process.

There is a considerable rising trend in the production of rice in Pakistan, therefore, it is considered to be the more important crop. In Pakistan it is being used as alternatives of the food, sometimes the byproduct of rice husk being used as a source of fuel for kilns. The use of rice husk as a fuel brings about a vast amount of ash. RHA has no practical usage, is regularly dumped in the fields in open area that causes environmental pollution. All out labors are being used to minimize environmental problem by making use of this waste as one of the supplementary cementing materials [2]. RHA has been used as a mineral admixture for concrete. The source of rice husk ash deemed to be an important factor in the different characteristics of cementitious material [3]. In order to produce an amorphous nature of RHA, it is to be burnt below The results proved its appropriateness as a cementing material up to 30% cement replacement with RHA.

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The authors [13-17] showed that the incorporation of RHA as a cement substitute material in concrete, a 800^{0}C [4-5]. Al-Khalaf et al. [6] used the RHA in cement as a binder, and have succeeded in cement replacement with RHA up to 40% without any significant change in the compressive strength than that of control mix. Le Anh-tuan Bui el al. [7] examined the impact of developed silica from the husk on the fundamental characteristics of concrete. They evaluated pozzolanic reactivity of an amorphous, partially crystalline and crystalline RHA, and come up with the results that amorphous RHA has an excellent characteristic in its mechanical and durability properties. Temperature range of an amorphous and crystalline RHA is at approximately 800^{o}C [8-10] and the burring of the husk above the stated temperature the produced silica will be with low pozzolanic activity. Cook, et al. [11] used an RHA as a cementing replacing material; the reactive silica was developed by flaming rice husk at a temperature 450^{0}C for four hours. The authors evaluated the strength and volumetric characteristics of RHA blended concrete. An expensive study was also carried out by Kartini K. [12] on RHA as sustainable cementing material. wide-ranging enhancement in durability characteristics have been noticed in concrete.

This research study relates to utilization of rice husk ash as a supplementary cementing material to develop strong, durable and an economical concrete.

2 Materials and Methods

2.1 Materials

2.1.1 Cement

Portland cement as per ASTM type I has been used. The physical & chemical characteristics of same cement are presented by are shown in Table 5.

2.1.2 Aggregate

The aggregate passing from 4.75 mm and 19 mm sieve has used as fine and coarse aggregate and aggregate, respectively. The physical properties, sieve analysis and gradation curve of fine aggregate and coarse aggregates are shown in Table 1, Table 2, Table 3, Figure 1 & Figure 2 respectively.

Table 1: Physical characteristics of F.A and C.A

Properties	F.A	C.A
Apparent specific gravity	2.69	2.75
Fineness Modulus	3.4	7.5
Absorption (%age)	-	0.59

Table 2: Sieve analysis for fine aggregate

Sieve No	fraction Retained	fraction Retained %age	Cumulative Retained %age	%age finer
No. 4	15	0.5	0.5	99.5
No. 8	300	10	10.5	89.5
No. 16	630	21	31.5	68.5
No. 30	735	24.5	56	44
No. 50	622.5	20.75	76.75	23.25
No. 100	630	21	97.75	2.25
No. 200	52.5	1.75	99.5	0.5
Pan	15	0.5	-----	------
Total	3000	100	372.5	------

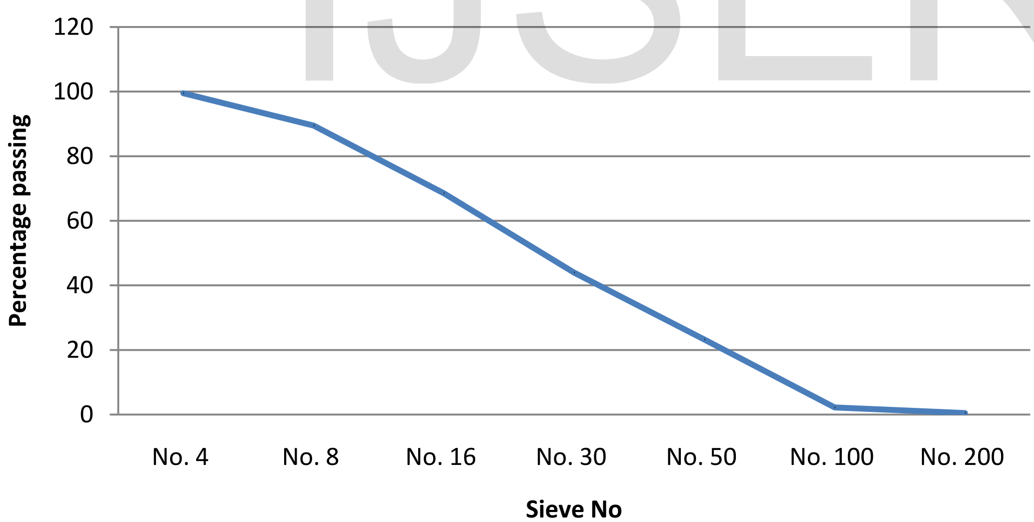

Figure 1. Gradation curve of fine aggregate

Table 3: Sieve analysis for coarse aggregate

Sieve No	fraction Retained	fraction Retained %age	Cumulative Retained %age	%age finer
1.25-in	0	0	0	100

1-in.	0	0	0	100
3/4-in.	300	6	6	94
3/8-in.	4640	92.8	98.8	1.2
No. 4	60	1.2	100	0
No. 8	0	0	100	0
No. 16	0	0	100	0
No. 30	0	0	100	0
No. 50	0	0	100	0
No. 100	0	0	100	0
Pan	0	-----	------	-----
Total	5000	100	747	-----

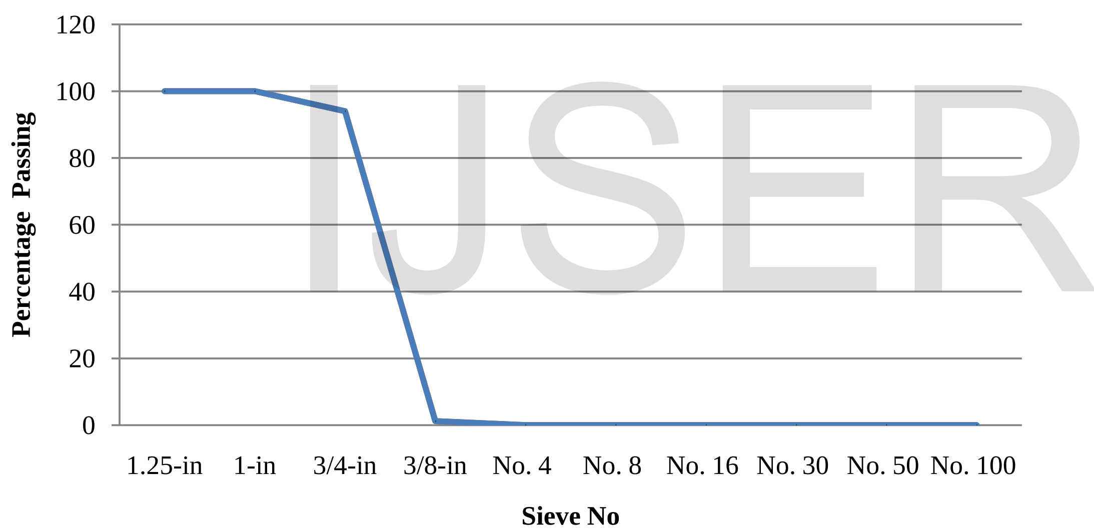

Figure 2. Gradation curve of coarse aggregate

2.1.3 Rice Husk Ash

Rice Husk Ash (RHA) was developed by combustion of rice husk in a drum like kiln for three hours as shown in figure 3, and was then allowed to cool approximately for 24 hr. The less burnt particles of RHA were separated through # 40 sieve and then the ash was pulverized in Los Angeles machine for one and half an hour.

Figure 3.Burning of rice husk in a drum like kiln

2.2 Concrete Mix Proportions
The concrete mixes, i.e. Control Mix (CM) and Modified Mixes (MM1-MM6) with cement replacement with RHA in different proportions were cast. The details are shown in Table 4.

2.3 Preparation of Specimens
A laboratory pan mixer for preparation of concrete was used. Seven different mixes were made. Total 35 cylindrical specimen of size 150 mm x 300 mm high were cast for compressive strength. After 24 hours the specimens were put in water tanks for 28-days wet curing.

3 Results and Discussion
3.1 Chemical Properties of Rice Husk Ash
The physical and chemical properties of the produced RHA and OPC given by [18] are shown in Table 5. The existence of silica in RHA is more than OPC; the SiO_2 in RHA is 75.48% along with other minor oxides. Furthermore, the sum of most important oxides, i.e. SiO_2+Al_2O_3+Fe_2O_3 of RHA is 77.95% that meets the ASTM C618-03 requirement for a pozzolanic material. The broad peak at angle of 22° in XRD pattern as shown in Figure 4 reveals that the ash is mainly in amorphous nature. The light grey colour of the ash reveals the presence of some un-burnt carbon in the ash.

Table 4: Mix proportion

Concrete Mix	RHA (%)	Kg/m^3		W/B	Kg/m^3			Slump (mm)
		Cement	RHA		Water	F.A	C. A	
CMix	0.0	346	0.00	0.55	190.30	692	1038	25-50
MM1 (2.5%)	2.5	337.35	8.65	0.56	194.19	692	1038	
MM2 (5%)	5.0	328.7	17.3	0.57	198.09	692	1038	
MM3 (7.5%)	7.5	320.05	25.95	0.58	201.98	692	1038	
MM4 (10%)	10.0	311.4	34.6	0.60	205.87	692	1038	
MM5 (12.5%)	12.5	302.75	43.25	0.61	209.76	692	1038	
MM6 (15%)	15.0	294.1	51.9	0.62	213.66	692	1038	

Table 5: Characteristics of cement and RHA

Material	Physical Properties		Chemical Analysis (%)						
	Specific Gravity	Blaine(cm^2/g)	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K2O	LOI
Cement	3.15	3008	20.78	5.11	3.17	60.89	3.00	0.00	1.71
RHA	2.07	2450	75.48	1.60	0.87	3.20	2.00	1.5	5

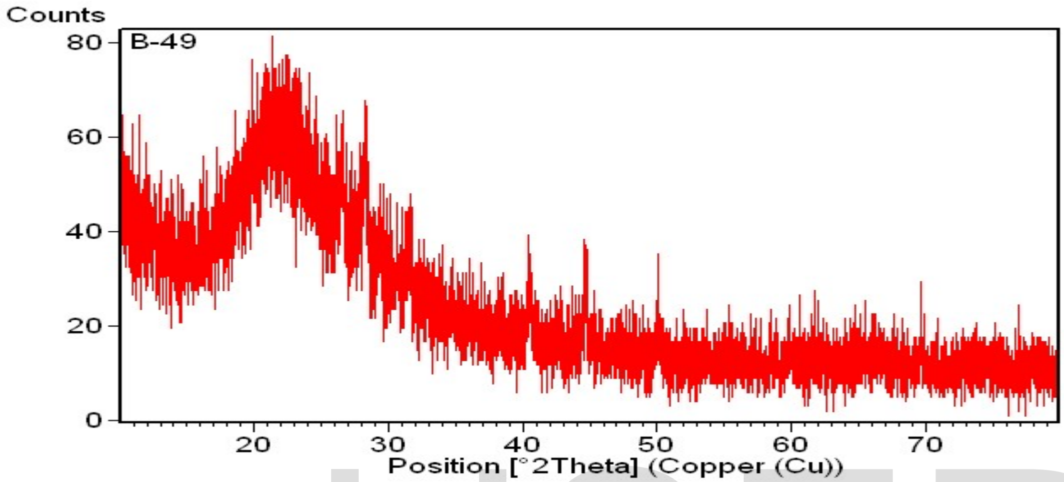

Figure 4. XRD of RHA

3.2 Workability

The slump of control mix and RHA blended mix are shown in the Figure 5. The figure shows that slump of the RHA concrete kept on decreasing as the replacement percentage level of cement with RHA kept on increasing. The trend is solely because of hygroscopic nature of RHA.

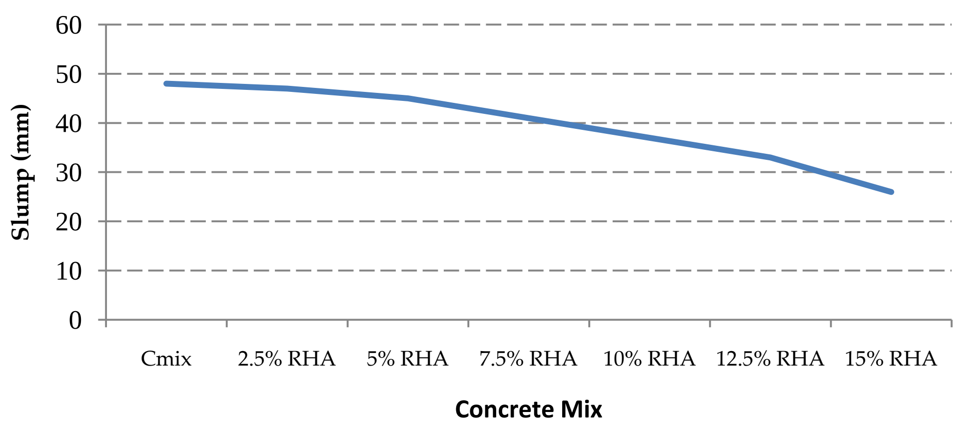

Figure 5. Slump of control and RHA blended concrete

3.3 Compressive Strength

Compressive strength of the controlled and RHA blended mixes are demonstrated in Table 6 and Figure 6. The compressive strength gradually increases up to 10% cement replacement and on further addition of RHA dosage strength decreases. This is because that the ash being utilized in the formation of secondary C-S-H gel. The maximum strength, 23.64 MPa with 4.19% increase as compared control concrete mix is achieved at 10% cement replacement with RHA.

Table 6: Compressive strength of control mix and cement replaced modified mixes

Mix Designation	Average Cylindrical Compressive Strength (Mpa)	%age Incr/Decr in Strength
Cmix	22.69	0.00
MM1(2.5% RHA)	23.2	2.25
MM2(5% RHA)	23.32	2.78
MM3(7.5% RHA)	23.5	3.57
MM4(10% RHA)	23.64	4.19
MM5(12.5% RHA)	17.26	-23.93
MM6(15% RHA)	13.71	-39.58

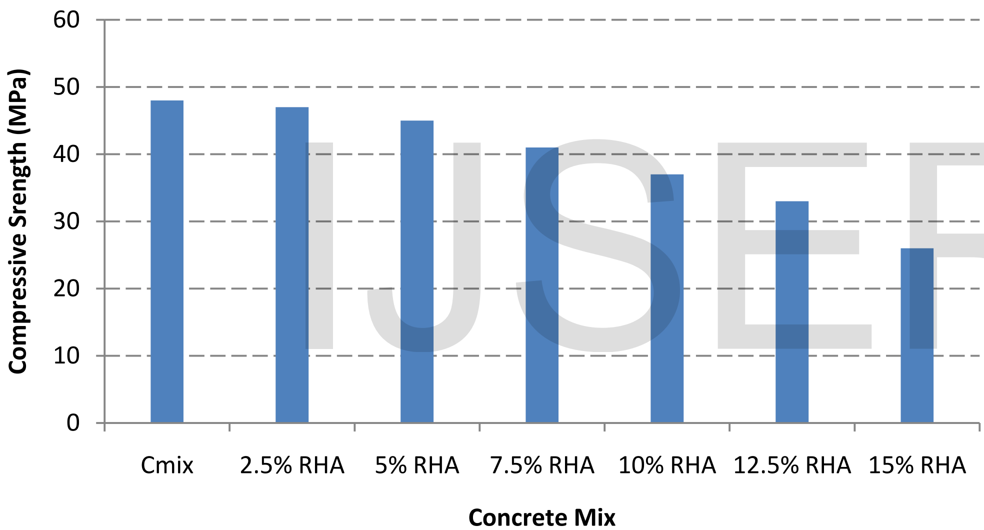

Figure 6. Compressive strength of RHA blended concrete

4 Conclusions

- The produced RHA is one of efficient pozzolanic materials; being in amorphous silica 75.48%. XRD analysis illustrates that silica in RHA exists in an amorphous nature which confirms non-crystallization of the ash.
- The fluidity of RHA blended concrete decreases because of the hygroscopic nature of RHA.
- The compressive strength gradually increases up to 10% cement replacement and on further increase of RHA dosage the strength decreases. The maximum strength, 23.64 MPa with 4.19% increase as compared control concrete mix is achieved at 10% replacement of cement with RHA.

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