Relationship between Compressive Strength and Ultrasonic Pulse Velocity of Engineered Cementitious Composites Inducing Rice Husk Ash

K.B Shoba, P.Asha

***Abstract*— The partial replacement of rice husk ash by cement in engineered cementitious composites had been reported to improve the properties of ECC especially its strength and extent of durability. There were no direct relation between the results of NDT in existing concrete structures. This article explores the relation between compressive strength of engineered cementitious composites and ultrasonic pulse velocity (direct and semi direct) method of hardened specimens. An experimental investigation was carried out which includes both destructive and nondestructive testing methods applied for ECC specimens containing rice husk ash and polypropylene fibres. Cubes of size 150mm * 150mm * 150mm are chosen for evaluation. Based on the outcome, relationships were derived for compressive strength and ultrasonic pulse velocity.**

Index terms: Rice husk ash, Non Destructive Testing, Ultrasonic pulse velocity, Compressive Strength, Direct Relationship

1. INTRODUCTION

Engineered Cementitious composites has significantly influenced the construction industry and engineering projects. Cementitious composites tend to set a benchmark in reducing the utilization of cement content by replacing with a substitutive material or other cementitious material. A material having not only potential but also economical to manufacture is known to be rice husk ash. Ash is obtained by igniting the husk in furnaces, hybrid incinerators and in open heaps. This activity generates a huge quantity say one fifth by volume of husk as ash. So far many research activities had been carried out on the utilization of rice husk ash as an effective pozzolanic material in engineered cementitious composites. A characteristic which seem to be peculiar is that the physical properties and chemical analysis of rice husk ash will vary based on the source, geographical coordinates, method of processing and testing adopted. This variation tend to alter the properties of engineered cementitious composites

Nondestructive testing is adopted to find whether the component can be used. Further it measures the quality of concrete in a structure. It can be predicted that the correlation with respect to the measured properties and strength tend to vary for various engineered cementitious composites.

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K.B Shoba, Research Scholar, Department of Civil Engineering, St. Peter's Institute of Higher Education & Research, Avadi, Chennai, Tamilnadu, India (Email: shoba.royalcivil1@gmail.com)

P.Asha, Sardar Professor, Department of Civil Engineering, St. Peter's Institute of Higher Education & Research, Avadi, Chennai, Tamilnadu, India (Email: ashap1905@gmail.com)

2. LITERATURE REVIEW

Chindraprasirt et.al (2007) and Sakir (2007) reported that the incorporation of RHA as partial replacement of cement improved the resistance of concrete subjected to acid and sulphate attack

Qing-ge et.al (2004) revealed that utilizing rice husk ash as mineral admixture provides several advantages. Incorporating as supplementary material led to increase in compressive strength and if the percentage of addition is more then the amount of calicium hydroxide will be less in composites attributing to one the main key reason for enhancing the strength. K.B.Shoba et al. (July 2018) Study on replacement of cement by micro silica (20 %) along with (1.5 %) of polypropylene fiber in ECC Matrix

Neville (2000) stated that the presence of voids in concrete seem to be the most important factor influencing the velocity of the ultrasonic pulse transmission. Also he added that, at the time of hydration Tri and Di calcium silicate compounds will fill those voids at the time of calcium hydroxide liberation resulting in cementitious composites of strong manner

Sugita et.al (2007) insisted that blending 20% by weight of RHA with portland cement increases the compressive strength at 28 days more than 25% respectively which significantly attributes to the reduction in effective water-cement ratio.

Kaplan (1960) identified that, composite material of same age, the effect of water-cement ratio and aggregate-cement ratio tend to balance each other such that at a particular time, at constant workability, there will be unique pulse velocity and strength of composite

Mehta (1977) concluded that voids in the composite get filled and adheres a strong bond manner while at the time of calcium hydroxide liberation at that instance.

3. RESEARCH SIGNIFICANCE

The main objective of this study is to determine the compressive strength and ultrasonic pulse velocity of different ECC proportions having percentage replacement of rice husk ash in terms of 0%, 5%, 10%, 15%, 20%, 25% and polypropylene fibres of 0%, 0.5%, 1%, 1.5%, 2% respectively thereby to compute a relationship between cube compressive strength and ultrasonic pulse velocity along with modulus of elasticity

4. EXPERIMENTAL PROGRAM

Ordinary Portland cement of grade 53 confirming to IS 12269-2013 was used in this study. Non crystalline rice husk ash having particle size lesser than 45 microns were chosen along with fine and coarse aggregate procured from local sources. The chemical analysis and physical properties are presented in Tables 1, 2 and 3 respectively.

Table.1 Physical Properties of OPC 53 grade

S. No	*Test Conducted*	*Results*
1	Fineness	277 m^2/kg
2	Initial setting time	182min
3	Final setting time	267min
4	Soundness by Le- Chatelier Method	1.2mm
5	Compressive Strength	
5 a	*3 days*	32 MPa
5 b	*28 days*	53 MPa

Table.2 Physical Properties of Rice Husk Ash

S. No	*Physical Properties*	*Results*
1	**Shape Texture**	Irregular
2	**Color**	Grey
3	**Size of the particle**	<45 microns
4	**Mineralogy**	Non Crystalline
5	**Specific Gravity**	2.27
6	**Odour**	Odourless
7	**Appearance**	Very fine

Table.3 Chemical composition of binders

S. No	*Chemical compositi*	*Rice husk ash*	*OPC*
1	**SiO2**	70	20
2	**Al2O3**	11	5
3	**Fe2O3**	0.16	2.5
4	**Na2O**	0.13	0.12
5	**K2O**	3.2	0.86
6	**CaO**	2.6	59.89
7	**MgO**	1.5	1.91
8	**P2O5**	0.6	0.14
9	**LOI**	7.5	1.03

Table.4 Mix Proportions of ECC Specimens

S. No	Mix ID	Cement (kg/m^3)	Rice Husk Ash (kg/m^3)	M. Sand (kg/m^3)	HRWR (%)	w/c Ratio	Addition of Polypropylene Fibre (%)
1	RHA0,F0	850	0	544	3	0.3	0
2	RHA5,F0	807.5					
3	RHA10,F0	765					
4	RHA15,F0	722.5					
5	RHA20,F0	680					
6	RHA25,F0	849.75					
7	RHA5,F0.5	807.75	42.5				0.5
8	RHA10,F0.5	765	85				
9	RHA15,F0.5	722.5	127.5				
10	RHA20,F0.5	680	170				
11	RHA25,F0.5	637.5	212.5				
12	RHA5,F1	807.5	42.5				1
13	RHA10,F1	765	85				
14	RHA15,F1	722.5	127.5				
15	RHA20,F1	680	170				
16	RHA25,F1	637.5	212.5				

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17	**RHA5,F1.5**	**807.5**	**42.5**				
18	**RHA10,F1.5**	**765**	**85**				
19	**RHA15,F1.5**	**722.5**	**127.5**				**1.5**
20	**RHA20,F1.5**	**680**	**170**				
21	**RHA25,F1.5**	**637.5**	**212.5**				
22	**RHA5,F2**	**807.5**	**42.5**				
23	**RHA10,F2**	**765**	**85**				
24	**RHA15,F2**	**722.5**	**127.5**				**2**
25	**RHA20,F2**	**680**	**170**				
26	**RHA25,F2**	**637.5**	**212.5**				

Composite mixtures were prepared with different constituents having the percentage replacement levels of rice husk ash and polypropylene fibres in the range of 5%, 10%, 15%, 20%, 25% by mass to portland cement. For each proportion three samples of 150 mm cube specimens were prepared. and stored in water at laboratory temperature. Samples were tested at 7 and 28 days in accordance with ASTM C 597-97 in which the energy propagates to the maximum extent at right angles to the face of the transmitting transducer. Measurements pertaining to pulse velocity are considered by placing two transmitters on either opposite or adjacent faces as shown in Fig.1

Fig.1 Transmitting and receiving ultrasonic pulses

Direct transmission is the most sensitive method when compared with indirect transmission since this has to be used when one face of the concrete specimen having access and to determine the extent of surface defect. Velocity is calculated from the distance between either of the transducers and time in transit measured electronically which shall be represented as

$$v = l/t$$

Considering the case in which huge air voids are present in the component then, ultrasonic pulses may not be transmitted. If it exists, the instrument will indicate the time taken by that particular pulse to circumvent the void through the fastest track. To confirm that the vibrational energy penetrates the specimen, a viscous material say jelly shall be used.

Fig.2 ECC Cylindrical specimen with 20% of RHA & 2% of polypropylene fibre

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5. RESULTS AND DISCUSSIONS

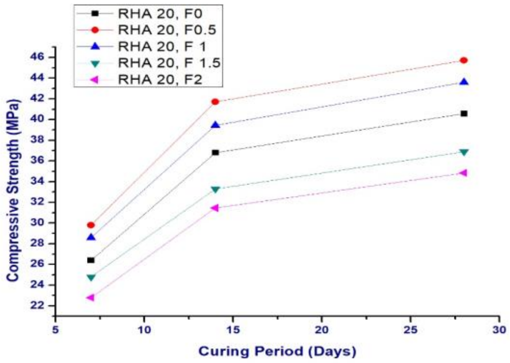

Fig.3 Relationship between compressive strength vs curing regime for RHA

5.1 Effect of RHA on the compressive strength and UPV

Fig. 3 indicates the increase in compressive strength at 7, 14 and 28 day curing regimes of the proposed ECC specimens. With respect to the outcome it is noted that UPV results decreased with the increase in percentage of RHA greater than 20% in ECC aspects .However the compressive strength of ECC specimens containing RHA greater than 20% had a linear dropdown concluding the optimum percentage of replacement in engineered cementitious composites.

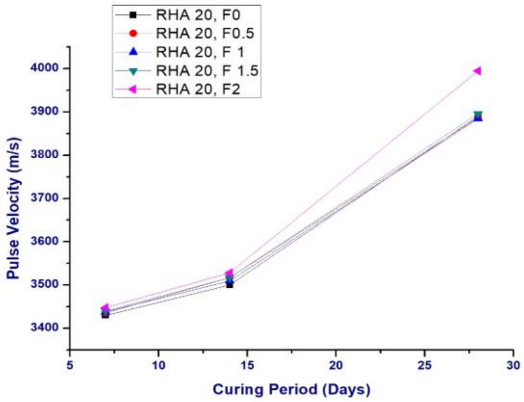

Fig.4 Relationship between UPV (m/s) vs curing regime for RHA

The impact of rice husk ash on the properties of engineered cementitious composites at different curing regimes shall be determined using UPV. Fig.4 represents the stabilized increase in strength as well as UPV when cement is replaced by 20% of RHA and 2% of polypropylene fibres and with respect to the rapid increase in UPV observations where 10% of rice husk ash replacement for Portland cement exhibited a rapid increase ranging from 3300 m/s to 3700 m/s and about 10 to 15% of linear increment exhibited for the overall identities. Also the UPV results were satisfying when the replacement levels of RHA were greater than 20% yet the compressive strength detained from that line.

CONCLUSIONS

With respect to the NDT analysis carried out for engineered cementitious composites containing rice husk ash, the following conclusions can be drawn.

(1) Lower strength and UPV outcomes had been exposed for all rice husk ash groups in early curing regime say 7 days

(2) There was a significant increase in compressive strength when 10% RHA were replaced by cement and the maximum compressive strength and UPV was observed for 20% replacement of rice husk ash and 2% of polypropylene fibres

(3) When the percentage of replacement exceeds 20%, compressive strength decreases whereas UPV values had an exponent for all groups.

(4) Adequate water content is required for ECC to attain fair workability

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