Effect of Rice Husk Ash on Compressive Strength of Concrete

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***Abstract*—Over the past decades concrete technology has entered the broad areas of research to enhance the properties and performance of concrete. Moreover there is the introduction of the new types of concrete such as self-compacting concrete (SCC), high strength concrete (HSC) or ultra-high strength concrete (UHSC). Now these types of concrete are being widely used in the world and they require the high cement binder. So high cement content means high loss to environment as in the manufacturing of one tonne of cement, about 1 tonne of CO2 is emitted. So it is necessary to reduce usage of cement by introducing new supplementary cementitious materials which are the by-products of industries to reduce debris. Rice Husk Ash is one of these. The potential of rice husk ash as a cement replacement or addition material is well established. A review of literature urges the need for optimizing the replacement level or additionof RHA in concrete for improved compressive strength at optimum water binder ratio. This paper discusses the improved compressive strength of RHA- High strength concrete at optimized conditions.**

***Index Terms*—compressive strength, concrete, RHA, High Strength Concrete (HSC), replacement, addition**

I. Introduction

The rice husk ash is one of the by product which is released from paddy. RHA generally referred to an agricultural by-product of burning husk under controlled temperature of below 800 ℃. Rice husk ash (RHA) is now accepted as a highly reactive pozzolanic material with silicon dioxide (Si02) more than 85% .The usage of rice husk ash in concrete leads to development of high strength concrete and also reduces the self weight of the structure. Less requirement of cement means less emission of result in reduction in green house gas emission.

By continuous research on properties of rice husk ash, the results shows that it contain high silica content which is more than 90%, it reduces shrinkage cracks and leads to increase the strength of concrete.

A Mechanism

The following reaction that will takes place in Rice husk ask concrete

$$SiO_2 + Ca\,(OH)_2 \longrightarrow CSH + SiO_2$$

When silicon burnt in the presence of Oxygen will form silica.

$$C_3S\ (Cement) + H_2O \longrightarrow CSH\ (gel) + Ca\,(OH)_2$$

Due to hydration of cement there will be formation of CSH gel and Calcium hydroxide. But Calcium hydroxide is soluble product and unstable in concrete.

$$SiO_2 + Ca\,(OH)_2 \longrightarrow CSH + SiO_2$$

The highly reactive silica reacts with Calcium hydroxide that will lead to form again CSH (gel) which will leads to get higher strength than that of ordinary concrete.

II. Materials

A ConcreteMaterials

Concrete mixtures to be examined were made in the laboratory using the following materials: cement, RHA, Super plasticizer, coarse aggregates and fine aggregates.

B Rice Husk Ash

RHA was obtained from burning rice husk in a Ferro cement furnace in the laboratory, and later ground using a Los Angeles machine for 5000 cycles. The fineness of RHA retained using a 45 micrometer sieve and its specific gravity were 18.5% and 2.05 respectively. The surface was 25250 m^2/kg.

C Cement

Locally produced ordinary Portland cement (OPC) was used. It has a specific gravity and specific surface of 3.11 and of 3200 m^2/kg respectively.

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TABLE I. CHEMICAL COMPOSITION OF OPC AND RHA

Materials	Oxides %								
	Sio_2	Al_2O_3	Fe_2O_3	MgO	Na_2O	K_2O	P_2O_5	CaO	MnO
OPC	20.99	6.19	3.86	0.20	0.17	0.60	0.05	65.96	0.06
RHA	88.82	0.46	0.67	0.44	0.12	2.91	1.00	0.67	0.08

D Superplasticizer

The new generation of polycarboxylic ether superplasticizer, Glenium 51, having a specific gravity and solid content of 1.09-1.10 and 34%-36% respectively was used.

E Coarse Aggregates

The coarse aggregate was crushed granite of 20 mm maximum size. Its specific gravity and water absorption were 2 .63 and 0.71% respectively.

F Fine Aggregates

Fine aggregate used was mining sand conforming to zone 1 of BS 410. Its specific gravity, water absorption and fineness modulus were 2.53, 3.36% and 4.53 respectively.

III. MIXTURE PROPORTION AND TESTS

Mixture proportioning for all the mixes was based on the Indian Standards. Using the codal provisions, the control concrete containing superplasticizer (SpOPC) was designed with water to cementitious (w/cm)ratio of 0.27 and cement content of 537 kg/m3.The coarse aggregate content forthis and subsequent mixes was fixed at 1055 $kg/m^{3.}$ A total of 6 series of "RHA addition" and"RHA replacement" mixtures were cast to evaluate the effects of method ofincorporating of RHA on properties of fresh and hardened concrete. RHA was"added" or "replaced" at 5%, 10% and 15% of the cement content. The property of fresh concrete investigated was Workability designed to produce slump in the range of 200-250 mm. The compressive strength of concrete samples was tested at 1, 3, 7, 28 and 180 days of water curing. The optimum mixes of the RHA "addition"and "replacement" were selected for further investigating the compressive strength(150 mm cube).

TABLE II. MIX PRO PORTIONS

Mix	Sp(%)	SLUMP(mm)	WATER(kg)	OPC(kg)	RHA(kg)	CA(kg)	FA(kg)
SpOPC	1	220	140	537	-	1055	669
RHA5A	1	240	152	537	26.9	1055	619
RHA10A	1	225	160	537	53.7	1055	657
RHA15A	1	200	167	537	80.6	1055	516
RHA5R	1	225	145	510	26.9	1055	657
RHA10R	1.1	200	145	486	53.7	1055	645
RHA15R	1.1	220	145	456	80.6	1055	636

IV. RESULTS AND DISCUSSIONS

A Workability

The measured slump values of all the mixes are given in Table 2. It isapparent that varying amounts of water between 145 kg and 167 kg andSuperplasticizer (Sp) between 0.9-1.0percent of cement content was needed tomaintain workability of concrete in the range of 200-250 mm. In general, forsimilar workability, Sp dosage for RHA addition mixes was lower than thereplacement series.

B Effect of RHA on Compressive Strength

The compressive strength for various concrete mixes is presented inTable 3. The effects of method of incorporation of RHA.i.e. by "addition" orcement "replacement" on the strength property of HSC are discussed below:

1) Effect of RHA "Addition"

From Table 3, it is noted that for theRHA addition series, the optimum strength resulted from 10% addition of RHA, similar to that found previously. Compared to the control SpOPC, except for 15% RHA content. All RHA mixes exhibited superior strength at 180 days.

2) Effect of RHA "Replacement" of Cement

For RHA replacement mixes, the highest strength was achieved at 5% cement replacement. At 1 0% replacement, strength of 80 N/mm^2 was still achievable. Increasing the RHA content further, decreases the strength significantly. Previous research indicatedthat the optimum replacement of cement by RHA for optimum strength was about I0% to 20%.

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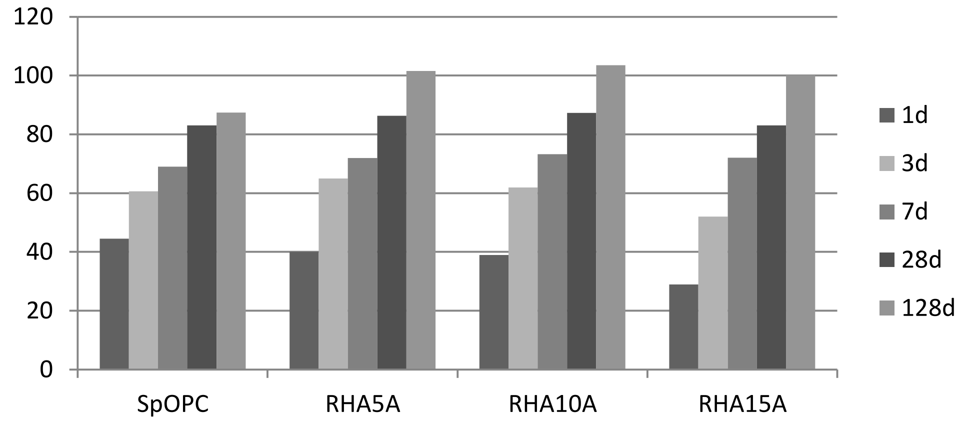
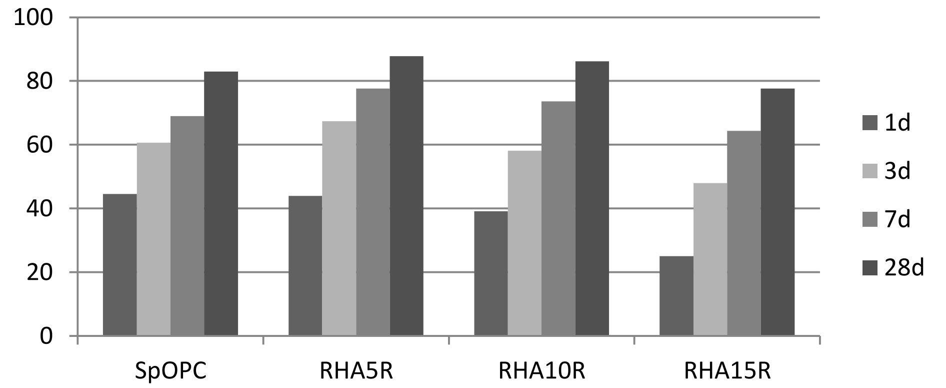
TABLE III. COMPRESSIVE STRENGTH OF HSC

Mix	Compressive Strength (N/mm^2)				
	1d	3d	7d	28d	128d
SpOPC	44.5	60.6	69	83	87.4
RHA5A	40	65	72	86.3	101.6
RHA10A	39	61.9	73.3	87.3	103.5
RHA15A	29	52	72.1	83	100.1
RHA5R	43.9	67.4	77.6	87.8	102.6
RHA10R	39.1	58.1	73.6	86.2	100.2
RHA15R	25	48	64.4	77.6	94.4



Graph 1 – Results showing compressive strength with addition of RHA



Graph 2 – Results showing compressive strength with replacement of RHA

V. CONCLUSION

Irrespective of method of inclusion or percentage of RHA. Theworkability of concrete of200 to 250 mm slump can be obtained with Sp dosage of less than 1.2 % of total cementitious content. The optimum "addition" or “replacement" level of RHA to produce optimum strength is 10% and 5%respectively. Both RHA concrete mixtures when subjected to water curing conditions were able to achieve compressive strength of 80 N/mm^{2}at 28 days. Concrete containing 10% RHA "addition" was able to attain 100N/mm^2 at 180 days.

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