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Durability of Mortar in Presence of Rice Husk Ash

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Abstract**—**The purpose of this paper is to investigate the durability of cement mortar in presence of Rice Husk Ash (RHA). The strength and durability of mortar with different replacement level (0%, 10%, 15%, 20%, 25% and 30%) of Ordinary Portland Cement (OPC) by RHA is investigated here. RHA was manufactured from an uncontrolled burning process. Test samples were prepared with river sand of FM 2.73. Samples were kept in controlled environment up to test time. The results show that addition of RHA was shown better results for 20% replacement level than OPC at 90 days. In durability test all samples passed for 20 cycles except 25% and 30% replacement level.

Keywords**—**Rice Husk Ash; durability; mortar, graded sand.

I. INTRODUCTION

RICE is the main crop in Bangladesh. There are main three biomass by product comes from rice viz., rice straw, rice shell and rice bran. Considerable efforts are being taken worldwide to utilize local natural waste and by product materials in making concrete, such as RHA as supplementary cementing materials to improve concrete properties (strength, durability etc.)[1]-[10].

Rice husk is the outer jacket of the grain of white rice with high concentration of silica. Generally this silica concentration is more than 80-88% [11]. After burning rice husk contributes 20% of its weight to Rice Husk ash [12]. According to Tashima RHA is a high pozzolanic material. [13].

A large number of researches have been conducted towards the utilization of waste materials. For the development work the utilization of blended cement is growing rapidly. Pozzolans from industrial and agricultural byproducts are receiving more attention due to their uses in concrete production which improve the concrete property, and reduce the negative environmental effects. According to Mehtha [14] when rice husk is burnt at temperatures lower than 700^0 C, rice husk ash with cellular microstructure is produced and contains high silica content in form of non-crystalline or amorphous silica and can be used as supplementary cementitious materials. Some other researchers wrote that the lower boundary of the temperatures is 550^0 C. [18], [19].

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When the rice husk is converted to ash by uncontrolled burning generally ranging from 300^0 to 450^0 C, the ignition was not completed and considerable amount of unburnt carbon was found in the resulting ash [20], [21]. The reactivity of amorphous silica is directly proportional to the specific surface area of ash [22]. Some research paper discovers that not only temperature but time is also one of the factors for burning the rice husk to produce effective ash [18], [19]. For the case of uncontrolled burning specially heap burning, the burning time totally depends upon the ambient environment ie. temperature, humidity and wind speed. Now limited researches were conducted again with the rice husk ash collected from uncontrolled burning process [2].

In this work RHA was collected from an uncontrolled burning system, where temperature and time was not controlled. After completion of burning, husk ash was collected and grinded for 30 minutes and pass the ash through 200 no sieve. The passed ash was collected and use as RHA in this work. It was found that the amount of Silicon Oxide in this ash is 90.20%. The summation of Silicon Oxide (SiO_2), Iron Oxide (Fe_2O_3) and Aluminum Oxide (Al_2O_3) is 92.43% and according to ASTM C-618, if the sum of Silicon Oxide, Iron Oxide and Aluminum Oxide is more than 70% in a material, then the material would be declared as a pozzolanic material.

So this ash which used in this work is a pozzolanic material. Pozzolans show different durability properties with the cement and type of active silica present in their composition. The amount and fineness of pozzolans in cement are factors that affect the strength of concrete.

Mortar is one of the most important components of a structure which as a material resulting of the close mixture of sand (Fine Aggregate), a binder (Lime, Cement, etc) and water. To improve some properties of mortar some different products or additional constituents are mixed with it. At the beginning the admixtures are composed of natural substances and currently that are industrial by product.

The research program, partially described in this paper, was carried out to asses the durability of mortar obtained with partial cement replacements with Rice Husk Ash in different percentages.

II. EXPERIMENTAL PROGRAM

Raw materials used in these experiments were ordinary Portland cement, rice husk ash, sand with FM 2.73 and water. The rice husk ash used in this work was collected from an open burning system, where the rice husk allowed to burn for about 72 hours. Ambient temperature at that time was recorded 14^0 to 19^0 C and the peak of the husk temperature was 422^0 C. Husk was heaped in 2 m square and 0.4m in height. For burning the husk, some rice husk briquette was fired and placed in the heap at a depth of 200mm from top. After placing the burned coal the central temperature of the heap was measured for 60 hours and the time temperature curve is shown in Fig.1.

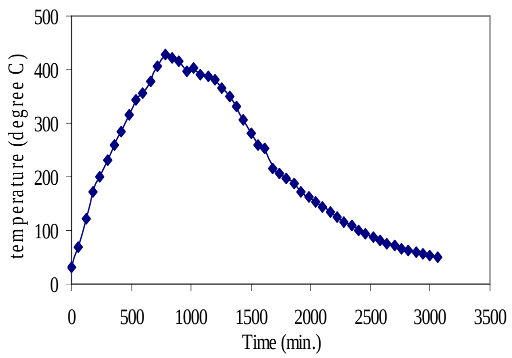

Fig. 1 Time VS Temperature Curve

Materials

Ordinary Portland Cement (OPC), river sand with specific gravity of 2.64, unit weight 1.63 gm/cc, absorption capacity 2.95% and fineness modulus of 2.73, details of sand fineness modulus is listed in Table I. Rice husk ash collected from open burning system and water were used.

TABLE I
FINENESS MODULUS OF SAND

Sieve size	Wt. retained (gm)	Cumulative Wt. ret. (gm)	Cumulative % Wt. ret.
#4	0	0	0
#8	22.5	22.5	4.5
#16	85.5	108	21.6
#30	179	287	57.4
#50	165	452	90.4
#100	41.5	493.5	98.7
Pan	5	-	-

Mix Proportion and Curing

Ordinary Portland Cement (OPC) was replaced by different amount of RHA (0%, 10%, 15%, 20%, 25%, and 30%) in dry condition. The mixture was thoroughly homogenized and kept in glass jar. Sample prepared with only OPC is called the controlled samples. The mix designations are in Table II. For preparing the sample sand to binder ration was 1:3.0 by weight of materials.

TABLE II
MIX CONSTITUENTS AND DESIGNATION

Mix designation	OPC (%)	RHA (%)
A0	100	0
A10	90	10
A15	85	15
A20	80	20
A25	75	25
A30	70	30

The mortar was mixed in laboratory at 22±2^0 C. After mixing, 50mm cubical specimens were cast from each mix for compressive strength and durability tests. After casting, all specimens were covered by poly paper in the casting room for 24 hours and then demolded and placed in a water bath (22±2^0 C) until the time of test.

III. TESTS

Consistency and Setting Time

Normal Consistency of OPC and RHA mixed cement was obtained according to ASTM C 187-98 [23]. The standard consistency was used to find out the initial and final setting time of the mortar.

Compressive Strength Test

After 3, 7, 28 and 90 day's the cured samples were removed from the curing pond and the area of loading face of cubes determined, and then placed at the center between plates of Universal Testing Machine.

Durability Test

The cured samples are immersed in water at a constant temperature of 20 ± 0.5^o C for a period of 16 hours. The specimen was removed and placed in an oven pre-heated to 105^o C to dry for six hours. Weights of the sample were measured. Samples were subjected to 20 such cycle.

IV. RESULT AND DISCUSSION

Consistency and setting time

The percentage of cement replacement level by RHA against standard consistency graph Shown in Fig. 2. It was observed that the water demand for standard consistency linearly increases with an increase of cement replacement level by RHA.

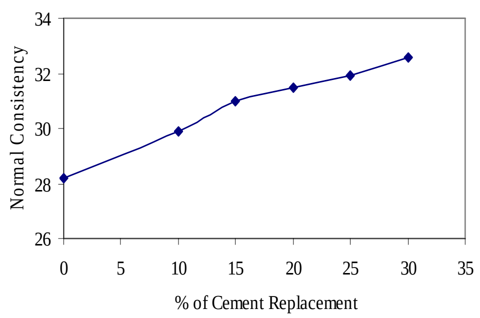

Fig. 2 Normal Consistency verses % of cement replacement

The specific surface area of RHA is higher than the cement and the ashes are hygroscopic in nature, so needs more water.[14]

Variation in Initial and final setting time is shown in Fig.3 and Fig.4. Maximum variation in initial setting time observed for 15% Cement Replacement Level (56.4%) and for 20% replacement level the variation is very close to the maximum (51.3%). For all replacement level the initial setting time observed is higher than the controlled mortar samples. The final setting time shows different results from the initial setting time. For all replacement level the final setting time shows decreasing nature with respect to OPC sample. From Fig. 4 it is observed that higher the replacement level shows lower the final setting time. The final setting time measured for 0% and 30% cement replacement level is found to be 309 min and 222 min. respectively. These values are well within the permissible limits as per ASTM C 191-04. Bhanumathidas and Mehta [15], Ganesan et.al [16] and Cook [17] have also made similar observations.

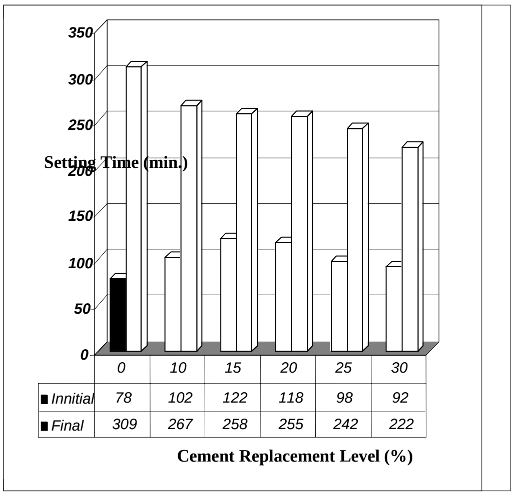

Fig. 3 Innitial and Final Setting time

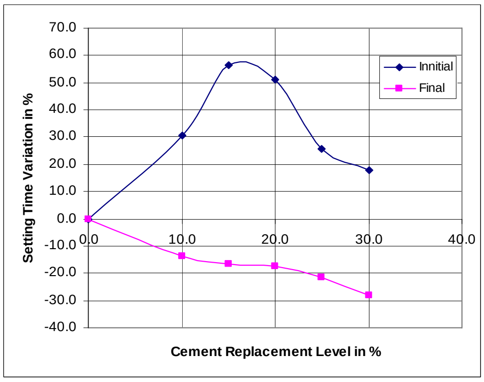

Fig. 4 Variation in setting time with % of cement replacement

Compressive Strength

Compressive strength of mortar specimens are shown in Table III. comparison of the data for curing time of 3,7 and 28 days shows that the compressive strength of OPC mortar is higher than the others but at later age (90 days), the samples having 10%,15% and 20% RHA show better result than the OPC one. For 30% replacement level compressive strength at all test time was lower than the OPC samples.

The increase in strength may be due partially to the pozzolanic reaction and the presence of reactive silica in RHA as reported by many researchers [9], [16], [21], [23]-[25].

TABLE III
COMPRESSIVE STRENGTH AT DIFFERENT AGES

Sample	RHA	Strength (psi)			
		3	7	28	90
ID	(%)	days	days	days	days
A0	0	1450	2137	3557	3671
A10	10	1150	2062	3579	3835
A15	15	1126	1994	3491	3729
A20	20	1217	1868	3326	3860
A25	25	1042	1806	3198	3405
A30	30	979	1575	2547	3061

Durability

The cured samples were taken at 90 days and perform durability test on it following the stated method. It was observed that A0, A10, A15 and A20 pass 20 cycles but A25 samples show crack at 18 cycles and some part of A30 samples was broken at 15 cycles. In Fig. 7 the amount of weight increases after 20 cycles of test is plotted. Here samples of A25 and A30 are not present. This happened due to the compactness of mortar in presence of RHA up to certain limit.

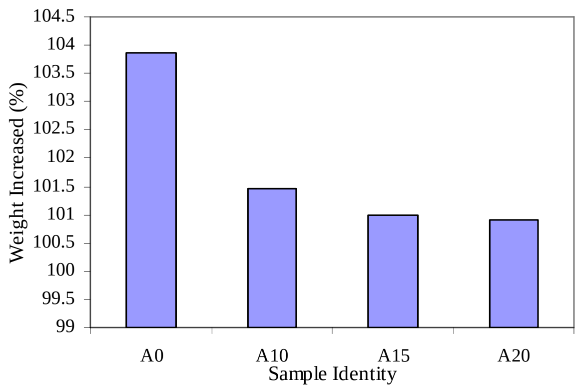

Fig. 7 Weight increase after Durability Test

V. CONCLUSION

This study indicates that up to 28 days OPC samples have higher strength than the RHA addition sample and at later age (90 day) the result is reverse up to 20% replacement level of OPC by Rice Husk Ash. Durability of mortar is also accepted for 20% replacement level.

It is concluded from the result that the mortar incorporating rice husk ash is more durable than OPC mortar up to 20% replacement level.

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