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Long Term Effect of Rice Husk Ash on Strength of Mortar

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***Abstract*—**This paper represents the results of long term strength of mortar incorporating Rice Husk Ash (RHA). For these work mortar samples were made according to ASTM standard C 109/C. OPC cement was partially replaced by RHA at 0, 10, 15, 20, 25 and 30 percent replacement level. After casting all samples were kept in controlled environment and curing was done up to 90 days. Test of mortar was performed on 3, 7, 28, 90, 365 and 700 days. It is noticed that OPC mortar shows better strength at early age than mortar having RHA but at 90 days and onward the picture is different. At 700 days it is observed that mortar containing 20% RHA shows better result than any other samples.

***Keywords*—**OPC, RHA, replacement level, long term, strength.

I. INTRODUCTION

SUSTAINABLE development is an emerging social issue in the world. For this the increasing needs for the concrete industry is to find out materials which comply with the basic goals of sustainable development and to decrease its impact on the environment. This leads the researchers to improve the properties of concrete products and use the waste materials as an alternative to cementing materials. Cement is an inorganic, nonmetallic material with hydraulic binding properties. After mixed with water it forms a paste, which hardens owing to formation of hydrates. After hardening, the cement retains its strength. Cement is often considered a key industry for a number of reasons. Cement is an essential material for Concrete production, is a primary building material for the construction industry. Cement production is a highly energy-intensive production process. Energy consumption by the cement industry is estimated at about 2% of the global primary energy consumption, or almost 5% of the total global industrial energy consumption [1].

Cement industry is a key source for CO_2 emission. Globally, CO_2 emission from cement production was estimated at 829 million metric ton (MMT) in the year 2007 [2] In addition to combustion-related emissions, cement production also is a source of process-related emissions resulting from the release of CO_2 during the calcinations of limestone. The warning of climate change is considered to be one of the most important environmental challenges for our civilization. Carbon dioxide (CO_2) is one of the major greenhouse gases.

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Anthropogenic sources of CO_2 are the combustion of fossil fuels, deforestation, unsustainable combustion of biomass, and the emission of mineral sources of CO_2.

The production of cement contributes to the emission of CO_2 through the combustion of fossil fuels, as well as through the decarbonization of limestone.

Global cement production grew from 594 Mt in 1970 to 1453 Mt in 1995 at an average annual rate of 3.6% [3]. In 2000, 17.75 billion tonnes of cement were produced worldwide [4].The production of clinker is the most energy-intensive step in the cement manufacturing process and causes large process emissions of CO_2. In blended cement, a portion of the clinker is replaced with industrial by-products, such as coal fly ash (a residue from coal burning), blast furnace slag (a residue from iron making),or other pozzolanic materials. These products are blended with the ground clinker to produce a homogenous product: blended cement. Blended cement has different properties than Portland cement, e.g., setting takes longer but ultimate strength is higher [5]. Romans were first to use volcanic ash, from the village Puzzoli near Naples, as building material. Hence the name puzzolana is derived [6]. Pozzolans are defined siliceous and aluminous materials which has a fine particle size act as a filler effect in the mixture. The physical effect of the finer grains allows denser packing within the cement and reduces the wall effect in the transition zone between the paste and the aggregates. [7], [8].

Over the year many waste materials , like fly ash, ashes produced from various agricultural wastes have been tried as pozzolans [9]-[14] in cement based product. The addition of a fine pozzolanic material reduces both pore sizes and porosity, and therefore raises strength [15].

Rice husk are possibly the leading mill generated source of biomass. A large quantity of rice husks are generally available at the rice mills without additional efforts or cost involvement. Some of the husks are used for paddy milling process itself, generating a huge volume of ash. This ash has no useful application and usually dumped directly and causes pollution and air contamination. Thus, the use of by-products is an ecological welcoming process of disposal of large quantities of materials that would otherwise pollute land, water and air.

The aim of the present investigation is to evaluate rice husk ash as supplementary cementitious materials. Studies on mortar specimens were conducted on short and long term compressive strength performance.

II. MATERIALS AND METHODS

Ash Preparation

Rice husk was thoroughly cleaned in open air to remove any other materials from it and dry it in sunlight for 4 hours before burning; at this time the ambient temperature is 36^0C.

After drying the husk through a kiln where previously placed some burned husk briquette. These briquettes placed over a fine wire mesh and this mesh is placed above the mid-height of the kiln. At the front face of the kiln, an air blower was placed and provides gentle wind flow in to the kiln. In Fig.1 detail of the kiln and other arrangement are shown.

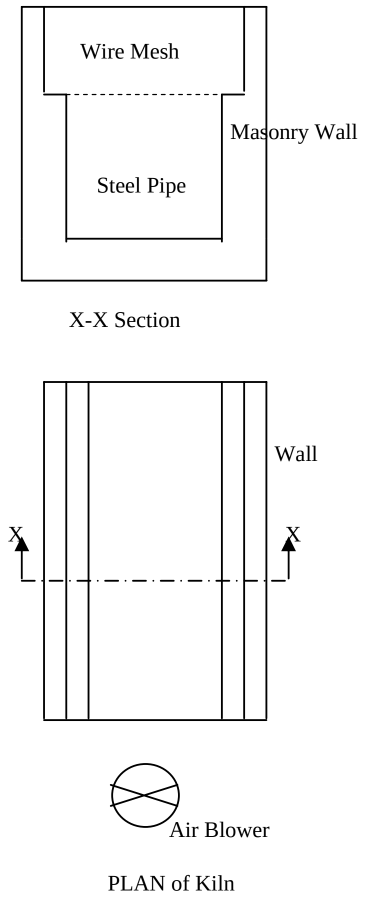

Fig. 1: Plan and Cross Section of Kiln.

At the time of burning, temperature was recorded continuously, maximum temperature was reached at 700^0 C just at the time of burning and after that the temperature was fall down. Temperature-time history is plotted in Fig. 2. At the time of firing the blower is slowly running to generate a gentle air flow in kiln and the blower was stopped at the last time of firing. Now the ash was cool down naturally. For complete cooling 54 hours time was needed when the ambient temperature was 29^0 C to 36^0 C. The ash was collected from the kiln and placed in a ball mill for 1 hour and 30 minutes and then sieved by 200 no sieve. The passed ash was collected for this work as a cement replacing material. The Blaine surface area of this ash is 6993 m^2/kg.

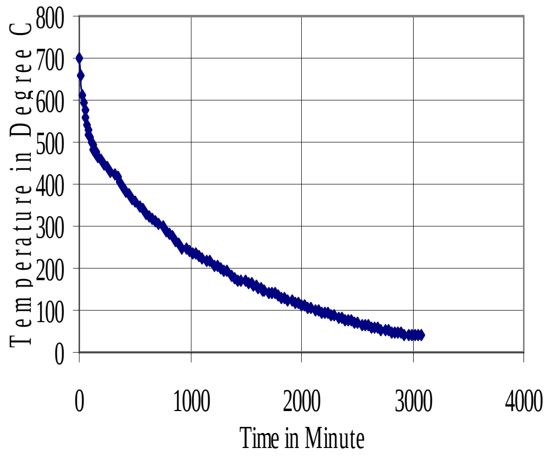

Fig. 2: Time–Temperature curve for Rice Husk burning.

Ordinary Portland Cement and Sand

The Blaine surface area of used OPC is 3164 m^2/kg. Sand used in this study was ASTM standard Graded sand confirm the specification of ASTM C 778-02.

III. PREPARETION OF SAMPLE

In this test 50 mm cubical sample were cast. At the time of casting the ambient temperature was maintained at 23 $\pm 3^0$ C. Basic mixing ratio is one part of Ordinary Portland Cement and 2.75 parts of standard sand proportioned by weight. After that the OPC was replaced by rice husk ash at 10, 15, 20, 25 and 30 percent. For all the 6 mixtures water cement ratio was previously fixed by flow table test and confirming a flow value of 110 ± 5 mm in 25 drops. The water mixing ratios is given in Table 1. The samples were compacted in two layers and demolded after one day of casting, at this time the samples are covered by plastic sheet and then immersed in lime water for a maximum of 28 days and then stored in normal weather where temperature variation was 11^0 to 43^0 C. The relative humidity also varied from 35 to 90% in a year. At the time of water curing temperature was maintained 23± 2^0 C.

TABLE I

MIXING PROPORTION AND WATER CEMENT RATIO

Mix ID	OPC (%)	RHA (%)	Water (%)
OPC	100	--	100
10RHA	90	10	103.1
15RHA	85	15	105.3
20RHA	80	20	107.6
25RHA	75	25	109.8
30RHA	70	30	112

IV. TEST

The compressive strength of mortar was determined after 3, 7, 28, 90,365 and 700 days. Maximum moist curing was done for 90 days. The reported results are the average of three samples.

V. RESULT AND DISCUSSION

Water Demand

Water demand was observed from the result of flow table test that the water demand is increased by 103% and 112%12% for 10% and 30% cement replacement level respectively, and this demand pattern is increasing for increased of RHA addition. This is due to the high fineness and porous surface of RHA. The result is similar to the previous study [16], [17]. The result is plotted in Fig. 3.

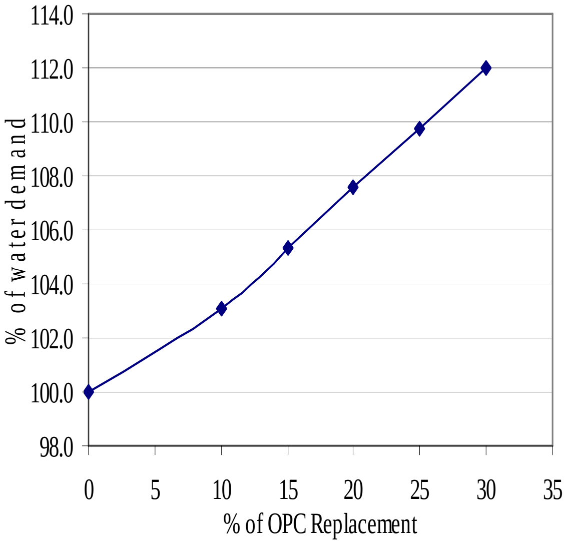

Fig. 3 Variation of water demand for RHA addition

Compressive Strength

The strength activity was tested according to ASTM C109 [18] ASTM C618 [19] specifies that fly ash mortar should have a strength activity index of at least 75% of the control mortar (OPC) at the age of 7 or 28 days when the fly ash is used to replace Portland cement at the rate of 20% by weight of binder [16].

The compressive strength of mortar with RHA shown lower strength than that of OPC samples at 3 and 7 days. For mortar 10RHA and 15RHA, the 28 days strength is 100.8 and 101.4% of the OPC one at the same days. For mortar samples of 20RHA, 25RHA and 30RHA the 28 d days strength are lower (88.4, 75.5 and 75.8% respectively) than the OPC one and these results are shown in Fig. 4. Strength development is the common feature of pozzolanic materials [20], [21]. At the age of 90 d, strength of 10RHA, 15RHA, 20RHA are higher than the OPC one and this trend also exhibits in long term strength. In Figure 3 it is shown that at 365 d and 700 d the strength is increased by an amount of 143% with respect to 28 d OPC sample.

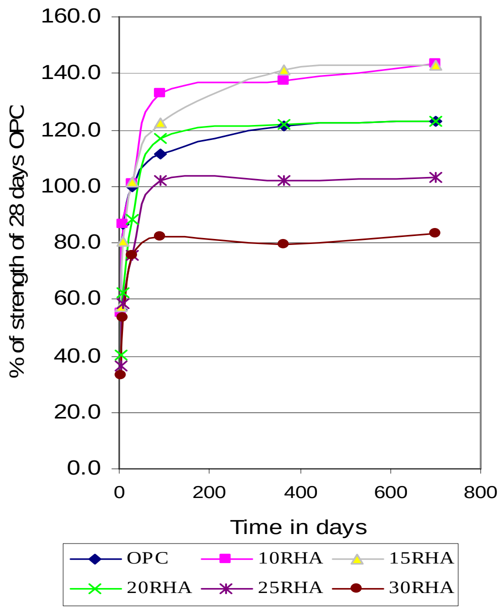

Fig. 4 Percentage of strength variation with respect to 28 days OPC mortar.

From Fig. 5 it is shown that sample 20RHA having equal result of OPC samples at 365 and 700 days and at 90 days it has 105% strength value with respect to OPC one, for 25RHA and 30RHA samples the strength values shows always lower than the OPC sample. This observation is similar to another work where it was stated that at 7 or 28 days the pozzolan replace OPC at the rate of 20% by weight of binder [16].

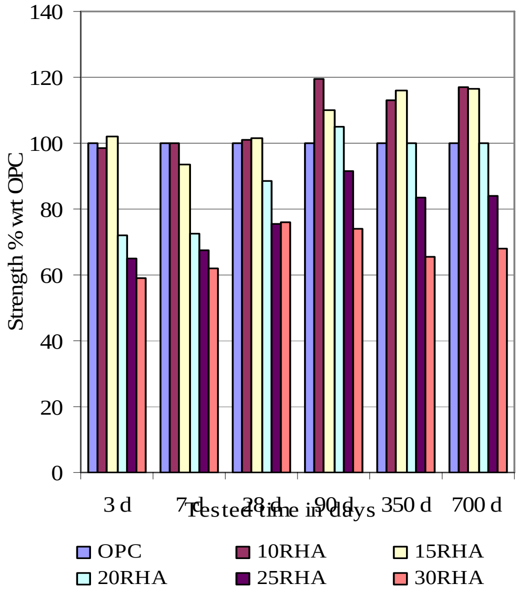

Fig. 5 Percentage of strength variation with respect to OPC mortar at different ages

VI. CONCLUSION

From the result presented in this paper, it may be concluded that the water demand for same workability of cement mortar is increased for increasing the amount RHA in the mix. The use of RHA at 20% replacement level results is good in compression at short and long duration. The used RHA is good for pozzolanic material and replace the OPC at 20% without an effect on the compressive strength at long time.

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