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Sustainable building blocks from Rice Husk Ash

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Sustainable building blocks from Rice Husk Ash

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ABSTRACT: Huge demand of building materials lead to excessive utilization of natural resources and adversely affect the construction costs. Incorporation of waste materials (agricultural/industrial) in the construction process brings sustainable benefits for construction industry and as well as for society. Cement is an inevitable material in construction. At the same time it is expensive and energy intensive. Replacement of cement partially or fully can contribute to economic and environmental sustainability. The potentials of rice husk ash (RHA) as a cement replacement material in concrete and mortar is well proven. Nowadays the building blocks made from concrete are extensively used worldwide. This paper focuses on an experimental investigation conducted on the utilization of rice husk ash in concrete building blocks. Studies indicate that RHA building blocks can overcome the drawbacks of conventional blocks and successfully proposed for framed construction as filler blocks with improved sustainability aspects.

Key words: Rice husk ash; Cement concrete blocks; Sustainable construction.

INTRODUCTION

Construction activities worldwide are responsible for the significant amount of environmental degradation, as it consumes large amount of natural resources including both renewable and non-renewable. Accumulation of unmanaged industrial or agricultural solid waste especially in developing countries has also resulted in greater environmental concern. Recycling and utilization of such wastes as sustainable construction materials appear to be a viable solution in the design of green buildings.

Globally, approximately 600 million tons of rice paddies are produced every year (Muthadhi et al, 2007). India is the second largest producer of rice next to China. In majority of rice producing countries much of the husk produced from the processing of rice is either burnt or dumped as a waste. In certain region, it is sometimes used as a fuel for parboiling mills. The partially burnt rice husk in turn contributes to more environmental pollution. Rice husk is unusually high in ash compared to other biomass fuels – close to 20%. The ash is 92 to 95% silica in chemical composition. It is highly porous, lightweight and has high external surface area. At 550°C-800°C amorphous ash is formed and temperature greater than this, crystalline ash is formed (Mehta 1978). Geographical location studies have shown

that the physical and chemical properties of ash are dependent on the soil chemistry, paddy variety, climatic conditions and fertilizers applied during rice cultivation (Chandrasekhar et al 2003). Rice husk ash (RHA) can be successfully used as a partial replacement to cement in concrete and other building material applications. In cement industry, substantial research has been carried out on the use of amorphous silica in the manufacture of high strength concrete (Ahmadi M A et al 2007, Andres Salas et al 2009, Bui D D et al 2005, Gemma Rodriguez 2006, Giaccio G et al 2007, Habeeb G A et al 2009, Mohammad Shoaib Ismail et al, 1996, Nehdi M et al 2003, Raman S N et al 2011 and Saraswathy V et al 2007) and few researches are done in the manufacture of building blocks (Oyekhan et al, 2008, Okpala et al 2006 and Oyetola E B et al 2006) on partial replacement of cement with RHA on Sand-Crete (cement-sand) blocks. According to Oyetola et al the compressive strength of OPC/RHA sand-Crete blocks increases with age of curing and decreases as the percentage of RHA content increases. Lersatitthanakorn et al 2009 examined the possibilities of RHA based sand cement block is an excellent insulator having low thermal conductivity.

Nowadays the building blocks made from concrete are extensively used in construction. This paper focuses on an experimental investigation on the application of rice husk ash as a partial cement replacement material in concrete building blocks.

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EXPERIMENTAL PROGRAMME

The succeeding sections give the details of materials and methods of this investigation.

MATERIAL CHARACTERISATION

Cement.

The cement used was Portland pozzolana cement satisfying the requirements of IS 4031-1988 under commercial name Ultratech.

Fine aggregate

The sand used was river sand (passing through 4.75mm sieve and retained at 150 micron sieve) satisfying the requirements of IS 2386-1963

Coarse aggregate

6mm broken stones satisfying the requirements of IS 2386-1970 was used as the coarse aggregate.

Rice Husk Ash

Rice husk in original form was collected from a rice mill. It is estimated that 1000 kg of rice grain produce 200 kg of rice husk and further it gives 40 kg of rice husk ash when subjected to control burning. The incineration of this rice husk was done in an annular kiln as described in Nair D G et al (2006) for obtaining amorphous silica. The physical and chemical properties of RHA from controlled burning thus obtained are tabulated in table 1.

Table 1. Properties of RHA

Properties	Rice Husk Ash
Physical properties	
Colour	Dull white
Specific gravity	2.16
Surface Area	2450 cm ² /g
Chemical composition	
Loss on Ignition	8.70%
Total silica	81.0%

The RHA from annular kiln were ground in the Los Angeles abrasion testing machine with 32 rpm for 2 hours and sieved through 75 micron IS sieve. The ash passing through this sieve was used for the study. The fineness of RHA is an important factor, which affects the strength of concrete. Hence it was inter ground with cement for 15 minutes in a ball mill immediately before the preparation of concrete to act as the cementitious binder.

MIX DESIGN

Mix design was done for 1:2:4 mix with a water-binder ratio of 0.50. The replacement levels of cement with RHA were fixed as 0% (reference mix), 5%, 15% and 25% and samples are thus designated as R0, R5, R15 and R25 respectively.

Fig. 1 gives the variation in compressive strength with respect to different replacement levels of cement to RHA for different period of time.

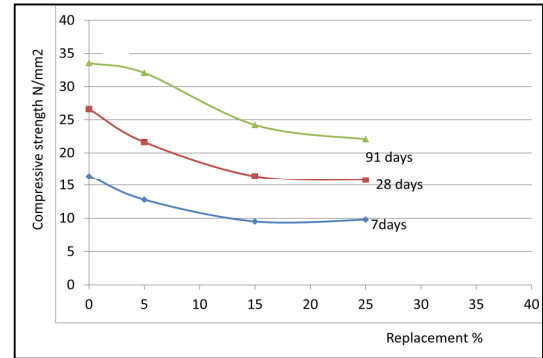


Fig 1 Compressive strength v/s percentage replacement of RHA cubes

R5 mix with lowest replacement, showed a reduction in strength of 19% on comparing with reference mix and R25 with a higher replacement level showed 41% reduction. These two mixes (Minimum and maximum replacement level of cement to RHA) were selected for the casting of building blocks and further studies were conducted on this.

BLOCK MAKING AND TESTING

The blocks were casted by using a hydraulic block making machine (H 800 from Nova Engineering Company, Thrissur, Kerala) showed in Fig 2.

1:2:4 Mix with a water-binder ratio of 0.50 was adopted. RHA in the required replacement level by weight and cement were inter-ground in a ball mill for duration of 15 minutes just before the time of casting. The binder mix was taken in the required quantity and subjected to the mixer machine and dry mixed with the aggregates. Required quantity of water is added to this and mixed properly. This mix is conveyed to the hydraulic block machine and casting was done. Five blocks were casted at a time. Concrete blocks (400mmX200mmX150mm) were kept as such for 24 hours and cured for 28 days by immersing in water. After 28 days, blocks were taken out of the tank, wiped off and allowed for natural drying and tests were conducted.



Fig 2 Hydraulic concrete block making machine

The RHA building blocks were subjected to different strength and durability tests such as Compressive strength, water absorption, density and fire resistance.

TESTS, RESULTS & DISCUSSIONS

Compressive Strength

Compressive Strength test was conducted as per ASTM-C 90,129 and IS: 2185(part I) 1979 for blocks. For the compression test on blocks, the testing machine should be equipped with two steel bearing blocks. One of which is a spherically seated block to transmit load to upper surface of the masonry specimen and the other a plane rigid block to which specimen rests. When the bearing area of the steel blocks is not sufficient to cover the bearing area of the masonry specimen, steel bearing plates meeting the requirements shall be placed between the bearing blocks and the capped specimen after the centroid of the masonry bearing surface has been aligned with the centre of thrust of the bearing blocks.

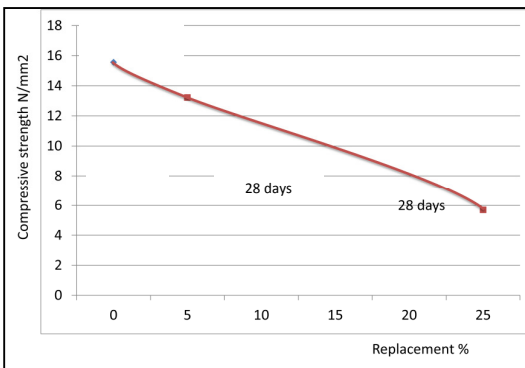


Fig 3 Compressive strength v/s percentage replacement of RHA blocks

Fig.3 shows the variation in compressive strength (28 days) with different replacement levels of cement with RHA. On comparing with reference

blocks, a strength reduction of 15% was reported for blocks with R5 mix and 63% strength reduction for R25 mix. Inferior pozzolanic property of RHA and the resulting reduction in the quantity of stable strength producing cementitious compounds during the hydration process can be attributed to strength reduction of RHA blocks. Filler effects caused by the fineness of RHA particles leads to a tight aggregate-cement interface packing against the surface of aggregates and results in the poor workability of the mix. This can also add to further reduction of strength on increasing the percentage of cement replacement with RHA.

Water absorption

Tests were conducted as per IS: 2185(part I) 1979. The unit weight of blocks were taken both in dry stage and after keeping immersed in water for 24 hours. The percentage of weight difference is noted. The results of water absorption were reported as 1.44%, 1.64% and 2.39 % respectively for R0, R5 and R25 blocks as shown in Fig 4. Even though the RHA building blocks showed a higher water affinity, the results were very much below the specified limits. These finding also match with the studies of Oyekhan et al (2008) and Lersatitthanakorn et al (2009).

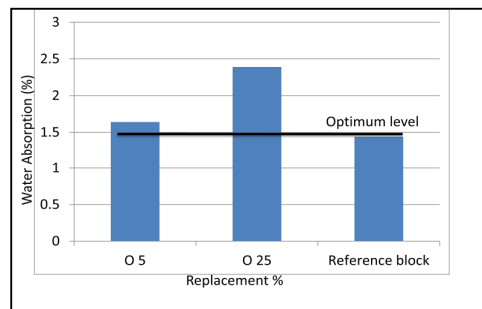


Fig 4 water absorption of various replacement % of both types of RHA

Density

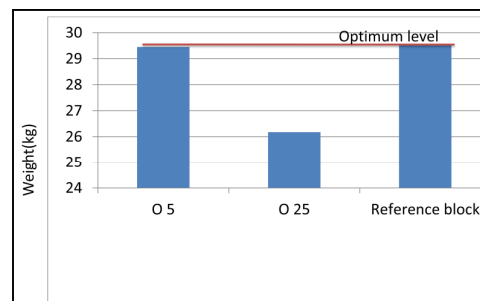


Fig 5 Density comparison of various replacement % of RHA

The density of the block was found out by taking the unit weight of both specimens in the dry stage after keeping immersed in water for 24hrs, taken out, wiped off and dried naturally. RHA-concrete building blocks were found lighter than conventional blocks (2% and 10% respectively for R5 and R25) as shown in Fig 5. This can be due to the lower specific gravity of RHA compared to cement. These results are supported by earlier finding of Oyekhan et al (2008) and Lersatitthanakorn et al (2009).

Fire resistance

Test for fire resistance was conducted as per ASTM 2748-11. The test was done in a muffle furnace at temperature 100^oC, and 200^oC for 1hr and 2hr respectively. For that, three identical specimens were weighed and compressive strength of one is taken. The other two were placed in the furnace for 1hr at 100^oc and 2hr at 200^oc respectively, after that furnace is turn off and kept in furnace for cooling and then weighed and compressive strength is taken. It was found that RHA blocks were able to withstand a temperature of 200^oc for duration of 2hr without any significant changes similar to that of reference block.

CONCLUSION

This research verifies that proposed RHA- concrete building blocks are successful in overcoming the drawbacks of the conventional concrete blocks with improved sustainability characteristics.

Strength and durability characteristics

Even though the incorporation of RHA in building blocks slightly decreases the compressive strength of blocks, RHA- concrete building blocks could satisfy the ASTM standards and Indian standards for load bearing building blocks at 5% replacement level. Blocks casted with higher replacement levels (25%) also satisfy the IS specification for load bearing building blocks.

RHA- concrete building blocks were lighter (2% to10%) compared with conventional concrete building blocks and showed higher insulating properties.

Economical aspects

RHA- concrete building blocks, showed a cost reduction in the range of 1.5% to 7% for the maximum and minimum replacement levels compared to conventional concrete blocks.

Environmental advantages

Utilization of RHA, an agricultural waste material as cement replacement in the proposed RHA- concrete building blocks adds to environmental sustainability.

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