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PERFORMANCE OF RICE HUSK ASH MIXTURE AS A SUSTAINABLE CONSTRUCTION MATERIAL.

Divya Justin O J
A.P Civil
Immanual Arasar JJ College of Engineering, Nattalam.

Abstract

Finding a replacement for cement to assure sustainability is crucial as the raw materials used in making cements which are naturally occurring are depleting. The raw materials are directly or indirectly mined each year for cement manufacturing and it is time to look into the use of agriculture waste by-products in replacing cement. Rice husk ash (RHA) which has the pozzolanic properties is a way forward. An intensive study on RHA was conducted to determine its suitability. it shows that up to 30% replacement of OPC with RHA has the potential to be used as partial cement replacement (PCR), having good compressive strength performance and durability,thus have the potential of using RHA as PCR material and this can contribute to sustainable construction.

Keywords
Rice Husk Ash, Pozzolan, Compressive Strength, Permeabilit

1.Introduction.

In this century, the utilization of rice husk ash (RHA) as cement replacement is a new trend in concrete technology. Besides, as far as the sustainability is concerned, it will also help to solve problems otherwise encountered in disposing of the wastes . Disposal of the husks is a big problem and open heap burning is not acceptable on environmental grounds, and so the majority of husk is currently going into landfill. The disposal of rice husks create environmental problem that leads to the idea of substituting RHA for silica in cement manufactured. The content of silica in the ash is about 92-97%.

Research had shown that small amounts of inert filler have always been acceptable as cement replacements, what more if the fillers have the pozzolanic properties, in which it will not only impart technical advantages to the resulting concrete but also enable larger quantities of cement replacement to be achieved. There are many advantages in using pozzolans in concrete, and they are; improved strength and durability workability, high resistance to chemical attack and low diffusion rate of chloride ions resulting in a higher resistance to corrosion of steel in concrete,reduced material cost, environmental benefits Studies had showed the outstanding

technical benefit of incorporating cement replacement materials (RHA) in which it significantly improves the durability properties of concrete. These properties are difficult to achieve by the use of pure Portland cement alone.

In the present investigation, rice husk ash was blendedwith ordinary Portland cement at various percentages bysimple replacement method and a realistic assessment of the properties has been made in additionto the mechanical properties and the resultwerecompared with conventional Portland cement concrete.

2.Experimental Details:

2.1 .Materials used

Ordinary Portlandcement (OPC):Conforming to IS 8112-1989 wasused for the investigation is givenin Table 1.

Graded fineaggregate: Local clean river sand (finenessmodulus of medium sand equal to 2.46)zone III

Graded coarseaggregates:Locally available well gradedaggregates of normal size greaterthan 4.75 mm and less than12 mm.

2.2 Material preparation

The rice husk was burnt in a ferrocement furnace to produce RHA. After burning and allow cooling inside the furnace for another 24 hours, the burnt ashes were taken out for grinding using a Los Angeles (LA) machine. Figure 1 shows the products obtained after the operation, i.e. rice husk ash (RHA).

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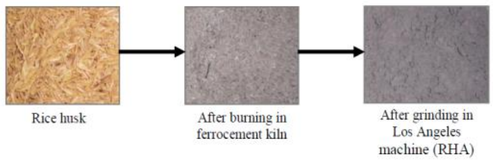
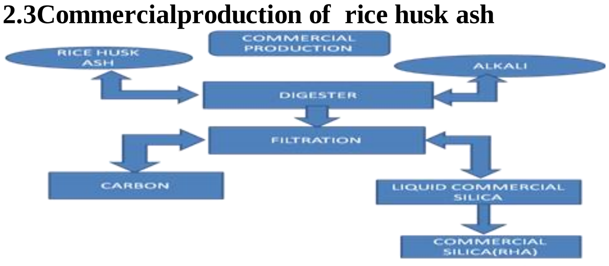


Figure 1: Product produced after each process

2.3Commercialproduction of rice husk ash



2.4Chemical Composition of RHA And OPC

Table 1

Chemical Composition(%)	SiO_2	Al_2O	Fe_2O_3	TiO_2	MgO
OPC	15.05	2.56	4.OO	0.12	1.27
RHA	96.7	1.01	.05	0.16	0.19

3. Test Conducted

(a) Compression test,
(b) Split tensile test,
(c) Pull-out test,
(d) Effective porosity,
(e) Coefficient of water absorption,
(f) Rapid chloride ion penetration test (RCPT)

3.1. Compressive strength

Compressive strength test was carried out in concretecubes of size 100 · 100 · 100 mm using 1:1.5:3.0 mix withW/C ratio of 0.53. Specimens with ordinary Portland cement concrete(control) and OPC replaced by rice huskash at 5%, 10%, 15%, 20%, 25% and 30%replacement levelswere cast. During moulding, the cubes were mechanicallyvibrated. After 24 h, the specimens were removedfrom the mould and subjected to water curing for 7, 14and 28 days. After a specified period of curing, the specimenswere tested for compressive strength using compression testing machine of 2000 kN capacity at a rateof loading of 140 kN/min. The tests were carried out ontriplicate specimens and the average compressive strength values were recorded.

Figure 2 compression testing machine

3.2. Split tensile test

Concrete cylinders of size 150 mm diameter and300 mm height were cast using 1:1.50:3.0 mix with W/C ratio of 0.53. Specimens with OPC and OPC replacedby rice husk ash at 5%, 10%, 15%, 20%, 25% and 30%replacement levels were cast. During moulding, the cylinders were mechanically vibrated using a table vibrator.After 24 h, the specimens were removed from the mouldand subjected to water curing for 7,14 and 28 days. Afterthe specified curing period was over, the concrete cylinderswere subjected to split tensile test by using universaltesting machine. Tests were carried out on specimensand average split tensile strength values wererecorded.

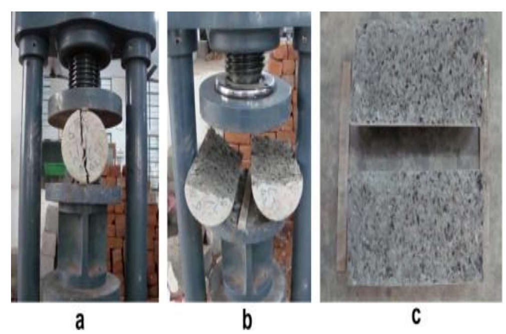


Figure 2 split testing procedure

3.3. Pull-out test

Cold twisted deformed bars of 12 mm 450 mm long were used for steel-concrete bondstrength determination. The rod was placed centrallyalong with helical reinforcement provided in the centreof the concrete cube of size 100 · 100 · 100 mm using aconcrete mix of 1:1.50:3.0 with W/C ratio equal to0.53. Specimens with OPC and OPC replaced by ricehusk ash at 5%, 10%, 15%, 20%, 25% and 30% replacementlevels were cast. The bar is projected down for adistance of about 10 mm from the bottom face of thecube as cast and projected upward from the top up to300 mm height in order to provide an adequate lengthto be gripped for application of load. During castingof concrete cubes, the moulds were mechanicallyvibrated. The cubes were removed from the mould after24 h and then cured for 28 days with complete immersionin distilled water. After the curing period was overthe steel-concrete bond strength was determined usingUniversal Testing Machine of capacity60t. The bond strength was calculated from the load atwhich the slip was 0.25 mm. Tests were carried out inspecimens and average bond strength valueswere obtained.

3.4. Effective porosity test

For determination of effective porosity and coefficientof water absorption, discs of size 83 mm diameterand 50 mm thick were cast with and without rice huskash at 5%, 10%, 15%, 20%, 25% and 30% replacement levelsand cured for 28 days in distilled water. After the curingperiod was over the specimens were dried in an oven at105 _C ±5 _C for 48 h in order to evaporate the moisturecontent present in the concrete. The effective porosity andcoefficient of water absorption are calculated as follows

$$\text{Effective porosity } (\%) = [(B-A)/V] \times 100$$

Where,

A=mass of oven dried sample in air

B=saturated mass of the surface dry sample in airafter immersion

V =bulk volume of the sample

3.5. Coefficient of water absorption

The same specimens used for effectiveporosity was used for this study also. Coefficient ofwater absorption is a measure of water permeability andis calculated as follows:

Coefficient of water absorption $K_a = (Q/A)^2 \times (1/t)$

K_a= Coefficient of water absorption

Q =Quantity of water absorbed by the oven driedspecimen in time t, t–60 min

A =Total surface area of concrete through whichwater penetrates

3.6. Rapid chloride ion penetration test (RCPT)

Concretedisc of size 85 mm diameter and 50 mm thickness withand without rice husk ash were cast and allowed to cure for28 days. After 28 days of curing the concrete specimenswere subjected to RCPT test by impressing 60 V. Twohalves of the specimen are sealed with PVC container ofdiameter 90 mm. One side of the container is filled with 3% NaCl solution (that side of the cell will be connectedto the negative terminal of the power supply), the other sideis filled with 0.3 N NaOH solution (which will be connectedto the positive terminal of the power supply). Current ismeasured at every 30 minutes up to 6 h. Chloride contaminationand temperature at every 30 min were also monitoredFrom the results using current and time, chloridepermeability is calculated in terms of Coulombs at theend of 6 h.

Figure 5 Rapid Chloride Ion Penetration Apparatus

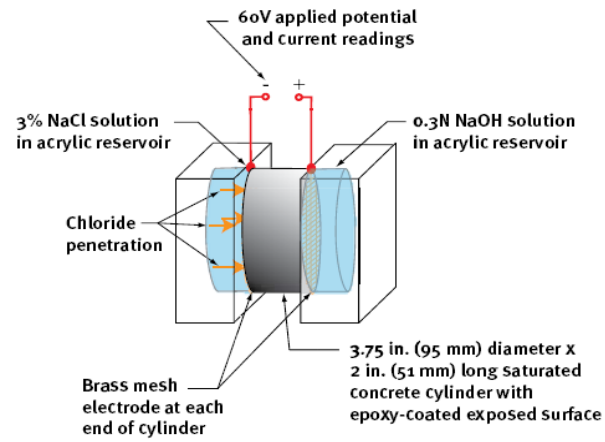


Fig. 1: Schematic of rapid chloride permeability test setup

4. Results and discussion

4.1. Compressive strength

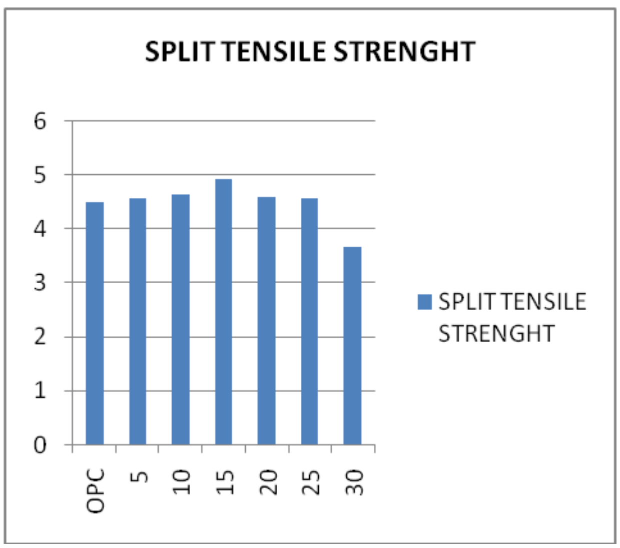
Table shows the compressive strength of rice husk ash\replaced concrete after 7, 14 and 28 days of curing. Fromthe table, it is found that the compressive strength increases withblending percentage and with age. This value is pronounced for all replacement levels.Higher concentrationRHA also can be used without strength loss. After 28days of curing also all the rice husk ash replaced concretesare showing a higher compressive strength than the controlconcrete. After 28 days of curing, conventional and 5% ricehusk ash replaced concretes are showed equal compressivestrength. Rice husk ash blended concretes showed highercompressive strength than control concretes beyond 5%replacement levels. Upto 30% replacement level of ricehusk ash there is no decrease in compressive strengthobserved when compared to conventional OPC concrete.

compressive strength of rice husk ash replaced concrete after,7,14, 28 days of curing

% Replacement	Average compressive strength(N/mm^2)		
	7 days	14 days	28 days
OPC	27.22	33.29	36.45
5	31.32	35.62	36.49
10	30.45	35.97	37.43
15	31.52	35.04	37.38
20	31.64	36.17	37.71
25	33.09	35.27	39.55
30	33.53	35.44	37.80

4.2. Split tensile strength

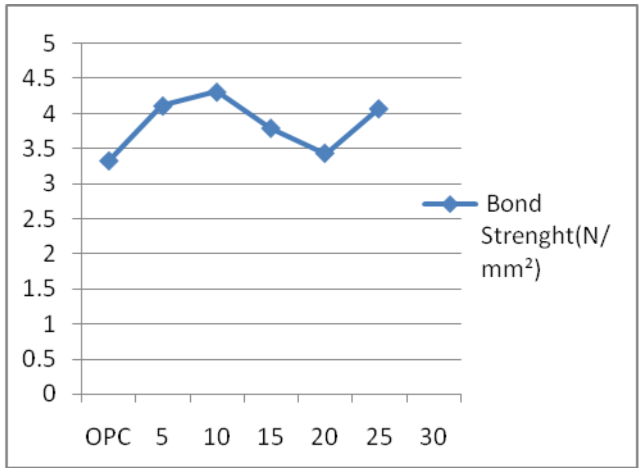
The split tensile strength (N/mm^2) of rice husk ash blended concreteup to 30% replacement levels after 28 days curingare shown in graph 1. It can be observed from the tablethat, up to 25% replacement of rice husk ash the splittensile strength has not been affected. After 25% replacementlevel, a slight decrease in split tensile strength isobserved.



4.3. Bond strength

Graph 2shows the bond strength results of OPC and ricehusk ash replaced concrete after 28 days of curing. Fromthe table it is observed that, all the rice husk replaced concretesare showing higher bond strengthvalues than theconventional concrete. So the replacement of rice huskash does not affect the bond strength properties.

Graph 2



4.4. Effective porosity test

Graph 3shows the porosity values of OPC and different percentage of rice husk ash replaced concrete after 28 day curing. From the table, it is observed that the porosity values decreases as the percentage of replacementincreases. It has also been reported that at early age of curing (7 and 28days) supplementary cementitious materials are more porous than the plain cement paste and the pore size distributionsare more porous, but at the later ages (90 days) this may be reversed. They have also reported that pozzolanic materials increased the porosity and reduced the pore structure .The same trend is observed in this case also.The small RHA particles improved the particle packing density of the blended cement, leading to a reduced volumeof larger pores.

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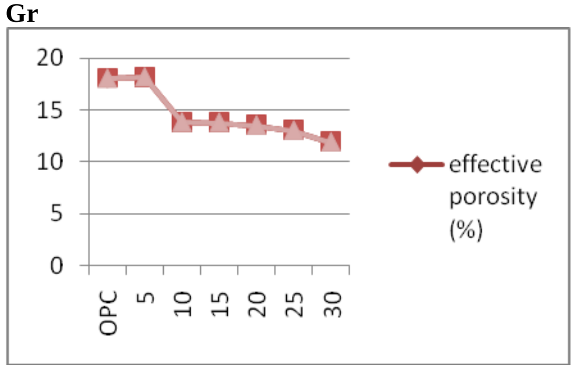

4.5. Coefficient of water absorption

Table 3indicates the coefficient of water absorption ofOPC and different percentages of rice husk ash replacedconcrete after 28 days curing. From the table it is observedthat, the coefficient of water absorption for rice husk ashreplaced concrete at all

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replacement levels is found to beless when compared to control concrete.

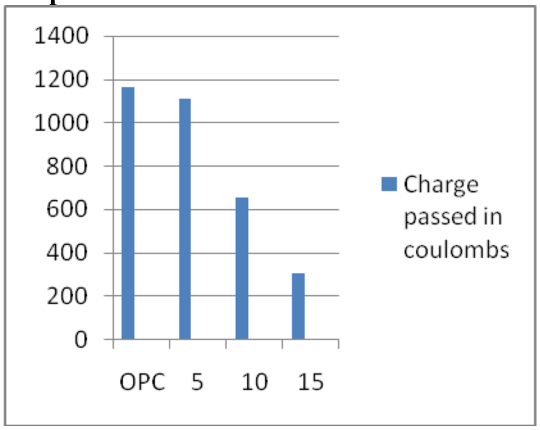
Table 3

% Replacement	Coefficient Of Water Absorption(m^2/s)
OPC	3.55×10^{-10}
5	6.75×10^{-11}
10	1.03×10^{-11}
15	1.06×10^{-11}
20	1.21×10^{-10}
25	1.45×10^{-10}
30	1.30×10^{-10}

4.6. Rapid chloride ion penetration test

Graph 4shows the rapid chloride permeation test resultsof rice husk ash replaced concrete after 28 days curing.From the table it is found that as the replacement levelincreases the charge passed decreases. Replacement of ricehusk ash drastically reduced the Coulomb values. As thereplacement level increases, the chloride penetrationdecrease.

Graph 4



5.Conclusion

From the above investigations it is found that the incorporationof RHA up to 30% replacement level reduces thechloride penetration, decreases permeability, improves strength and corrosion resistance properties.The RHA containingconcrete hasmore resistance to chemicalattacks than OPC concrete mixture containing 25% RHA as a replacement of OPCproduced the same strength as the concrete containing 100%OPC. Therefore, this concrete could be used to reduce environmentalproblems associated with OPC production and RHAdumping.partial replacement of cementby RHA can result in substantial cost savings with addedbenefits of alleviating environmental problems related to cement production . From this study it is concluded that the replacement level of RHAis recommended up to 25%.

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