ISSN (e): 2250 – 3005 || Vol, 05 || Issue,02 || February – 2015 ||
International Journal of Computational Engineering Research (IJCER)

Impact of Using RHA and CD in Replacement of Cement for Mix

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ABSTRACT

The introduction of sustainable development to overcome issues of natural resource depletion has been gaining increased attention. The major objective of this study is to address the potential use of both agricultural and industrial wastes namely RHA (Rice Husk Ash) and CD (Copper Dust) as raw material in production of concrete. This study is an experimental investigation performed on replacement of copper dust and rice husk in cement concrete. It enhances the mechanical properties of concrete cube subjected to split tensile test and compressive strength test .This study provides comparison between the performance of using copper dust and rice husk cement concrete, as a strengthening material of concrete cube. The samples were tested and proved its promising results which were found to be increased compressive strength upto 25% and increased split tensile strength upto 40%.

KEYWORDS:*CD, RHA, mix design, compressive strength, split tensile strength, electrical resistivity*

I. INTRODUCTION

Globally, approximately 600 million tons of rice paddy is produced each year. On average 20% of the rice paddy is husk, giving an annual total production of 120 million tons. In the majority of rice producing countries much of the husk produced from the processing of rice is either burnt or dumped as a waste.The treatment of rice husk as a 'resource' for energy production is a departure from the perception that husks present disposal problems. The concept of generating energy from rice husk has great potential, particularly in those countries that are primarily dependant on imported oil for their energy needs. Rice husks are one of the largest readily available but most under-utilized biomass resources, being an ideal fuel for electricity generation.If a long term sustainable market and price for rice husk ash (RHA) can be established, then the viability of rice husk power or co-generation plants are substantially improved. Many more plants in the 2 - 5 MW range can become commercially viable around the world and this biomass resource can be utilized to a much greater extent than at present.Copper dust consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (bentonite, sea coal, resins) and dust. Copper dust can be used in concrete to improve its strength and other durability factors. Copper dust can be used as a partial replacement of cement or as a partial replacement of fine aggregates or total replacement of fine aggregate and as supplementary addition to achieve different properties of concrete. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates. In modern foundry practice, sand is typically recycled and reused through many production cycles. Industry estimates that approximately 100 million tons of sand is used in production annually of that 6 - 10 million tons are discarded annually and are available to be recycled into other products and in industry. The automotive industries and its parts are the major generators of foundry sand. Foundries purchase high quality size-specific silica sands for use in their molding and casting operations.

II. MATERIALS AND METHODS

The following materials are used for replacing cement and sand

- Rice husk ash
- Copper dust

2.1. RICE HUSH ASH (RHA)

Rice husk is unusually high in ash compared to other biomass fuels – close to 20%. The ash is 92% - 95% silica, highly porous and lightweight, with a very high external surface area. Its absorbent and insulating properties are useful to many industrial applications.

RHA is a general term describing all types of ash produced from burning rice husks. In practice, the type of ash varies considerably according to the burning technique. The silica in the ash undergoes structural transformations depending on the conditions (time, temperature etc) of combustion.

At 550°C – 800°C amorphous ash is formed and at temperatures greater than this, crystalline ash is formed. These types of silica have different properties and it is important to produce ash of the correct specification for the particular end use.

2.1.1. CONSEQUENCES

- The addition of RHA to cement has been found to enhance cement properties:
- The addition of RHA speeds up setting time, although the water requirement is greater than for OPC (Ordinary Portland Cement).
- At 35% replacement, RHA cement has improved compressive strength due to its higher percentage of silica.
- RHA cement has improved resistance to acid attack compared to OPC
- More recent studies have shown RHA has uses in the manufacture of concrete for the marine environment. Replacing 10% Portland cement with RHA can improve resistance to chloride penetration.
- Several studies have combined fly ash and RHA in various proportions. In general, concrete made with Portland cement containing both RHA and fly ash has a higher compressive strength than concrete made with Portland cement containing either RHA or fly ash on their own.

2.2. COPPER DUST

Copper dust is high quality silica sand with uniform physical characteristics. It is a by- product of ferrous and nonferrous metal casting industries, where sand has been used for centuries as a molding material because of its thermal conductivity. It is a byproduct from the production of both ferrous and nonferrous metal castings. The raw sand is normally of a higher quality than the typical bank run or natural sands used in fill construction sites. The sands form the outer shape of the mould cavity. These sands normally rely upon a small amount of betonies clay to act as the binder material. Depending upon the geometry of the casting, sands cores are inserted into the mould cavity to form internal passages for the molten metal. Once the metal has solidified, the casting is separated from the moulding and core sands in the shakeout process. In the casting process, moulding sands are recycled and reused multiple times. Eventually, however, the recycled sand degrades to the point that it can no longer be reused in the casting process. At that point, the old sand is displaced from the cycle as by-product, new sand is introduced, and the cycle begins again. Although there are other casting methods used, including die casting and permanent mould casting, sand casting is by far most prevalent mould casting technique.Sand is used in two different ways in metal castings as a moulding material, which focuses the external shape of the cast part and as cores that form internal void spaces in products such as engine blocks. Since sand grains do not naturally adhere to each other so binders must be introduced to cause the sand to stick together and holds its shape during the introduction of molten metal into mould and cooling of casting.

2.3. METHODOLOGY

2.3.1. COLLECTION OF RAW MATERIALS

The raw materials used in our project are rice husk ash (RHA), copper dust. Copper dust has been collected from the sterlite, Tuticorin and RHA from rice mill Rajapalayam.

2.3.2. TESTING OF RAW MATERIALS

The following tests have been conducted for the collected raw materials to know about their characteristics.

RICE HUSK ASH

- Specific gravity
- Fineness

COPPER DUST

- Specific gravity
- Fineness
- Crushing value

2.3.2.1. DETERMINATION OF SPECIFIC GRAVITY

Specific gravity is determined by pycnometer using the following formula,

FORMULA:

$$\text{Specific gravity of the soil} = \frac{(w2 - w1)}{[(w2 - w1) - (w3 - w4)]}$$

Where,

W1 - empty weight of the pycnometer/density bottle.

W2 - weight of pycnometer/density bottle with copper alone.

W3 - weight of pycnometer/density bottle with copper and water.

W4 - weight of pycnometer/density bottle with water alone.

MATERIALS	SPECIFIC GRAVITY
CEMENT	3.15
SAND	2.65
COARSE AGGREGATE	2.76
RICE HUSK ASH	2.52
COPPER DUST	4.16

2.3.2.2. DETERMINATION OF FINENESS OF RHA

Fineness of RHA is determined using Sieve Analysis method.

As a result percentage of fineness of the RHA=75%

III. CUBE CASTING AND TESTING

The mix design of concrete has been done according to DOE (department of environment) guidelines for M20 grade. Based upon the quantities of ingredient of the mixes, the quantities of RHA, COPPER DUST for 20%, 30% and 40% replacement by weight have been estimated and mixes have been made.

3.1. PROPORTIONING OF CONCRETE MIX

MIX1- Control concrete

MIX2- Concrete with 30% Rice husk Ash

MIX3 - Concrete with 20% RHA + 30% Copper Dust

MIX4 - Concrete with 20% RHA + 40% Copper Dust

MIX5 - Concrete with 30% RHA +30% Copper Dust

MIX6 - Concrete with 30% RHA +40% Copper Dust

3.1.2. MIX DESIGN FOR NORMAL CONCRETE

Characteristic compressive strength required in the field at 28days = 20 N/mm^2

Maximum size of aggregate = 20mm

Degree of quality control = good

Type of exposure = mild

3.1.3 TARGET MEAN STRENGTH OF CONCRETE

The target mean strength for specified characteristic cube Strength is

fck =fck + (t*s)

Where,

fck = characteristic compressive strength at 28 days

s = standard deviation for each grade of concrete, which shall be determined separately according to IS: 456-1978.

t = a statistical value depending on expected of low results (risk factor) according to IS: 456-1978.

fck = fck + (t*s)

= 20+ (1x4.6)

= 24.6 N/mm^2.

3.1.4. DESIGN STIPULATIONS

Characteristic compressive strength

required in the field at 28days = 20 N/mm2

Maximum size of aggregate = 20mm

Degree of quality control = good

Type of exposure = Mild

3.1.5. TEST DATA FOR MATERIALS

Specific gravity of cement =3.15

Specific gravity of fine aggregates =2.65

Specific gravity of coarse aggregates =2.78

3.1.6. SELECTION OF WATER – CEMENT RATIO

C = ((100-PW)/(100-0.7P){W/C+0.3F}

Where, **p =100F/(C+F)**

Fly ash content, **F =pC/ (100-p)**

(i.e.). p is the percentage of fly ash in the. total cementitious material.

W -is the free water content

W/(C+0.3F) is the free water / cementitious ratio for design strength.

The free water/ cementitious material ratio w/c + F should then be compared with the specified value.

Hence the total cementitious material content is =300kg/m3

The free water/cementitious material ratio is =0.65

3.1.7. CALCULATION OF WATER CONTENT

Cement content satisfies the durability requirement. But water/cementitious material ratio does not satisfy the durability requirement. Therefore adopt water/ cementitious material ratio of 0.65, instead of 0.51

Then water content = 300*0.65

= 195.2 kg/m3

3.1.8. CALCULATION OF COARSE AND FINE AGGREGATE CONTENT

For water content of 195kg/m3, average specific gravity of 2.65 of aggregates, the wet density of concrete comes to 2420 kg/m3.

Hence the total weight of aggregates

=2420-(300+195+0)

=1925.4 kg/m^3.

For free water/cementitious material ratio of 0.50, and for F.A 40% passing through 600μ sieve, and for slump of 30-60 mm the proportion of F.A is =40%.

Weight of F.A = (40/100)*1925.4

= 770.2 kg/m^3

Weight of C.A = 1925.4-770.2

= 1152.6 kg/m^3

The above weights of F.A, C.A are to be adjusted depending upon the free moisture content and absorption characteristics of aggregates. The corresponding correction is also to be made in the quantity of actual water added. And also consequent changes in the quantities of aggregates.

Then trial mixes are made to see that the concrete satisfies all the requirements in plastic conditions and strength at 28days. If not, minor adjustment is made in the quantities of material worked out.

TABLE 1 MIX PROPORTION

Water kg/m^3	**Cement kg/m^3**	**RHA kg/m^3**	**Sand kg/m^3**	**Coarse aggregate kg/m^3**
195	300	0	770.2	1152.5
0.65	1	0	2.5	3.5

3.2. MIX DESIGN FOR 20% RHA+40% COPPER DUST CONCRETE

Design stipulations

Characteristic compressive strength required in the field at 28days = 20 N/mm^2

Maximum size of aggregate = 20mm

Degree of quality control = good

Type of exposure = Mild

3.2.1. TEST DATA FOR MATERIALS

Specific gravity of cement =3.15

Specific gravity of fine aggregates =2.65

Specific gravity of coarse aggregates =2.78

3.2.2. SELECTION OF WATER – CEMENT RATIO

C= ((100-PW)/(100-0.7P){W/C+0.3F}

Where, **p =100F/(C+F)**

Fly ash content, **F=pC/(100-p)**

(i.e.).,p is the percentage of fly ash in the total cementitious material.

W is the free water content

W/(C+0.3F)is the free water / cementitious ratio for design strength.

The free water/ cementitious material ratio w/c + F should then be compared with the specified value.

For slump of 60mm, for maxim size aggregate of 20mm, in case of crushed aggregate, the approximate water content is 210kg/m^3.Since 20percent of flu ash is used,

Therefore the water content =195kg/m^3

Then cement content =279.1kg/m^3

Fly ash content, F = pC/(100-p) = 69.7kg/m3

Hence the total cementitious material content is 348.8kg/m^3. The free water/cementitious material ratio is (195/348.8)=0.56.

3.2.3. CALCULATION OF WATER CONTENT

Cement content satisfies the durability requirement. But water/cementitious material ratio does not satisfy the durability requirement. Therefore adopt water/ cementitious material ratio of 0.56, instead of 0.51

Then water content = 348.8*0.56

= 195.33 kg/m^3.

3.2.4 CALCULATION OF COARSE AND FINE AGGREGATE CONTENT

For water content of 195kg/m^3, average specific gravity of 2.65 of aggregates, the wet density of concrete comes to 2420 kg/m^3.

Hence the total weight of aggregates

=2420-(295+279.1+69.7)

=1875.8 kg/m^3

For free water/cementitious material ratio of 0.50, and for F.A, 40% passing through 600µ sieve, and for slump of 30-60 mm the proportion of F.A is =40%.

Weight of F.A = (40/100)*1875.8

=750.32 kg/m^3

Weight of C.A =1875.8-750.32

=1125.5 kg/m^3.

The above weights of F.A, C.A are to be adjusted depending upon the free moisture content and absorption characteristics of aggregates. The corresponding correction is also to be made in the quantity of actual water added. And also consequent changes in the quantities of aggregates.

Then trial mixes are made to see that the concrete satisfies all the requirements in plastic conditions and strength at 28days. If not, minor adjustment is made in the quantities of material worked out.

Table 2 Mix proportion

Water kg/m^3	Cement kg/m^3	RHA kg/m^3	Sand kg/m^3	Coarse aggregate kg/m^3
195	279.1	69.7	750.32	1125.5
0.56	1	0.25	2.68	3.9

Thus, for all replacements the mix design has done similarly.

IV. CASTING OF SPECIMENS

For each mix, cited in above table, good number of 150mm side cube were casted. Immediately after casting, these specimens were covered with wet burlap at the casting site for 24 hours. Following this the test specimens were transferred to the curing tank. The cubes were tested for 7-days and 28-days strengths. The test results are shown in table. It is seen that the nature curves for normal concrete with RHA and Copper Dust concrete were similar.

4.1. Test for compressive strength

Age at test: Usually testing is done after 7 days and 28 days, the days being measured from the time the water is added to the dry ingredients.

COMPRESSIVE TEST RESULTS OF SPECIMEN

S.No	REPLACEMENT OF CEMENT BY RHA	7th DAY COMPRESSIVE STRENGTH	28th DAY COMPRESSIVE STRENGTH
1	Control Concrete	21.47	27.35
2	30% Rice husk Ash	16.19	24.45
3	**20% RHA & 30% Copper Dust**	**21.27**	29.92
4	20% RHA & 40% Copper Dust	21.56	30.34
5	30% RHA & 30% Copper Dust	17.61	26.98
6	30% RHA & 40% Copper Dust	13.03	22.78

(20% RHA and 40% CD is advisable)

7 DAYS COMPRESSIVE STRENGTH

Replacement of RHA & Copper Dust

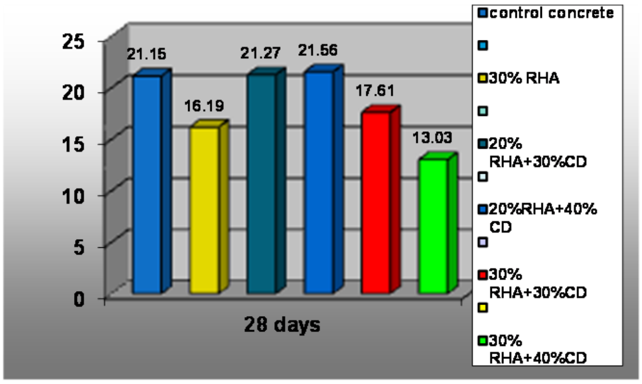

Fig 1 compressive strength result after replacement for 7days

28 DAYS COMPRESSIVE STRENGTH

Replacement of RHA & Copper Dust

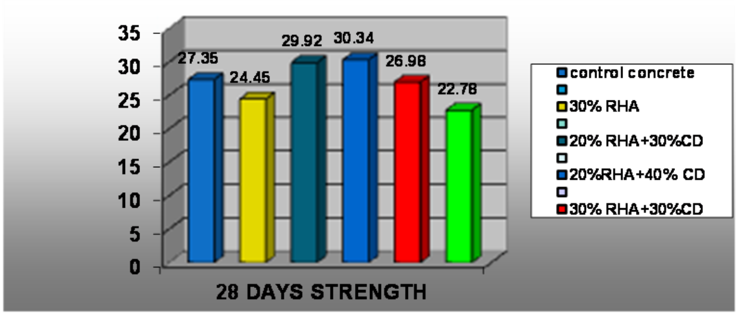

Fig 2 increased compressive strength result after replacement for 28days

4.2. Test for split tensile strength

Age at test: Usually testing is done after 7 days and 28 days, the days being measured from the time the water is added to the dry ingredients.

Table 3 Tensile test results of specimen

S.No	REPLACEMENT OF CEMENT BY RHA	7th DAY TENSILE STRENGTH	28th DAY TENSILE STRENGTH
1	Control Concrete	3.77	4.9
2	30% Rice husk Ash	2.66	5.0
3	20% RHA & 30% Copper Dust	4.68	5.39
4	**20% RHA & 40% Copper Dust**	**3.75**	**6.17**

5	30% RHA & 30% Copper Dust	3.07	**4.78**
6	**30% RHA & 40% Copper Dust**	**2.85**	**3.49**

(20% RHA and 40% CD is advisable)

7 DAYS SPLIT-TENSILE STRENGTH

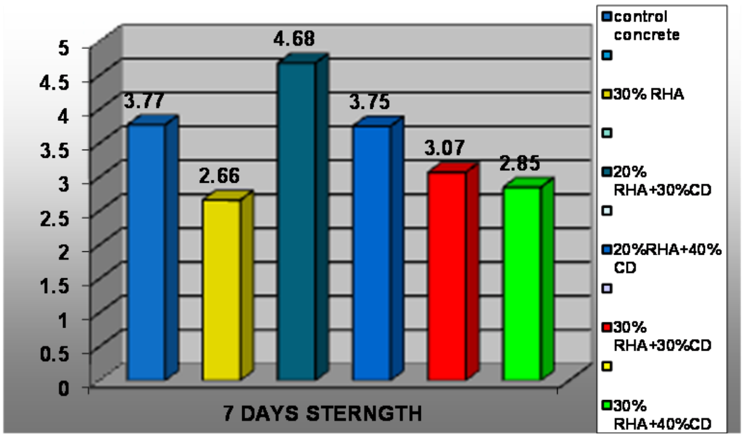

Fig 3 increased split tensile strength result after replacement for 7days

28 DAYS SPLIT-TENSILE STRENGTH

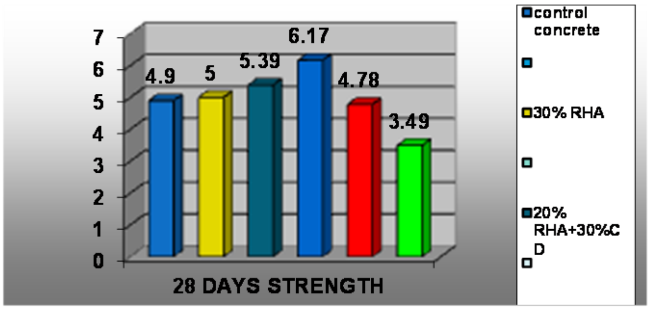

Fig 4 increased split tensile strength result after replacement for 28days

V. ELECTRICAL RESISTIVITY TEST

Resistivity is fundamental property of a particular material. The electrical resistivity of any material is defined as the resistance, in ohms, between opposite faces of unit cube of the material.

Thus, if þ is the resistivity of concrete then,

Þ=RA/L ohm m

R -Resistance

Þ – Resisstivity

A –Area of the specimen in m^2

L - Length between electrodes in ‘m’.

Generally the conventional concrete does not conduct electricity. The resistivity of conventional concrete varies from 6.54×103 ohm m to 11.40×103 ohm m, Hence it acts as a pure resister.

R=V/I

R-Resistivity

V- Voltage applied to the conductive specimen 230v

I – Alternate current taken by the conductive specimen.

R=230/0.1

= 2300

=2.3×103 ohm m

VI. CONCLUSION

- ✓ The RHA used in this study was efficient as a pozzolanic material because it contains high amorphous silica of 88.32%
- ✓ From the test results it was found that concrete with 20% **RHA** and 40% **COPPER DUST** have shown high compressive strength. Hence up to 20% RHA replacement would not adversely affect the strength and mechanical properties.
- ✓ The addition of RHA and **copper dust** to a concrete mix improved the mechanical properties of concrete with respect to compressive strength and it is nearly about upto 25%.
- ✓ Split Tensile Strength has shown an increase with increase in replacement levels of **copper dust upto 40%** with fine aggregate.
- ✓ Split Tensile Strength also increased with increase in age.

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