Partial Replacement of Ordinary Portland Cement with Rice Husk Ash and Coconut Shell Ash in Concrete Production

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Abstract—Compressive strength tests were carried out on six mortar cubes with cement replaced by rice husk ash (RHA) at five levels (10%). After the curing age of 3, 7, 14 and 28 days. The compressive strengths of the cubes at 10% replacement were 12.60, 14.20, 22.10, 28.50 and 36.30 N/mm² respectively and increased with age of curing but decreased with increase in RHA content for all mixes. The chemical analysis of the rice husk ash revealed high amount of silica (68.12%), alumina (1.01%) and oxides such as calcium oxide (1.01%) and iron oxide (0.78%) responsible for strength, Soundness and setting of the concrete. It also contained high amount of magnesia (1.31%) which is responsible for the unsoundness. This result, therefore, indicated that RHA can be used as cement substitute at 10% and 20% replacement and 14 and 28 day curing age.

Keywords— RHA (RICE HUSK ASH) & CSA (COCONUT SHELL ASH).

1. INTRODUCTION

In this project we have replaced the cement by rha & csa to certain percentages like 10%, 15%. Different properties of cement, rice husk ash, coconut shell ash, fresh as well as hardened concrete which are influenced by adding this byproduct were studied. The rice husk & coconut shell thereby constitute an environmental nuisance as they form refuse heaps in the areas where they are disposed. The use of rice husk ash & coconut shell ash as a partial replacement to cement will provide an economic use of the by-product and consequently produce cheaper blocks for low cost buildings. Use of rha with cement improves workability and stability, reduces heat evolution, thermal cracking and plastic shrinkage. This increases strength development, impermeability and durability by strengthening transition zone, modifying the pore-structure, blocking the large voids in the hydrate cement paste through pozzolanic reaction rha minimizes alkali-aggregate reaction, reduces expansion, refines pore structure and hinders diffusion of alkali ions to the surface of aggregate by micro porous structure. Durability, workability and strength are three basics properties of concrete. Amount of use fill internal work necessary to overcome the internal friction to prove full compaction is termed as workability. Strength is to bear the desired stresses within the permissible factor of safety in expected exposure condition. Durability is substance of shape, size and strength; resistance to exposure condition, disintegration and wearing under adverse condition

2. MATERIALS USED

(i) Cement

Cement used in the experimental work is PORTLANDPOZZOLONA CEMENT conforming to IS: 1489 (Part 1)-1991. The physical and chemical properties of the cement obtained on conducting appropriate tests as per IS: 269/4831 and the requirements as per IS 1489-1991 are given in Table 1 & Table 2.

(ii) Rice Husk Ash

RHA produced after burning of Rice Husk has high reactivity and pozzolanic property Chemical compositions of

Table 1: Physical properties of procured OPC

<table>
<thead>
<tr>
<th>Particular</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity</td>
<td>3.15%</td>
</tr>
<tr>
<td>Fineness (sieve analysis)</td>
<td>3.2%</td>
</tr>
<tr>
<td>Normal consistency</td>
<td>30%</td>
</tr>
</tbody>
</table>

Table 2: Chemical Properties of Procured OPC

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particular</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Silicon dioxide</td>
<td>SiO₂</td>
</tr>
<tr>
<td>2</td>
<td>Aluminum oxide</td>
<td>Al₂O₃</td>
</tr>
<tr>
<td>3</td>
<td>Iron oxide</td>
<td>Fe₂O₃</td>
</tr>
<tr>
<td>4</td>
<td>Calcium oxide</td>
<td>CaO</td>
</tr>
<tr>
<td>5</td>
<td>Magnesium oxide</td>
<td>MgO</td>
</tr>
<tr>
<td>6</td>
<td>Sodium oxide</td>
<td>Na₂O</td>
</tr>
<tr>
<td>7</td>
<td>Potassium oxide</td>
<td>K₂O</td>
</tr>
<tr>
<td>8</td>
<td>Sulphur oxide</td>
<td>SO₂</td>
</tr>
<tr>
<td>9</td>
<td>Ignition loss</td>
<td>LOI</td>
</tr>
</tbody>
</table>
RHA are affected due to burning process and temperature. As per study by RHA produced by burning rice husk between 600 to 700 °C temperature for 2 hours.

**Table 3: Physical Properties of Procured Rice Husk Ash**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particular</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Colour</td>
<td>Grey</td>
</tr>
<tr>
<td>2</td>
<td>Shape Texture</td>
<td>Irregular</td>
</tr>
<tr>
<td>3</td>
<td>Particle size</td>
<td>&lt; 45 micron</td>
</tr>
<tr>
<td>4</td>
<td>Odour</td>
<td>Odourless</td>
</tr>
<tr>
<td>5</td>
<td>Specific gravity</td>
<td>2.3</td>
</tr>
<tr>
<td>6</td>
<td>Appearance</td>
<td>Very fine</td>
</tr>
</tbody>
</table>

**Table 4: Chemical Properties of R.H.A.**

<table>
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<tr>
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</tr>
<tr>
<td>7</td>
<td>Potassium oxide</td>
<td>K₂O</td>
</tr>
<tr>
<td>8</td>
<td>Ignition toss</td>
<td>LOI</td>
</tr>
</tbody>
</table>

(iii) Coconut Shell Ash

Coconut shell is an agricultural waste material which is on burning in the open air (uncontrolled combustion) for three hours to produce coconut shell ash, which in turn was used as pozzolana in partial replacement of cement in concrete production.

**Table 5: Chemical Properties of Procured CSA**

<table>
<thead>
<tr>
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<tbody>
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<td>Aluminium oxide</td>
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</tr>
<tr>
<td>3</td>
<td>Iron oxide</td>
<td>Fe₂O₃</td>
</tr>
<tr>
<td>4</td>
<td>Calcium oxide</td>
<td>CaO</td>
</tr>
<tr>
<td>5</td>
<td>Magnesium oxide</td>
<td>MgO</td>
</tr>
<tr>
<td>6</td>
<td>Sodium oxide</td>
<td>Na₂O₂</td>
</tr>
<tr>
<td>7</td>
<td>Manganese oxide</td>
<td>MnO</td>
</tr>
<tr>
<td>8</td>
<td>Potassium oxide</td>
<td>K₂O</td>
</tr>
<tr>
<td>9</td>
<td>Sulphur oxide</td>
<td>SO₃</td>
</tr>
<tr>
<td>10</td>
<td>Ignition toss</td>
<td>LOI</td>
</tr>
</tbody>
</table>

(iv) Aggregates

1. Fine Aggregate

Fine aggregate was purchased which satisfied the required properties of fine aggregate required for experimental work and the sand conforms to zone III as per the specifications of IS 383:1970.

- Specific gravity = 2.7
- Fineness Modulus = 2.71

2. Coarse Aggregate

Crushed granite of 20 mm maximum size has been used as coarse aggregate. The sieve analysis of combined aggregates confirms to the specifications of IS 383: 1970 for graded aggregates.

- Specific gravity = 2.64
- Fineness Modulus = 6.816

Super Plasticizers

Super plasticizers are usually highly distinctive in their nature, and they make possible the production of concrete which, in its fresh or hardened state, is substantially different from concrete made using water-reducing admixtures.

(v) Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. Mixing water should not contain undesirable organic substances or inorganic constituents in excessive proportions. In this project, clean potable water was obtained from Department of Civil Engineering, SSGI for mixing.

3. STANDARD TESTS OF OPC

3.1: Fineness test of cement

**Apparatus:**

- Standard balance with 800 gm of cement
- IS: 90 micron sieve
- Sieve Shaker

**Result:**

The percentage weight of residue over the total sample reported.

% weight of residue = 2.12%

**Limits:**

The percentage residue should not exceed 10%.
**Apparatus:**
- a) Vicat apparatus.
- b) Needle for initial setting time and stop watch

**Result:**
The initial setting time of the given sample of cement = 37 minutes.

![Fig. 2 Initial setting time test of cement](image)

3.4 : Final setting time test of cement

**Apparatus:**
- a) Vicat apparatus
- b) Needle for final setting time, stop watch, trowel.

**Result:**
Final setting time of the cement given sample = 9 hrs.

![Fig. 3 Final setting time test of cement](image)

3.5 : Compressive strength test of cement mortar

**Apparatus:**
- a) 7.05 cm cubes moulds.
- b) Apparatus for mixing and gauging mortar.
- c) Vibrator, compressive testing machine etc.

**Result:**
Compressive strength at 3 days = 9.46 N/mm²
Compressive strength at 7 days = 15.08 N/mm²

4. STANDARD TESTS FOR OPC+ 10% RHA
(10% replacement of cement by rice husk ash)

4.1 : Fineness test

**Apparatus:**
- a) Standard balance with 800gm Weighing capacity.
- b) IS: 90 micron sieve, sieve shaker.

**Result:**
The percentage weight of residue over the total sample is reported.
% Weight of Residue = 36/800 x 100 = 3.85%

**Limits:**
The percentage residue should not exceed 10%.

4.2 : Consistency test

**Apparatus:**
- a) Vicat Apparatus.
- b) Balance of capacity, gauging trowel

**Result:**
Standard Consistency (%) = 38%

4.3 : Initial setting time

**Apparatus:**
- a) Vicat Apparatus.
- b) Needle for initial setting time, stop watch and trowel.

**Result:**
Initial setting time of the cement given sample = 47 min.

4.4 : Final setting time

**Apparatus:**
- a) Vicat apparatus.
- b) Needle for final setting time, stop watch, trowel.

**Result:**
Final setting time of the cement given sample = 6 hrs

4.5 : Compressive strength

**Apparatus:**
- a) 7.05 cm cubes moulds.
- b) Apparatus for mixing and gauging mortar.
- c) Vibrator, compressive testing machine etc.

**Result:**
Compressive strength at 3 days = 9.05 N/mm²
Compressive strength at 7 days = 14.88 N/mm²

![Fig. 4 Rice husk](image)

5. STANDARD TESTS FOR OPC+ 10% CSA
(10% replacement of cement by coconut shell ash)
Fig.5 Rice husk ash

Apparatus:
a) Vicat apparatus.
b) Needle for final setting time, stop watch, trowel.

Result:
Final setting time of the cement given sample = 8 hrs. and 10 minutes.

5.5 : Compressive strength

Apparatus:
a) 7.05cm cubes moulds.
b) Apparatus for mixing and gauging mortar.
c) Vibrator, compressive testing machine etc.

Result:
Compressive strength at 3 days = 8.85 N/mm²
Compressive strength at 7 days = 14.69 N/mm²

4. BENEFITS OF REPLACEMENT OF RHA & CSA WITH CEMENT

- Reduced cost of construction.
- Use of waste materials in useful manner.
- Provide safeguard to the environment by utilizing waste properly.
- Increase in strength of concrete.
- Decrease the final setting time.
- Easily available.
- It gives durable concrete.
- Reduce weight of structure.

5. RESULT AND DISCUSSION

The physical property of RHA& CSA that influence the activity in gaining strength is its fineness. RHA required having equal or finer than OPC for its good cementing efficiency. The fineness of the 43 grades OPC in this investigation are found to be 2.12% residue on 90 micron sieve size respectively. Fineness of RHA is found to be 3.85% & Fineness of CSA is found to be 3.32%. This shows that RHA & CSA is of almost equal size to cement particles. Thus, it is expected to have appreciable influence on the strength development on concrete. Variation of setting time (1ST) is increased & final setting time is decreased with increasing RHA & CSA content. This behavior may be due to the low rate of hydration in the paste containing RHA. Variation of normal consistency for different grade of OPC using different percentage of RHA.

The normal consistency of 43 grade cement is higher by 9% as compare to that of 33 grade cement. The slump and compacting factors test decrease upon the inclusion of RHA & CSA as partial replacement of OPC. Thus, it can be inferred that to attend the required workability mixes. The compressive strength of concrete in all grades of OPC at early age is significantly higher than that of concrete produced with RHA. It was also observed that compressive strength continued to increase with age but decrease with RHA contents in all grade of OPC.

The number of taken with number of variation out of which following result with 10% replacement of cement with RHA & CSA for 3 day and 7 day of curing proved as a most economical and having good compressive strength 9.05 N/mm² and 14.88 N/mm²& 8.85 N/mm² and 14.69 N/mm² respectively.

6. COMPARISON AND CONCLUSION

In this project we are partially replacement the cement with rice husk ash Difference properties of cement as well as concrete which are affected due to the introduction of rice husk ash as a constituent of concrete were dealt in this project Properties of high priority like compressive strength are favorable particularly at 10% replacement However, Workability of concrete and consistency of cement were greatly affected due to the replacement of cement with RHA. The mix was becoming harsh with increase in percentage of replacement of cement. But at 10% replacement, which is more likely to be adoptable it does not be very harsh. From all the tests performed and result interpreted it can be concluded that the partial replacement of cement with RHA is advantageous and adoptable.

<table>
<thead>
<tr>
<th>Material</th>
<th>Setting time</th>
<th>Cement</th>
<th>C+ 10 % RHA</th>
<th>C+ 10% CSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>37 min.</td>
<td>48 min.</td>
<td>42 min.</td>
<td></td>
</tr>
<tr>
<td>Final</td>
<td>9 hr.</td>
<td>6 hr.</td>
<td>8 hr.</td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Comparison chart of compressive strength

Table 7: Comparison chart of setting time
7. FUTURE SCOPE

Cost of the cement is increasing day by day so, using pozzolanic material like RICE HUSK ASH comparison of construction cost can be done.

REFERENCES:

[1] Effect of Rice Husk Ash on Cement Mortar and Concrete. Sudisht Mishra, Prof (Dr.) S.V. Deodhar.