Effect of Rice Husk Ash [RHA] on Cement Concrete

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Abstract :
Cement is widely noted to be most expensive constituents of concrete. The cement industry is one of the largest producers of carbon dioxide. The carbon dioxide (CO_2) emission from the concrete production is directly proportional to the cement content in the concrete mix; 900 kg of CO_2 are emitted for the fabrication of every ton of cement. The entire construction industry is in search of a suitable and effective waste product that would considerably minimize the use of cements and ultimately reduces the construction cost. For this objective, the use of industrial waste products and agricultural byproducts are very constructive. Rice Husk Ash (RHA) is one of the promising pozzolanic materials that can be blended with Portland cement for the production of durable concrete. Addition of rice husk ash to Portland cement not only improve the strength of concrete but also forms the calcium silicate hydrate gel around the cement particles which is highly dense and less porous. Thus in the present investigation a realistic approach has been made using different techniques such as Compressive strength, Flexural strength using different percentage of RHA and varying curing period.

Keywords : Rice Husk Ash (RHA), Cement, Pozzolanic material, Carbon Dioxide (CO_2), Partial replacement.

1. Introduction :

Concrete is the most widely used man-made construction material in the world. It is obtained by mixing cementitious materials, water, aggregate and sometimes admixtures in required proportions. The Ordinary Portland Cement (OPC) is one of the main ingredients used for the production of concrete and has no alternative in the civil construction industry. Unfortunately, production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for green house effect and the global warming, hence it is inevitable either to search for another material or partly replace it by some other material. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. Supplementary cementitious materials are added to concrete as part of the total cementitious system. They may be used in addition to or as a partial replacement of Portland cement or blended cement in concrete, depending on the properties of the materials and the desired effect on concrete be available annually on a global basis for pozzolona production. Fly ash, Ground Granulated Blast furnace Slag, Rice husk ash, Silica fume are some of the pozzolanic materials which can be used in concrete as partial replacement of cement.

One of the most suitable sources of pozzolanic material among agricultural and industrial waste components is Rice husk ash, as it is available in large quantities and contains a relatively large amount of silica. It is worth to mention that the use of RHA in concrete may lead to the improved workability, the reduced heat evolution, the reduced permeability, and the increased strength at longer ages. The use of waste material like RHA due to an assumption is that material can be replaced the existing material in order to reduce cost and improve mechanical properties of the composite structure.

There is an increasing importance to preserve the environment in the present era. RHA from the parboiling plants is posing a serious environmental threat to dispose them is a another issue. This material is actually a super pozzolona since it is rich in silica and has about 85% to 95% silica content. A good way of utilizing this material is to use it for making "High performance concrete".
On average about 0.9 tonnes of CO_2 are emitted for every tonne of clinker produced. Energy use is currently responsible for between 0.3 and 0.4 tonnes of this CO_2; these emissions could be reduced. The 0.53 tonnes of CO_2 emitted per tonne of clinker cannot be reduced. These are known as "process emissions", this is the CO_2 released from the calcination of limestone. When it is heated, it breaks down into quick lime and CO_2.

The cement industry is reducing its CO_2 emissions by improving manufacturing processes, concentrating more production in the most efficient plants and using wastes productively as alternative fuels in the cement kiln. Despite this, for every tonne of cement produced, roughly 0.75 tonnes of CO_2 (greenhouse gas) is released by the burning fuel, and an additional 0.5 tonnes of CO_2 is released in the chemical reaction that changes raw material to clinker (calcinations). The potential to earn CERs comes primarily from substituting Portland cement with RHA. There are other environmental benefits of substituting Portland cement with RHA. The need for quarrying of primary raw materials is reduced, and overall reductions in emissions of dust, CO_2 and acid gases are attained.

2. Materials and Properties:

2.1 Rice Husk Ash:

Rice husk ash is obtained by burning rice husk in a controlled manner without causing environmental pollution. When it is properly brunt it has high SiO_2 content and can be used as a concrete admixture. Rice husk ash exhibits high pozzolanic characteristics and contributes to high strength and high impermeability of concrete. Rice husk ash essential consists of amorphous or non crystalline silica with about 85- 90% cellular particle, 5% carbon and 2% K_2O. There is a good potential to make use of RHA as a valuable pozzolanic material to give almost the same properties as that of micro silica.

Table 2 Physical Properties of RHA

S.No.	Particulars	Properties
1	Colour	Grey
2	Shape texture	Irregular
3	Mineralogy	Non crystalline
4	Particle size	25 micron-mean
5	Odour	Odourless
6	Specific gravity	2.3

Table 2 Chemical properties of RHA

S.No.	Particulars	Proportion (%)
1	Silicon dioxide	86.94
2	Aluminum oxide	0.2
3	Iron oxide	0.1
4	Calcium oxide	0.3-2.2
5	Magnesium oxide	0.2-0.6
6	Sodium oxide	0.1-0.8
7	Potassium oxide	2.15-2.30
8	Ignition loss	3.15-4.4

2.2 Cement:

Ordinary Portland cement (OPC) of grade 43 was used in which the composition and properties is in compliance with the Indian Standard Organization. Cement can be defined as the bonding material having cohesive and adhesive properties which makes it capable to unite the different construction materials and form the compacted assembly.

Table 3 Constituents of OPC

S.No.	Constituents	Proportion (%)
1	Lime (CaO)	62-67
2	Silica (SiO_2)	17-25
3	Alumina (Al_2O_3)	3-8
4	Calcium Sulphate ($CaSo_4$)	3-4
5	Iron Oxide (Fe_2O_3)	3-4
6	Magnesia (MgO)	1-3
7	Sulphur (S)	1-3
8	Alkalies	0.2-1

2.3 Aggregates:

The inert minerals such as gravel such as sand, gravel, etc used for manufacture of concrete are known as aggregates. Aggregate properties greatly influence the behavior of concrete, since they occupy about 80% of the total volume of concrete. Requirements of good aggregates:

(a) It should be sufficiently strong.
(b) It should be hard.
(c) It should have rough surface.
(d) It should be in spherical or in cubical in shape.

2.4 Plastisizers:

Plasticizers or water reducers are chemical admixtures that can be added to concrete mixtures to improve workability. Unless the mix is “starved” of water, the strength of concrete is inversely proportional to the amount of water added or water – cement ratio. In order to produce stronger concrete , less water is added (without “starving” the mix), which makes the concrete mixtures less workable and difficult to mix, necessitating the use of plasticizers, water reducers, super plasticizers or dispersants.

Plasticizers are commonly manufactured from pop lignosulfonates, a by- product from the paper industry.

2.5 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 in to very carefully. Mixing water should not contain undesirable organic substances or inorganic constituents in excessive proportions.

3. Experimental Work Done:

The mix proportioning of the various replacements of cement with rice husk ash (RHA) are mentioned in the tables below.

Table 4 Mix Proportion of concrete with 0% RHA replacement

S.No.	Material	In kg	In cum
1	Cement	1	383
2	RHA	0	0
3	Fine aggregate	1.65	633
4	Coarse aggregate	3.44	1318
5	Water	0.4	153

Table 5 Mix proportioning of concrete with 5% RHA replacement

S.No	Material	In kg	In cum
1	Cement	0.95	363.85
2	RHA	0.05	19.15
3	Fine aggregate	1.65	633
4	Coarse aggregate	3.44	1318
5	Water	0.4	153

Table 6 Mix proportioning of concrete with 10% RHA replacement

S.No.	Material	In kg	In cum
1	Cement	0.90	344.70
2	RHA	0.10	38.3
3	Fine aggregate	1.65	633
4	Coarse aggregate	3.44	1318
5	Water	0.4	153

Table 7 Mix proportioning of concrete with 20% RHA replacement

S.No.	Material	In kg	In cum
1	Cement	0.80	306.4
2	RHA	0.20	76.6
3	Fine aggregate	1.65	633
4	Coarse aggregate	3.44	1318
5	Water	0.4	153

Table 8 Mix proportioning of concrete with 25% RHA replacement

S.No.	Material	In kg	In cum
1	Cement	0.75	287.25
2	RHA	0.25	95.75
3	Fine aggregate	1.65	633
4	Coarse aggregate	3.44	1318
5	Water	0.4	153

4. Results and Discussion:

4.1 Test Results:

Table 9 Compressive strength results of concrete mixes

S.No.	% RHA Replacement	Compressive strength (MPa)		
		7 days	14 days	28 days
1	0%	22.42	26.48	34.53
2	5%	21.79	25.40	35.10
3	10%	20.27	24.43	36.29
4	20%	19.66	23.87	38.36
5	25%	17.23	21.31	32.15

Table 10 Flexural strength results of concrete mixes

S.No.	% RHA Replacement	Flexural strength (MPa)		
		7 days	14 days	28 days
1	0%	1.91	2.24	2.44
2	5%	1.8	2.38	2.51
3	10%	1.5	2.22	2.60
4	20%	1.1	2.16	2.66
5	25%	0.83	1.92	2.3

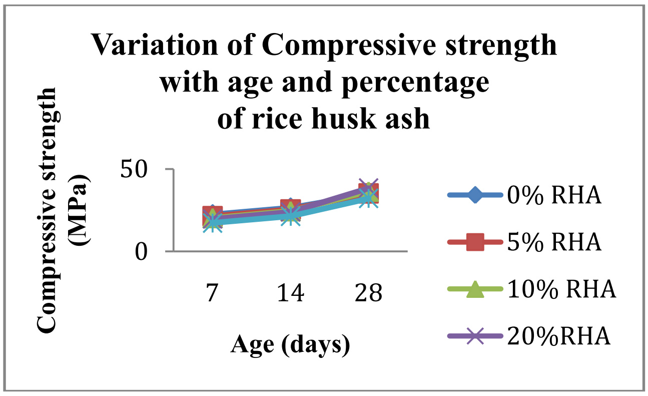

Fig 1 Effect of age on compressive strength of concrete w.r.t different % replacement of rice husk ash

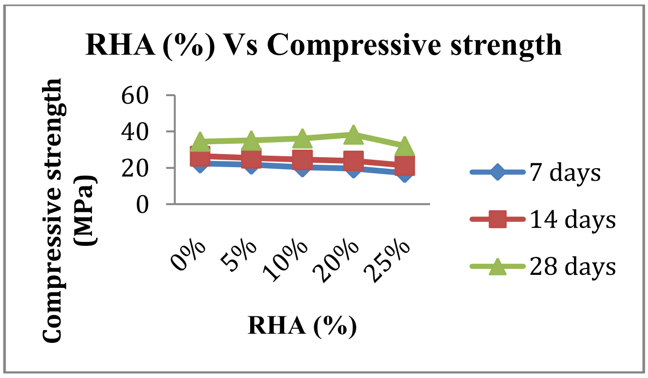

Fig 2 Effect of Rice Husk Ash percentage on compressive strength of concrete

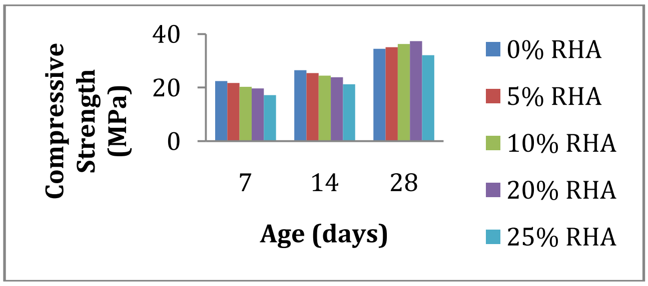

Fig 33 Comparison of Compressive Strength at different age w.r.t % RHA replacement

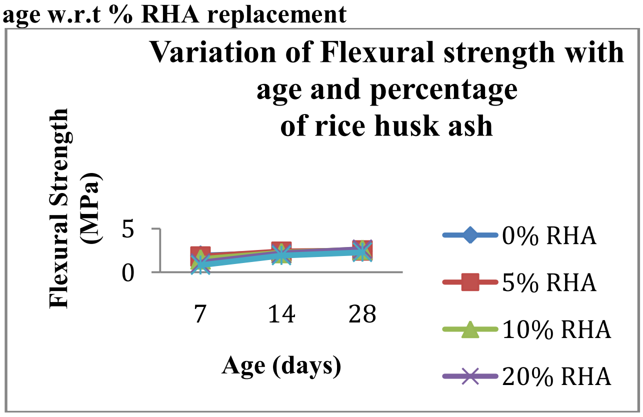

Fig 4 Effect of age on Flexural strength of concrete w.r.t different % replacement of rice husk ash

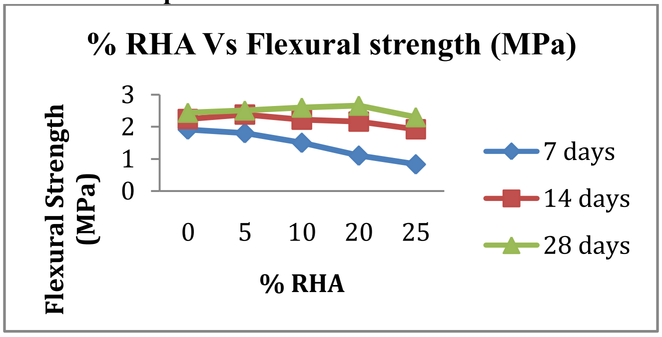

Fig 5 Effect of Rice Husk Ash percentage on Flexural strength of concrete

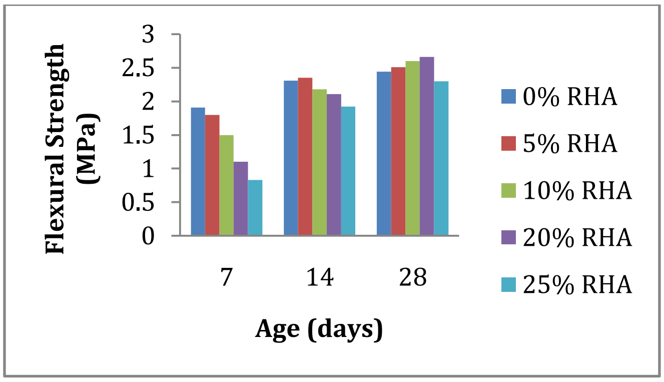

Fig 6 Comparison of Flexure Strength at different age w.r.t % RHA replacement

4.2 Discussion:

Compressive Strength

The detailed results for compressive strength including the average strength are given in table above and presented graphically in figures. However, the largest strength development noticed between 14 and 28 days, as can be seen from fig. The increase in strength may be due to the pozzolanic reaction and the presence of reactive silica in RHA or due to development of more C-S-H gel in concrete with RHA may progress the concrete properties due to the reaction among RHA and calcium hydroxide in hydrating cement. Comparison of the data for 28 days of curing age shows that the compressive strength of concretes with up to 20% RHA replacement attain values more than that of control concrete specimens due to the capacity of the pozollona of fixing the calcium hydroxide, generated during the reactions of hydrate of cement. But as we increase the percentage of rice husk ash [RHA] to 25% there is decrease in the compressive strength of the concrete at different ages as shows in the table and figures above.Therefore 20% of RHA can be identified as the optimum percentage to replace the cement in concrete.

Flexural Strength

The results of Flexural strength for mixes with different RHA replacement are shown in table and figures. By observing the results, it can be seen that strength development is about the same order as those in compression test. In other words, the flexural strength for both RHA and normal lining concrete will increase with age. At early age the flexural strength of RHA concrete decrease with the increase in the percentage replacement of RHA. At the age of 28 days it can be clearly seen that the flexural strength value increases with RHA content up to 20%. The flexural strength was higher than that in control mix at the age of 28 days. But as we increase the percentage of rice husk ash [RHA] 25% there is decrease in the flexural strength of the concrete at different ages of curing as shown in the table and figures above. Therefore 20% of RHA can be identified as the optimum percentage to replace the cement in concrete.

5. References:

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