Behaviour of Rice Husk Ash-based Concrete under Compression

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Abstract

This research work was experimentally carried out to investigate the effects of partially replacing Ordinary Portland cement (OPC) with our local additive Rice Husk Ash (RHA) which is known to be super pozzolanic in concrete at optimum replacement percentage which will help to reduce the cost of housing. Five different replacement levels namely 2.5%, 5%, 7.5%, 10% and 12.5% are chosen for the study concern to replacement method. A range of curing periods starting from 7 days, 14 days and 28 days are considered.RHA reduce the heat of hydration and increase the resistance to carbonation and also higher abrasion compared to control mortar specimens, considerable reduction in alkali silica and sulphate expansions. A replacement of 7.5% RHA concrete shows better strength properties comparatively.

Keywords: *Rice Husk Ash (RHA), Compression, Sulphate expansions*

I. INTRODUCTION

Concrete is a composite construction material made primarily with aggregate, cement and water. There are many formulations of concrete which provide varied properties and concrete is the most used man-made product in the world. Also there is a rapid growth in industrialization and construction field nowadays, so we require large amount of cement for this purpose. Rate of cement is high in order to prevent such crisis we have found an apt solution of using RHA in partial replacement instead of cement to improve the concrete properties.

The production and use of RHA in India should be considerably increased as RHA contributes significantly to a green building. It not only reduces the consumption of cement due to bleeding but also solves waste disposal problem. Here we have made five different replacement levels of RHA namely 2.5%, 5%, 7.5%, 10% and 12.5%.

Rice Husk Ash is obtained by burning rice husk in a controlled manner without causing environmental pollution. When properly burnt it has high Sio2 content and can be used as a concrete admixture. Rice Husk Ash exhibits high pozzolanic characteristic and contributes to high strength and high impermeability of concrete. Rice Husk Ash (RHA) essentially consists of amorphous silica (90% Sio2), 5% carbon, and 2% k2O. The specific surface of RHA is between 40-100 m2/g.

India produces about 122 million ton of paddy every year. Each ton of paddy produces about 40kg of RHA. There is a good potential to make use of RHA as a valuable pozzolanic material to give almost the same properties as that of microsilica. In U.S.A, highly pozzolanic Rice Husk Ash is patented under trade name Agro silica and is marketed. Agro silica exhibit super pozzolanic property when used in small quantity i.e., 10% by weight of cement and it greatly enhances the workability and impermeability of concrete. It is a material of future as concrete admixtures.

2. LITERATURE STUDY

In [1], finding a replacement for cement to assure sustainability is crucial as the raw materials (limestone, sand, shale, clay, iron ore) 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. From the various grade of concrete (Grade 30, 40, 50) studied, 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.

In [2], due to the pozzolanic reactivity, Rice Husk Ash (RHA) is used as supplementary cementing material in mortar and concrete and has demonstrated significant influence in improving the mechanical and durability properties of mortar and concrete. It has economical and technical advantages to use in concrete. In this paper, a critical review on the influences of RHA on the strength of mortar and concrete are mainly presented. In addition, properties and pozzolanic activity of RHA, advantages and disadvantages of supplementary use of RHA in mortar or concrete are mentioned here. Based on the available documented literature, it can be concluded that RHA could be used as supplementary cementing material up to a certain level of replacement (about 20-30% of binder) without sacrificing strength of concrete. Proper consumption of these RHA contributes in solving environmental pollution and production of cost-effective concrete; it can also play a vital role for the production of sustainable concrete.

In [3], Rice Husk Ash (RHA) is a pozzolanic material that can be blended with the Portland cement in concrete to obtain a better performance of normal concrete. This paper proclaims an experimental investigation on utilization of RHA for the concrete as it is a byproduct of brick-kilns in Sri Lanka. The results of three different replacement percentages of RHA in concrete (10%, 20% and 30% by mass of cement) were compared with the concrete that does not contain RHA. Those samples were tested for compressive strength, tensile strength, surface water absorption and for durability aspects. A comparative study on chemical composition and physical properties was carried out and the experimental results were discussed. A significant improvement on the compressive strength at early stage is identified and optimum strength was achieved at the 20% RHA replacement by mass of cement. The strength of the concrete with different sizes of RHA particles was compared to identify the effects of particle size of RHA. Around 50% of the RHA collected from the brick-kiln can be utilized for the concrete after proper grinding.

In [4], the study of structural characteristics and thermal performance of Rice Husk Ash (RHA) based sand cement blocks through an experimental investigation. Strength characteristics of the blocks were investigated by conducting laboratory experiments. Thermal behavior of the block was investigated by comparing the variation of indoor temperatures in two model houses constructed with the sand cement blocks and Rice Husk Ash (RHA) based sand cement blocks. It was found that the optimum compressive strength of RHA based cement sand block is achieved at 5% replacement level. The RHA based sand cement block make indoor environment more thermally comfortable than the sand cement block.

In [5], RHA is a by-product material obtained from the combustion of rice husk which consists of non-crystalline silicon dioxide with high specific surface area and high pozzolanic reactivity. It is used as pozzolanic material in mortar and concrete and has demonstrated significant influence in improving the mechanical and durability properties of mortar and concrete. This paper presents an overview of the work carried out on the use of RHA as partial replacement of cement in mortar and concrete. Reported properties in this study are the mechanical, durability and fresh properties of mortar or concrete.

In [6], Among the different existing residues and by products, the possibility of using rice husk ash in the production of structural concrete is very important for India. India is the second largest rice paddy cultivating country in the world. Both the technical advantages offered by structural concrete containing rice husk ash and the social benefits related to the decrease in number of problems of ash disposal in the environment have simulated the development of research into the potentialities of this material. The objective of the present investigation is to evaluate one type of commercially available RHA as supplementary cementitious material for cement and to evaluate the threshold limit of replacement of cement. The main aim of this work is to determine the optimum percentage (0, 5, 10, 15 & 20%) of RHA as a partial replacement of cement for M30 and M60 grade of concrete and also the effect of super plasticizer on mechanical properties. The physical properties of cement have to be determined and will be tabulated as given below. Ordinary Portland cement (OPC) of 53 grade obtained from single source is to be used in this investigation. The properties of cement tested as per IS: 4031-1988 are given in table 2 and is found to conform to various specifications of IS:12269-1987. Locally river sand is to be used as fine aggregate and also determine its specific gravity and fineness. Tests determining the Mechanical properties of concrete are to be determined using rice husk ash with different percentages.

In [7], India is a major rice producing country and the husk generated during milling is mostly used as a fuel in the boilers for processing paddy, producing energy through direct combustion and / or by gasification. About 20 million tones of Rice Husk Ash (RHA) is produced annually. This RHA is a great environment threat causing damage to the land and the surrounding area in which it is dumped. Lots of ways are being thought of for disposing them by making commercial use of this RHA. RHA can be used as a replacement for concrete (15 to 25%).This paper evaluates how different contents of Rice Husk Ash added to concrete may influence its physical and mechanical properties. Sample Cubes were tested with different percentage of RHA and different w/c ratio, replacing in mass the cement. Properties like Compressive strength, Water absorption and Slump retention were evaluated.

3. OBJECTIVES

To improve the strength and durability to the concrete

- To reduce the heat of hydration
- To decrease permeability of concrete
- To reduce water demand which in turn reduce the bleeding effect in the concrete
- To minimize the drying shrinkage

4. EXPERIMENTAL WORKS

4.1. Cube Casting

Casting is a manufacturing process by which a liquid material is usually poured into a mould, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mould to complete the process. Casting materials are usually metal or various cold setting materials that cure after mixing two or more components together; examples are epoxy, concrete, plaster and clay. Casting is most often used for making complex shapes that would be otherwise difficult or uneconomical to make by other methods. Figure 1 represents the Rice husk ash and Table 1 shows the properties of the materials used.

Figure 1 Rice Husk Ash

Table 1 Properties of Materials

Materials	Description of tests	Values
Cement	Specific gravity	3.9
	Normal consistency	34%
	Initial setting time	90 mins
Fine Aggregate	Specific gravity	2.7
	Fineness Modulus	4.17
Coarse Aggregate	Specific gravity	2.9
	Fineness Modulus	3.6

4.2. Compaction

The process of including a closer packing of the solid particles in freshly mixed concrete or mortar during placement by reducing the volume of voids, usually by vibration, centrifugation, tamping ,or some combination of these actions. Compaction is to eliminate the air bubbles and to obtain maximum density.

4.3. Curing

Curing is an important procedure that should always be used to prevent the evaporation of the water used to mix concrete, grout and mortar (which for ideal performance should be an amount as low as possible in comparison to the amount of cement or cementitious powder binder). Curing is done for the purpose of successfully maintaining moisture in freshly placed, set and slowly hardening concrete. Curing will depend upon the quality and long-term performance of the hardened concrete it, last for about 7 to 28 days from the time of setting.

4.4. Testing

Compressive strength is the capacity of a material or structure to withstand axially directed pushing forces. When the limit of compressive strength is reached, materials are crushed. Concrete can be made to have high compressive strength, (e.g.) many concrete structures have compressive strengths more than 50 MPa whereas a material such as soft sandstone may have a compressive strength as low as 5 or 10 MPa. Compressive strength is often measured on a universal testing machine; its capacity varies from 200 tons which is shown in Figure 2. Then the test results for each percentage are compared using the graph. Table [2, 3, 4, 5] presents the results of compressive strength and Figure [3,4,5,6] shows the graphical view of the results.

Figure 2 Compression Test

Table 2 Compressive Strength on Conventional Concrete

Mix M_{20}	Compressive Strength in N/mm²		
	Specimen 1	**Specimen 2**	**Average**
7 days	19.11	20	19.55
14 days	24.44	25.33	24.88
28 days	26.22	26.66	26.44

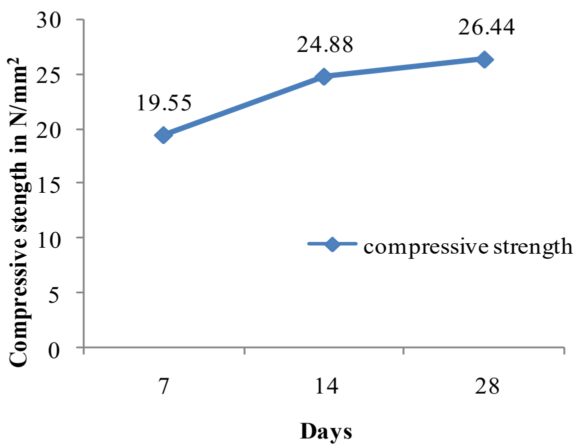

Figure 3 Compressive Strength in conventional concrete

Table 3 7-Days Compressive Strength

Mix M_{20}	Compressive Strength in N/mm^2		
	Specimen 1	**Specimen 2**	**Average**
RHA 2.5	12.8	13.77	13.32
RHA 5.0	18.66	19.11	18.88
RHA 7.5	19.55	20.44	19.99
RHA 10.0	18.22	21.33	19.77
RHA 12.5	14.66	15.55	15.10

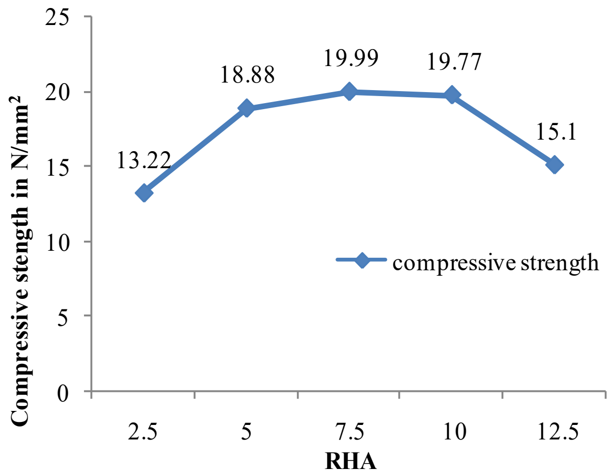

Figure 4 Compressive Strength in 7 days

Table 4 14-Days Compressive Strength

Mix M_{20}	Compressive Strength in N/mm^2		
	Specimen 1	**Specimen 2**	**Average**
RHA 2.5	16	16.88	16.44
RHA 5.0	20	21.33	20.66
RHA 7.5	22.66	23.55	23.10
RHA 10.0	20.44	21.77	21.11
RHA 12.5	16.44	18.22	17.33

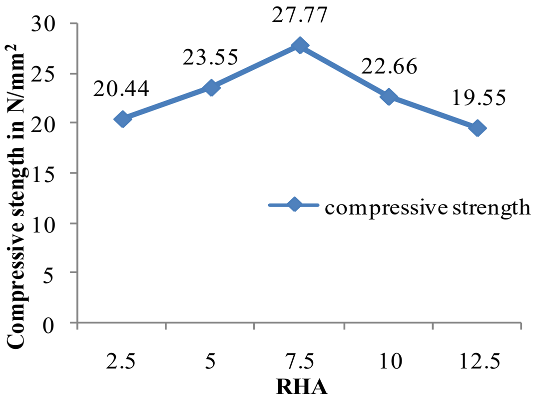

Figure 5 Compressive Strength in 14 days

Table 5 28-Days Compressive Strength

Mix M_{20}	Compressive Strength in N/mm²		
	Specimen 1	Specimen 2	Average
RHA 2.5	16	16.88	16.44
RHA 5.0	20	21.33	20.66
RHA 7.5	22.66	23.55	23.10
RHA 10.0	20.44	21.77	21.11
RHA 12.5	16.44	18.22	17.33

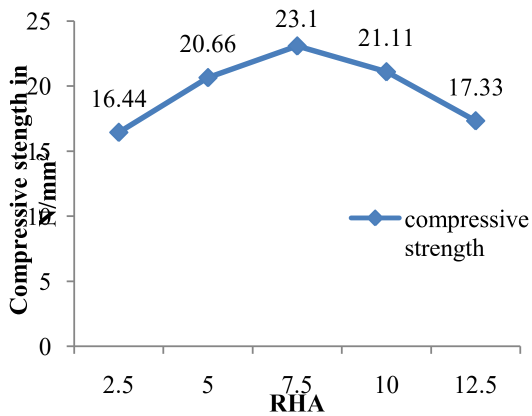

Figure 6 Compressive Strength in 28 days

CONCLUSION

The study has proved that the replacement of cement with 7.5% percentage of RHA shows better strength. Use of RHA in civil construction, besides reducing the environmental polluting factors and also may bring several improvements for the concrete characteristics. Use of Rice Husk Ash leads to enhanced resistance to segregation of fresh concrete compared to a control mixture with Portland cement alone. Also RHA can significantly reduce the mortar-bar expansion. Partial replacement of cement with RHA reduces the water penetration into concrete by capillary action.RHA replacement of cement is effective for improving the resistance of concrete to sulphate attack. There are huge amounts of RHA produced as by-product from the rice processing mills, mainly in developing countries, which are disposed to environment without any return price. Thereafter, disposal cost is increased in order to transport this ash; also a large land area becomes useless and the fertility of land is reduced. So the problem can be solved or minimized by properly utilizing the RHA through the production of cement or concrete. Because, RHA contains a large amount of silica and also exhibits excellent pozzolanic property. In fact incorporation of RHA either in cement or in concrete not only fulfills the demand of cement but also makes a role in production of durable concrete. The strength development of concrete produced with a particular level of RHA replacement is the same or higher as compared to OPC concrete.

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