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Mechanical Properties of Rice Husk Ash Based Concrete Composites

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Abstract

The production of rice is important all over the world. The husk that is made is usually used as a combustible material to prepare fields, giving energy through both direct combustion and gasification. The material rice husk ash may be quite fine. A common particle size for rice husk ash is 3 to 75 µm. This research demonstrates how the rice husk ash affects the mechanical properties of concrete composites. For this purpose, five different concrete mixes were used in this experimental program. All the concrete mixes were prepared by using rice husk ash as percentage replacement of cement. M30 grade of concrete was prepared with 0, 5, 10, 15 and 20 percent replacement of cement with rice husk ash. Fresh samples of various concrete mixtures were tested to determine the slump and mechanical properties of concrete. The compressive strength, split tensile and flexural strength of hardened samples were tested after 7, 28 and 56 days of curing. The results of the experimental observations showed that using RHA based concrete mixes increase the compressive, split tensile and flexural strength of concrete composites. The optimum utilization of rice husk ash was 20 percent. Additionally, the addition of RHA to concrete lowers the total amount of carbon that is embodied in the material, decreases costs, and makes use of agricultural waste.

Keywords: Composites, rice husk ash, concrete, compressive strength, split tensile, flexural strength, slump

INTRODUCTION

Concrete is the most often utilized composite material in the world, coming in second only to water. Every year, more than 25 billion of ton of concrete is manufactured, and a proportionally significant number of materials are used. And the industries of concrete have been identified as the business that consumes the most resources that are produced naturally. Aside from the loss of these resources, the manufacturing of Ordinary Portland cement (OPC), the principal binder is concrete, which is a substantial contribution to the carbon dioxide emissions induced by world's persons. Furthermore, greater carbon emissions from OPC manufacturing are projected as the demand for concrete/cement rises exponentially in the next years. As a result, there is an urgent need for the concrete sector to identify ways to cut emissions [1].

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Several approaches, such as fractional for entire alternate of OPC, waste materials used as an aggregate in concrete, using wastewater, and so on, have been investigated throughout the periods. The most important approaches to minimize the carbon content of concrete are to partially replace OPC with extra cementitious ingredients. The waste materials having pozzolanic and hydraulic capabilities are known as SCM. SCM such as class F and class C fly ash, pozzolanic, silica fume, GGBF slag, rice husk ash (RHA), and others which have been used as some substitute for decades. The SCM used in concrete also offers a channel for waste management, eliminating any negative environmental effect from their demolition. These SCM has various impacts on the initial and final (after strengthened) properties of concrete and alternative or replacement level also reported into concrete with these waste materials [2]. Compressive strength decreases after 28 and 56 days because to increasing porosity and fiber content, which affects specific mass. Tensile strength with diametrical compression peaks at 15% replacement at 28 days, suggesting procedural faults or other reasons may cause variations [3].

RHA, a form of SCM and agro-waste, is discovered to improve the mechanical and long lasting qualities of concrete. Because of its strong reactivity and silica concentration, RHA is a preferred SCM above fly ash and silica fume. RHA's strong reactivity is due to its vast facing area of surface and high concentration of unstructured and irregular form of silica [4]. Furthermore, it is important to acknowledge that the utilization of these materials plays a significant role in mitigating environmental harm and decreasing the utilization of traditional aggregates in road construction also, so contributing to the establishment of a more sustainable global environment [5]. Surface modification by chemically treating natural fibers like Sansevieria cylindrica with restricted alkali results in a good rubber interface, especially with 30% fibers of 10 mm [6].

This document compiles the findings of many investigations on the use of RHA in concrete in order to encourage further study and exploitation of RHA as a partial substitute for OPC. The aim of this study is to investigate the consequence of incorporating RHA into concrete, with an emphasis on the influence on the main mechanical characteristics of concrete. This assessment is expected to act as a guideline for numerous academics focusing on manufacture of the construction sector eco-friendlier for building materials. This evaluation also serves as a catalyst for many R & D by using Rice Husk Ash in concrete [7]. Nitrogen diffusion surface modification of molds and dies is useful in plastic injection. Electroerosion machining can machine complicated, intricate, and hard objects, making it useful in this field [8].

In emulsifying liquids, typical cutting fluids' disposal is a major drawback. These fluids pollute soil and water and harm operators. To extract heat with less environmental impact, better methods have been sought [9].

Rice husk ash (RHA) is a pozzolanic material that is very reactive and comes from burning rice husks. It is added to concrete composites to make the concrete better in a number of ways. There are a few important parts and processes in the chemistry of RHA-based concrete composites that enhanced performance. Pozzolanic reaction is the main chemical reaction in RHA-based concrete composites. Amorphous silica in RHA reacts with $Ca(OH)_2$ produced during Portland cement hydration. Calcium Silicate Hydrate (C-S-H) is formed by combining SiO_2 (from RHA) with $Ca(OH)_2$ and H_2O.Calcium Silicate Hydrate (C-S-H) is formed from SiO_2 (from RHA) and $Ca(OH)_2$.

Materials and Methods

In this study, the concrete composite material was prepared by cement, rice husk ash, coarse aggregate, fine aggregate and water. Mix design was done to maintain the slump value as 100 mm. M30 grade of concrete was prepared. The materials used in this study are given in brief.

Rice husk ash (RHA): Rice husk is a natural fiber. Rice husk burning took place in open air and remained uncontrolled for almost 48 hours. 400 to 6000 ˚C was the temperature range. The recovered ash was grey in color after being passed through a 75-m BS standard sieve. Volumetric batching was carried out with replacement percentages of 0, 5, 10, 15 and 20%.

Cement: When producing concrete, ordinary Portland cement of 53 grade was utilized.

Aggregates: The only material used in the project is sand from the river. The sand was collected to ensure that no hazardous substances were present. The aggregates used in this investigation have a maximum size of 20 mm. It was properly inspected to ensure that no dangerous materials were present.

Water: It is cleaned by filtration and chemical treatment after which it is free of germs, while it may still contain necessary mineral solutes.

Method of experiment: Water, cement, aggregates, and additives are the main ingredients in concrete. Full compaction must be achieved, the constituent materials must remain evenly distributed throughout the mass of the concrete during the various handling stages, and the consistency, mobility, and compatibility of the concrete must be in compliance with the applicable practices of the code.

TEST RESULTS AND DISCUSSION

Compressive Strength

Compressive strength of concrete is the most important property as all other mechanical qualities are connected to it. Earlier studies found that the concrete with no Rice Husk Ash has higher compressive strength in comparison to concrete with RHA at alternative amounts ranging from 20% - 30% [10]. Concrete having no SCM and silica fume as a 10% replace of OPC had a greater compacting or (tendency to compress) strength than concrete containing RHA at the equal replacement level [11]. However, Wada found that concrete containing RHA had a better compressive strength than concrete that does not include RHA. De Sensale also founded more compressive strength for 91 days. He also determined that a 20% OPC/RHA replacement level generated the maximum compressive strength. [12] According to Habeeb and Mahmud the maximal OPC replaced level with RHA should be 20%, as there may be negative impacts on the characteristics of concrete subsequent to this replaced level. It was discovered that a replaced level of OPC with RHA less than 5% was not sufficient to increase the initial time of compressive strength of concrete [13]. Kartni also proposed that an ideal level of OPC replacement with RHA be 10% since increasing the quantity of RHA reduced compressive strength [14].

In this study, compressive strength was examined for different percentage replacement of cement by rice husk ash. Figure 1 showed that compressive strength of concrete at 7, 28 and 56 days of testing. The test results showed that compressive strength increased with the percentage replacement of cement with RHA up to 15 percent then its value decreased. It was 15.9 %, 15.38 % and 15.32 % at higher than control mix at 7, 28 and 56 days of testing, respectively. Previous research on high strength concrete by Ismail and Waliuddin found similar findings when finer RHA was employed as an alternative for OPC [15].

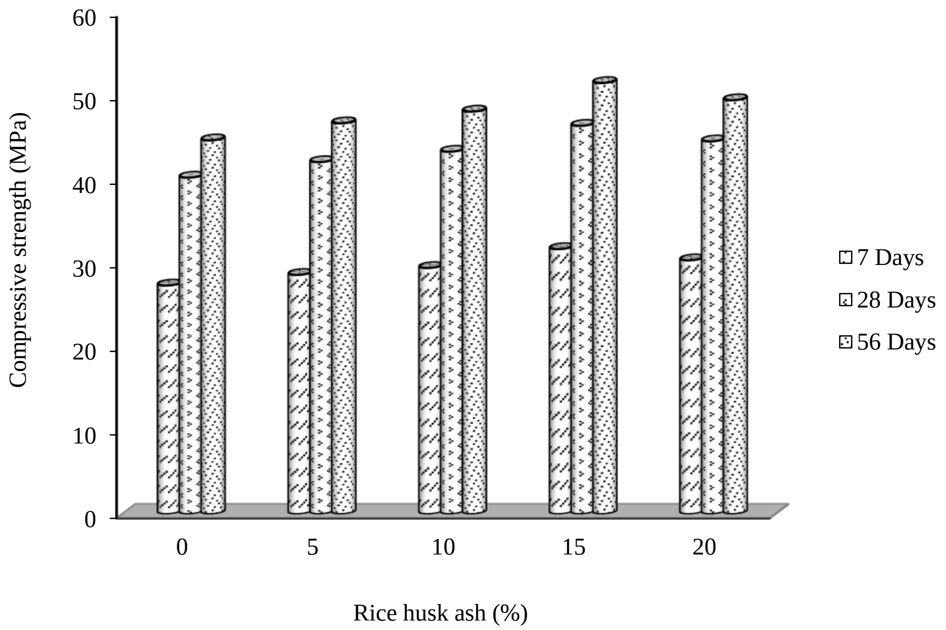

Figure 1. Compressive strength of rice husk ash concrete

Split Tensile Strength

Concrete has a high compressive strength but low tensile strength. However, improving concrete tensile strength is critical in situations at the point where load will exert a tension or elastic force on concrete specimen. The split tensile test is used to assess the tensile strength of concrete. RHA have higher split tensile strength when used as a partial substitute for OPC in concrete (12). The pozzolanic and filler action of RHA has been attributed to the increased tensile strength. Ramezanianpour et al. also found that substitution for OPC which increases tensile strength is by using RHA partially [16]. Foong [17] and Le[18] showed a rise in split tensile strength. The water-to-cement ratio was also shown to be important in this test of concrete including RHA as a restricted substitute for OPC (18).

In this study, split tensile strength was examined for different percentage replacement of cement by rice husk ash. Figure 2 showed that split tensile strength of concrete at 28 and 56 days of testing. The test results showed that split tensile strength increased with the percentage replacement of cement with RHA up to 15 percent. It was 6.20 % and 6.04 % at higher than control mix at 28 and 56 days of testing, respectively. From the experimental data, it was clear that rice husk ash could be utilized up to 20 percent in place of cement. Ganesan et al found the similar results, and concluded that replacing OPC with RHA increased split tensile strength by up to 20%. Although, this strength at 30% is found to be comparable with RHA free concrete [19].

Flexural Strength

It is also known as modulus of rupture, defined as capacity of concrete against deformation caused by bending. The split tensile strength mentioned above of concrete using RHA as a substitute for OPC was shows a relationship with its flexural strength. Talsania et al. found that RHA increased flexural strength to a 20 % OPC alternatives [20]. Although, other research by Baskar and Vinothan found that merely a 10% replacement level of OPC with RHA results in an incriment in flexural strength [21].

In this study, flexural strength was examined for different percentage replacement of cement by rice husk ash. Figure 3 showed that flexural strength of concrete at 28 and 56 days of testing. The test results showed that flexural strength increased with the percentage replacement of cement with RHA up to 20 percent. It was 7.46 % and 7.52 % higher than control mix at 28 and 56 days of testing, respectively. From the experimental data, it was clear that rice husk ash could be utilized up to 20 percent in place of cement.

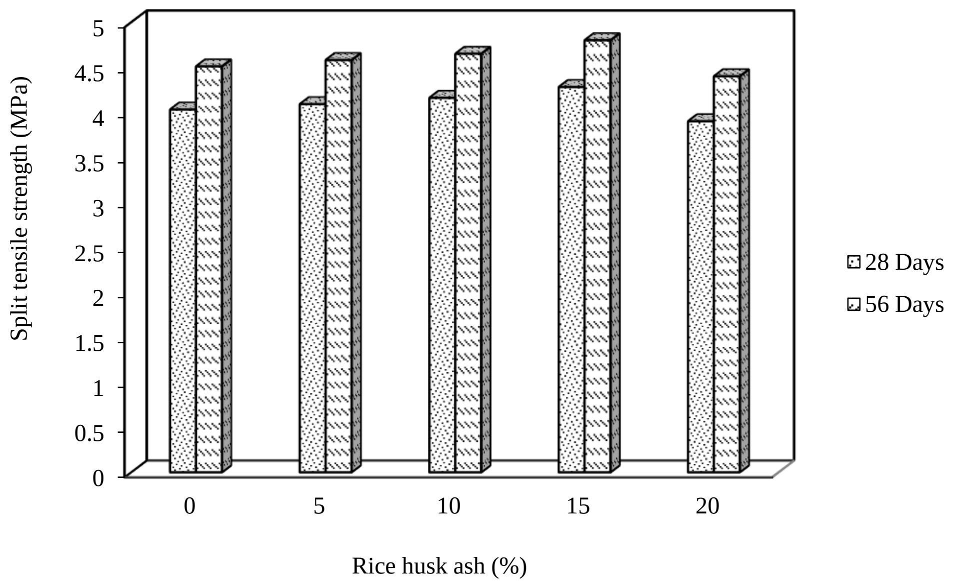

Figure 2. Split tensile strength of rice husk ash concrete.

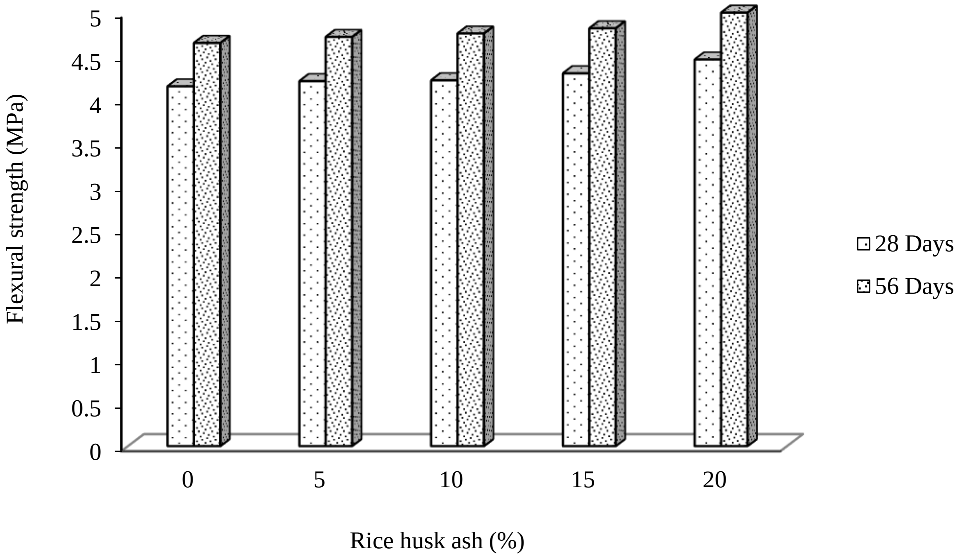

Figure 3. Flexural strength of rice husk ash concrete.

CONCLUSION

On the basis of experimental study, the following conclusions were made.

1. Replacing OPC in concrete with RHA improves both its initial and later age compressive strength.
2. It was observed that the optimum replacement level 15 % is recommended. The percentage increment of compressive, split tensile and flexural strength was 15.32, 6.04 and 7.52 respectively at this optimum level, at 56 days of testing.
3. The use of RHA as an alternative for OPC results in increased mechanical strength due to its pozzolanic and filler properties.
4. From experimental data, it was concluded that using RHA in concrete provides a means of managing ash of rice husk in a sustainable and effective manner.
5. Furthermore, using RHA as a substitute for OPC can result in significant cement savings. Saving of cement results in reduction in carbon dioxide, thus sustainable to environment.
6. More additional studies like shear, bending are required to understand the entire mechanical properties of concrete that incorporates RHA as an alternative for Ordinary Portland Cement.

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