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Effect of Chicken Feather Fibre and Rice-Husk Ash on the Mechanical Properties of Interlocking Mortar Blocks

Adetola Sunday Olufemi* & Adepoju Sunday Adedayo
Department of Mechanical Engineering
Ladoke Akintola University of Technology
Ogbomoso, Nigeria
Corresponding Author Email: *soadetola@lautech.edu.ng
*Phone Nos: +2348034889242, +2348150744829

ABSTRACT

Interlocking mortar blocks have gained significant attention in sustainable construction due to their inherent advantages, including reduced mortar requirements, enhanced stability, and ease of assembly. This research investigates the influence of incorporating agricultural waste materials, specifically Chicken Feather Fibre (CFF) and Rice Husk Ash (RHA), on the mechanical properties of interlocking mortar blocks. Concrete mix proportions were established with a mix ratio of 1:2:4 (cement-CFF and RHA), and a water-to-cement (w/c) ratio of 0.5. The mixtures, including ground chicken feather fibre (GCCF), RHA, and granite, undergone sieve analysis to determine particle size distribution in accordance with BS 812-103.1standards. Manual concrete mixing was carried out following the procedures outlined, and the resulting concrete mixes were poured into plastic molds and subsequently placed in a curing room at a temperature of 27 ± 5 ^{o}C. Selected samples were tested for compressive strength (CS), splitting tensile strength (STS) and water absorption capability. The study achieved its objectives of preparing and characterizing the CFF and RHA blended IMB and evaluating the splitting tensile strength, compressive strength and water absorption of concrete samples incorporating CFF and RHA.

Keywords: Sustainable construction, blended cement, CFF, RHA, interlocking mortar blocks

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1. INTRODUCTION

Blended cement is a type of cement that is produced by blending or mixing different supplementary cementitious materials (SCMs) with Portland cement clinker (ASTM C595). The purpose of using blended cement is to enhance specific properties of the final concrete or mortar, such as durability, workability, and sustainability (Becerra *et al*. 2022). Blended cement can also contribute to reducing the carbon footprint of the construction industry by utilizing waste materials and byproducts as SCMs (Barritt and Talbot, 2011).

Supplementary cementitious materials (SCMs) are soluble siliceous, alumino siliceous, or calcium alumino siliceous powders used as partial replacements of clinker in cements or as partial replacements of Portland cement in concrete mixtures which will in finely divided form in the presence of moisture react chemically with calcium hydroxide at ordinary temperature (ASTM C618-84). The increasing demand for cement is expected to be met by partial cement replacement (Coutinho, 2002). Ash from agricultural leftovers, which are typically classified as agro-residue, is found to exhibit pozzolanic qualities and has been employed in place of cement in the search for an alternative binder. This study aims to investigate the influence of incorporating Chicken Feather Fibre (CFF) and Rice-Husk Ash (RHA) on some selected mechanical properties of interlocking mortar blocks.

Previous studies explore different aspects of concrete technology, including the use of quarry rock dust (QRD) and steel fibers (SF) in geopolymer concrete, the development of structural lightweight aggregate concrete (SLWAC) using sintered fly ash aggregates (SFA), and the investigation of autoclaved aerated concrete (AAC) blocks made from industrial waste materials. The researchers conducted a comprehensive investigation with 18 different mix proportions, varying the QRD content (0-20%) and steel fiber inclusion (0.75% and 1.5%). The study found that the mechanical strength of GPC mixes without steel fibers increased with up to 15% QRD content at 28 days. However, further increases in QRD content resulted in a decrease in mechanical strength.

The addition of steel fibers enhanced compressive, tensile, and flexural strength, with an optimal mix observed at 15% QRD and 0.75% steel fibers. Also, Dhemla *et al*. (2023), focused on developing structural lightweight aggregate concrete (SLWAC) using sintered fly ash aggregates (SFA) with different binders, including Portland Pozzolana Cement (PPC), Ordinary Portland Cement (OPC), and Micro Fibre Cement (MFC). Pozzolans can be used as supplementary cementitious materials (SCM) or as mineral additives in Concrete. Several researchers have investigated the use of pozzolan such as rice husk ash, coal, fly ash, corn cob ash, wood ash, sawdust ash etc. to partially replace energy intensive Ordinary Portland Cement (OPC) in the production of concrete (Raheem and Kareem, 2017; Adesanya and Raheem. 2009; 2010; Raheem *et al*., 2012; Raheem and Adenuga, 2013).

The study investigates mechanical behaviors such as compressive strength, split tensile strength, flexural strength, and impact resistance at different water-cement ratios. Microstructure analysis was also conducted to validate the mechanical results. The study revealed that SLWAC made from OPC exhibited superior mechanical strength compared to PPC and MFC, attributed to faster hydration and early strength gain.

2. MATERIALS AND METHODS

Chicken Feather Fibre (CFF) and Rice Husk (RH) were obtained from Dayntee Poultry Farm in Ajasse-Ipo, Kwara State and a threshing site at Ogbomoso Oyo State, Nigeria, respectively. The findings focused on strength characteristics of the interlocking mortar block through trials involving different percentages of cement, ranging from 20% to 25%, in order to attain the maximum cement content for good strength. The CFF were washed under running water.

Thereafter, a 6% NaOH solution by volume was prepared and added to distilled water for further washing so as to remove the impurities completely. The treated and dried CFF were soaked in NaOH-distilled water solution for three hours and washed again properly under running water.

The CFF were then sun-dried for ten hours adopting the method of (Jagadeeshgouda *et al.* 2014). Finally, CFF was immersed in ethanol solution for 24 hours to sterilize and were sundried for 8 hours to absorb the residual moisture content. CFF were ground to fine particles using a Welay milling machine as used by Adetola *et al*. (2014) while RH were calcined to ash at temperature of 600 ^{o}C. The CFF powder, RHA and stone-dust were sieved to ensure uniform particle sizes using equipment like sieve size of 45μm and mechanical sieve vibrators. Mortar of different compositions were made from the mixture of cement (20-25 wt%), CFF powder (0-2.5 wt%), RHA (0-2.5 wt%) and stone –dust (75 wt%). The component were mixed thoroughly to form mortar based on cement-water ratio of 0.5. The mortar was poured into plastic mould and cured at 27 ± 5 ^{o}C for 7 to 28 days. The laboratory procedures involved a range of tests to assess the mechanical properties.

3. RESULTS AND DISCUSSIONS

3.1 Results of Particle Size Determination

Sieve analysis of stone-dust using different sieve sizes of 8mm, 4mm, 2mm, 1mm, 500micrometer, 400micrometer, 300micrometer, 200micrometer and 100micrometer were used to determine the particle size distribution in which the particle passing were 100%, 86%, 68%, 60%, 40%, 32.5%, 25%, 12.5% and 7.5% respectively. The result is further presented in Figure 1.

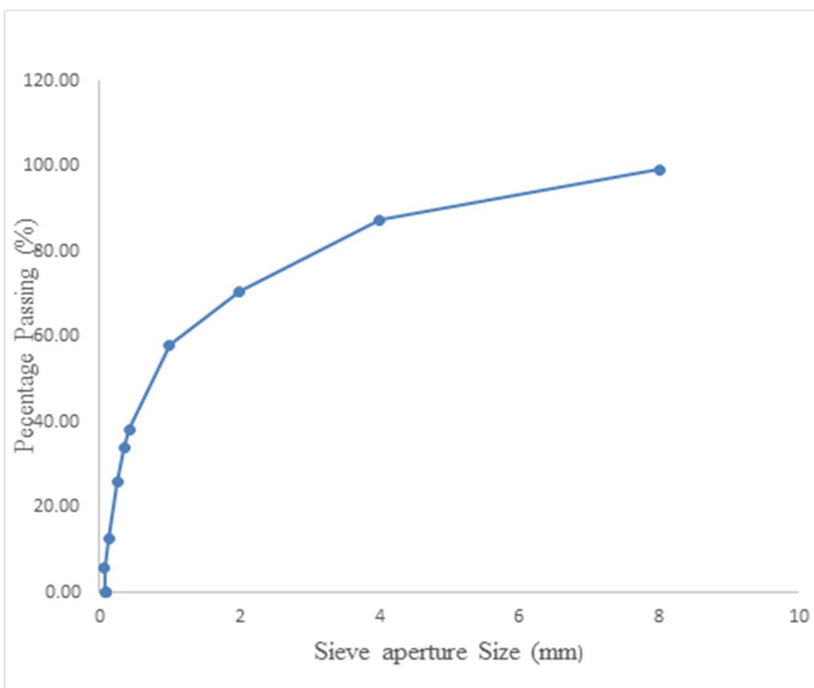

Fig 1: Sieve Analysis Of Stone-Dust Using Different Sieve Sizes

3.2 Results of Compressive Strength Test of IMB

The determination of compressive strength test of control and experimental samples were carried out on samples cured between 7 to 28 days and the results ranged from 2.2N/mm² to 3.9N/mm² for control. However, samples with 1% to 10% blended CFF and RHA have compressive strength ranged from 2.8N/mm² to 4.2N/mm², 3.2 N/mm² to 3.8N/mm², 3.1N/mm² to 3.8N/mm², 3.1N/mm² to 4.2N/mm², 2.2N/mm² to 4.3N/mm², 2.0N/mm² to 4.9N/mm², 1.9 N/mm² to 4.8 N/mm²,1.8N/mm² to 5.5N/mm², 1.8N/mm² to 5.9N/mm² and 1.7N/mm² to 6.5N/mm², respectively.

The implication of the results obtained is that further increase in percentage of CFF and RHA for the replacement of OPC reduces the compressive strength of the mortar blocks. The result is also presented in Figure 2.

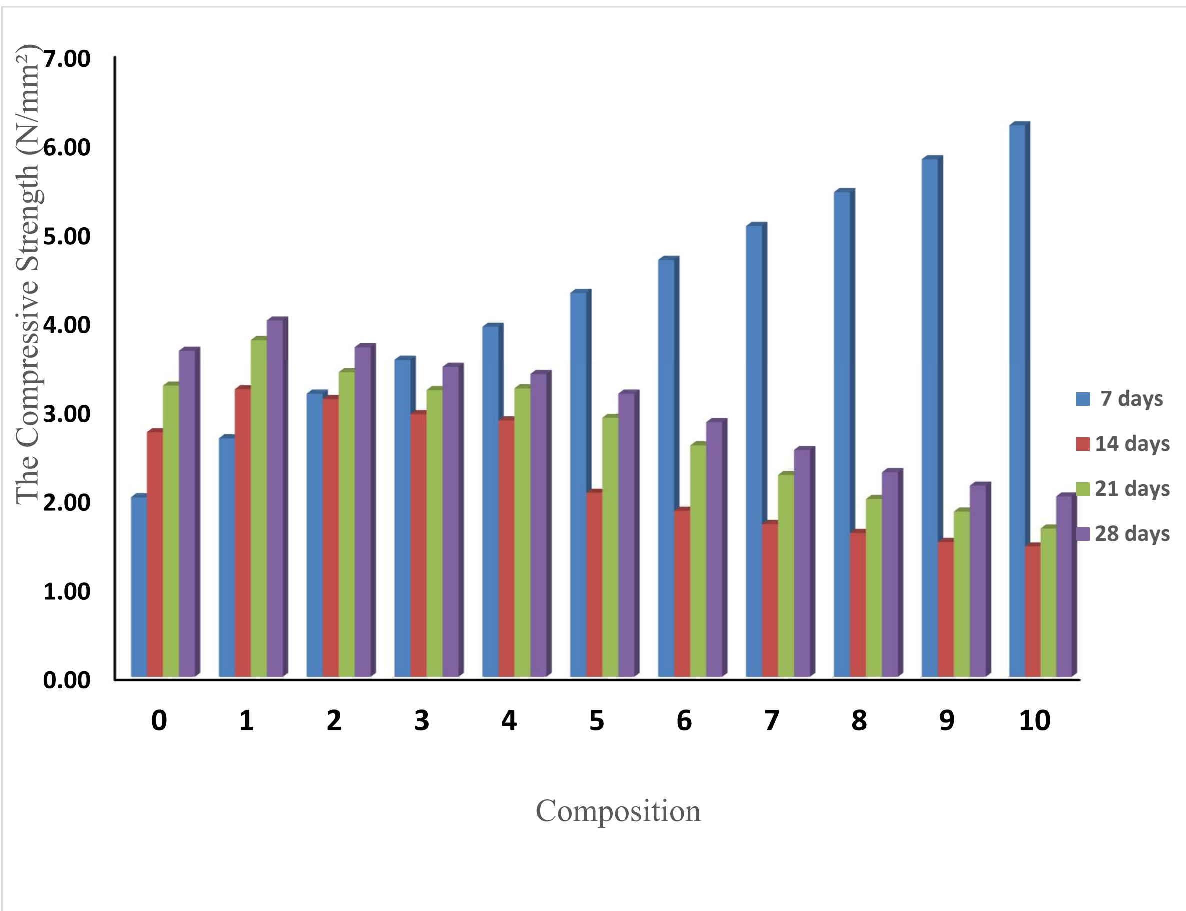

Figure 2: Graph of compressive strength of samples of IMB at different days of curing

3.3 Results of Splitting Tensile Strength Test of IMB

These ranges of results were obtained for the splitting tensile test for both the control with no blended CFF and RHA and experimental samples with 1% to 10% blended CFF and RHA as follow; 0.22N/mm² to 0.53N/mm² (control), 0.29N/mm² to 0.59N/mm², 0.28N/mm² to 0.57N/mm², 0.27N/mm² to 0.49N/mm², 0.22N/mm² to 0.39N/mm², 0.21N/mm² to 0.37N/mm², 0.18N/mm² to 0.33N/mm², 0.19N/mm² to 0.31N/mm², 0.16N/mm² to 0.28N/mm², 0.12N/mm² to 0.27N/mm² and 0.18N/mm² to 0.19N/mm², respectively.

Similarly, the results obtained showed that further increase in percentage of CFF and RHA for the replacement of OPC also reduces the splitting tensile strength of the mortar blocks. The result is also presented in Figure 3.

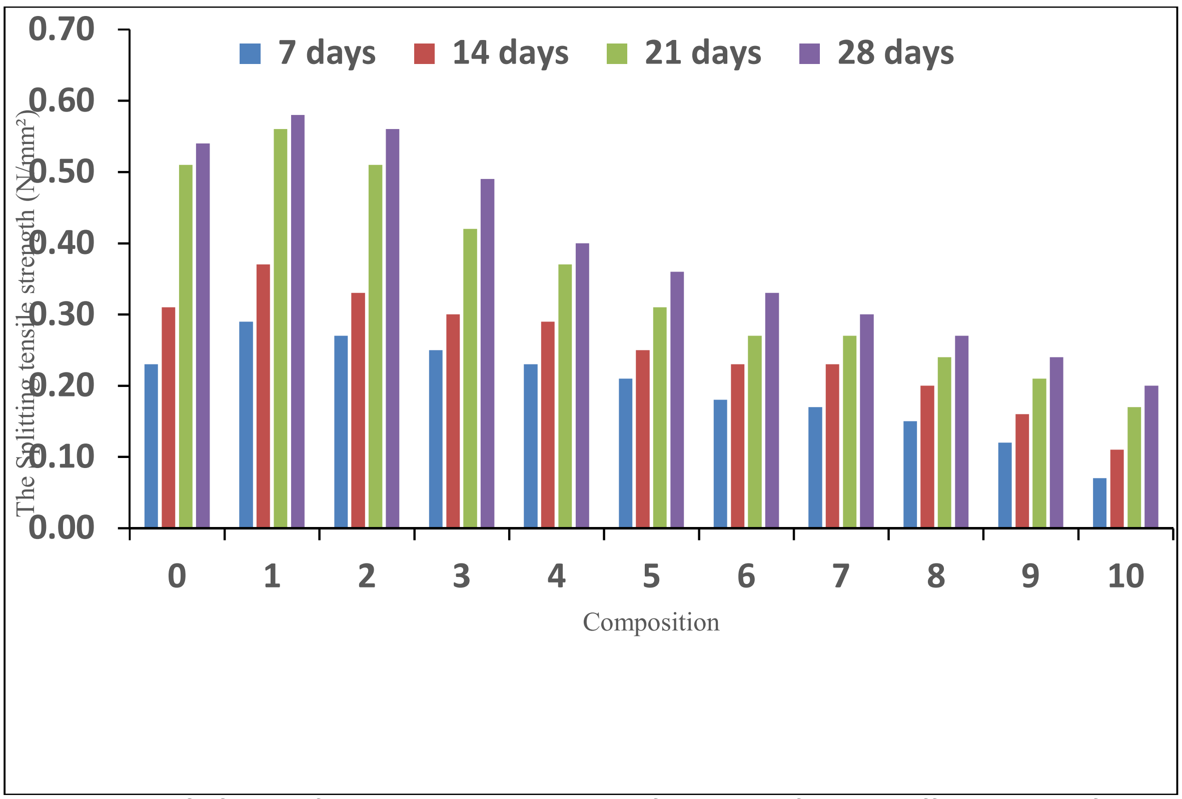

Figure 3: Graph of splitting tensile strength of samples of IMB at different days of curing

3.4 Results of Water Absorption Test of IMB

The determination of water absorption test of control and experimental samples were carried out on samples cured between 7 to 28 days and the results were as follow; 1.5%, 2.5%, 2.6%, 4.9%, 5.3%, 7.5%, 7.9%, 15.2%, 17.5%, 20.0% and 30.1% both for control with no blended CFF and RHA and experimental with 1% to 10% blended CFF and RHA, respectively as also presented in Figure 4.

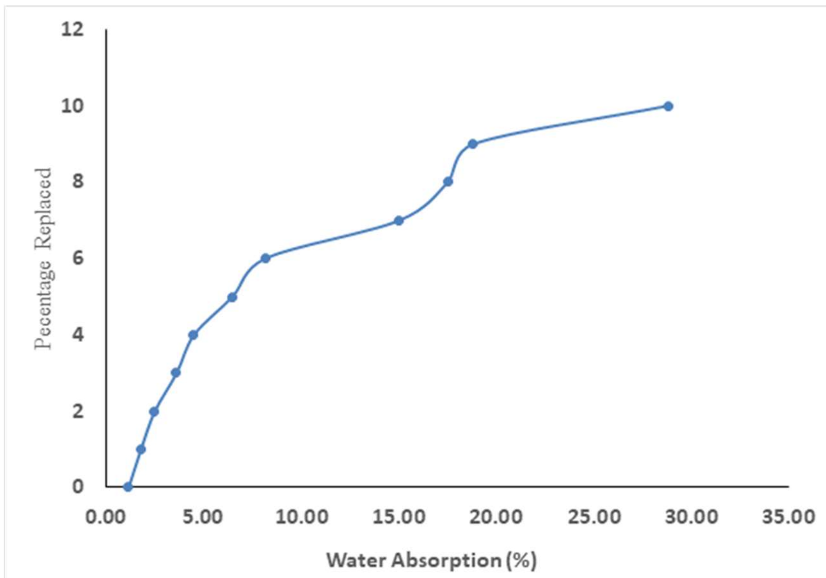

Figure 4: Graph of water absorption of samples of IMB with 0 – 10wt% of CFF and RHA

4. CONCLUSIONS

The results obtained from partial replacement of ordinary Portland cement (OPC) with blended CFF and RHA indicated some level of mechanical properties as present in the OPC. The tests carried out revealed the compressive strength, splitting tensile strength and water absorption for different CFF and RHA replacements. Each CFF and RHA proportion led to distinct values of strengths and absorption, demonstrating how the interlocking mortar blocks changed with increasing CFF and RHA content. Furthermore, the results highlighted the maximum percentage weight for different CFF and RHA additions. The analysis achieved the initial aim by providing the effects of partial replacement of OPC with CFF and RHA.

The samples exhibit higher compressive strengths with the inclusion of 1 to 10% CFF and RHA. However, samples exhibit lower splitting tensile strengths, necessitating reduced inclusion of CFF and RHA to 1 to 2% for maximum splitting tensile strengths. Similarly, samples exhibit lower water absorption capacity, requiring a reduction of the inclusion of CFF and RHA to 1 to 2% for good water absorption capacity. The addition of CFF and RHA influences the mechanical properties of the interlocking mortar blocks.

Summarily, the following conclusions were drawn from the study:

i. Samples of interlocking mortar blocks exhibiting compressive strength with addition of CFF and RHA ranges from 1% to 10% showcase promise for subgrade use.
ii. Samples of interlocking mortar blocks exhibiting splitting tensile strength with addition of CFF and RHA ranges from 1% to 2% display good characteristics for subgrade use.
iii. Samples of interlocking mortar blocks with addition of CFF and RHA for partial replacement of OPC may have inherent stabilizing property as possessed by OPC.

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