INVESTIGATION ON THE USE OF WOOD ASH AND COCONUT SHELL IN VARIOUS STRENGTH CONCRETE

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ABSTRACT

This study investigates the potential of utilizing wood ash and coconut shell as partial replacements for cement and coarse aggregate, respectively, in the production of concrete of varying strengths. The increasing environmental concerns associated with conventional concrete materials and the disposal of agro-industrial wastes have prompted the need for sustainable alternatives. The research aims to evaluate the mechanical performance and sustainability benefits of incorporating these waste materials into concrete. Mix designs were developed for concrete grades 15, 20, and 25, incorporating 5% wood ash and 15% coconut shell by weight. Workability, density, and compressive strength tests were performed at curing ages of 3, 7, and 28 days. The results indicated that concrete mixes containing these alternative materials exhibited lower slump values for grades 15 and 20, while grade 25 achieved a slump of 90 mm. Compressive strength increased with curing age and remained comparable to that of conventional concrete. The findings suggest that 5% wood ash and 15% coconut shell can be effectively utilized in structural concrete, promoting both sustainability and efficient waste management. It is recommended that these materials be considered for use in non-critical structural applications, especially in regions with abundant supply of such agro-wastes.

Keywords: Wood Ash; Coconut Shell; Concrete Grades; Compressive Strength

1 INTRODUCTION

Concrete remains the most widely used construction material globally due to its versatility, availability of raw materials, and relatively low cost. However, the production of its major constituents such as cement and natural aggregates has raised environmental concerns. Cement manufacturing contributes significantly to global carbon dioxide emissions, while the excessive exploitation of natural aggregates results in resource depletion and ecological imbalance [1]. In recent years, attention has shifted towards incorporating industrial and agricultural by-products into concrete production as partial replacements for cement and aggregates. This trend aligns with the global push towards sustainable construction practices and waste management. Among such by-products, wood ash and coconut shell have shown potential due to their pozzolanic and lightweight aggregate properties, respectively. Wood ash, a residue from the combustion of wood and wood products, contains silica, calcium, and alumina,

which are key components of cementitious materials [2]. Studies have shown that wood ash can enhance the durability and strength of concrete when used in appropriate quantities [3]. On the other hand, coconut shell, an agricultural waste abundantly available in tropical regions, has been identified as a potential lightweight aggregate. It offers reduced density and insulation properties, making it suitable for non-load-bearing and low-cost housing applications [4]. This study investigates the effects of partially replacing cement with wood ash and coarse aggregate with coconut shell in concrete of various strength grades (15 MPa, 20 MPa, and 25 MPa). The goal is to evaluate the resulting workability, density, and compressive strength of concrete mixes incorporating some proportions of these agro-waste materials. The use of wood ash and coconut shell not only reduces the environmental footprint of concrete production but also presents a cost-effective alternative for developing nations grappling with material scarcity and waste disposal challenges. By identifying the effect of the wood ash and coconut shell, this study contributes to the development of eco-efficient concrete and promotes sustainable construction technologies.

2 MATERIALS AND METHODS

2.1 Material

The key materials used in this study were Ordinary Portland Cement (OPC), fine aggregate (river sand), coarse aggregate (granite), wood ash, and coconut shell.

Cement: The binder material used for this experiment is Dangote Portland Cement of grade 42.5N conforming to the specifications of [5]. It was obtained from a local cement vendor at Sangere Futy, Girei LGA of Adamawa State, Nigeria.

Fine Aggregate: The research work was carried out using clean and air-dried river sand as the fine aggregates. These are smaller particles, typically less than 4 mm in size which was obtained at the River Benue at hayin gada, Girei L.G.A, Adamawa state, Nigeria.

Coarse Aggregates: These are larger particles, typically greater than 20 mm in size. The coarse aggregate was obtained from the local crushing zone in Girei L.G.A. of Adamawa State, Nigeria.

*Coconut Shell***:** A Coconut shell is collected from the local coconut sellers behind Jimeta Shopping complex, Adamawa State, Nigeria. It was crushed manually, and sieved to conform with coarse aggregate size distribution, then used as partial replace for the coarse aggregate.

Wood Ash: Wood ash is obtained from suya vendors which is opposite Yakubu shopping mall at Sangere Futy, Girei L.G.A., Adamawa State, Nigeria.

Water: Clean and potable water for mixing the concrete was obtained in Civil Engineering department of Modibbo Adama University, Yola for the research work.

2.2 Mix Design and Proportions

Concrete mixes were designed for three strength grades: 15 MPa, 20 MPa, and 25 MPa, in accordance with [6]. For each grade, cement was partially replaced by wood ash at 5%, while coarse aggregate was replaced by coconut shell at 15% by volume.

2.3 Batching, Mixing, and Casting

Concrete was batched by volume using standard laboratory equipment. Mixing was done manually on a clean concrete platform until uniformity was achieved. Fresh concrete was cast into 150 mm cube moulds in three layers with proper compaction using a tamping rod.

2.4 Curing

After demoulding at 24 hours, the specimens were transferred to a curing tank and submerged in water at room temperature for 3, 7, and 28 days, in accordance with [7].

2.5 Tests Conducted

The following standard tests were conducted: Slump Test: To determine workability using procedures from [8]. Density Test: Carried out on hardened concrete cubes at each curing interval. Compressive Strength Test: Performed in accordance with [9] using a compression testing machine. The average of three specimens per test age was recorded.

3 RESULTS AND DISCUSSION

3.1 Workability (Slump Test)

Concrete with 5% wood ash and 15% coconut shell in grade 15 and 20 shows a medium workability (Table 1). However, the slump value of 60mm for grade 25 shows a low workability for the concrete mix. This result is attributed to the irregular and rough surface texture of coconut shells and the fine particle size of wood ash, both of which increase water demand [10].

Table 1. Workability (Slump Test) Results

Grade of Concrete	Mix Ratio	Height of Cone (mm)	Slump Value (mm)
C15	1:2:4	300	100
C20	1:1.5:3	300	110
C25	1:1:2	300	60

3.2 Density of Concrete

The concrete density decreases across all strength grades. The reduction in density is primarily due to the lower specific gravity of coconut shell compared to coarse aggreagte [12]. This shows the potential of using coconut shell in the production of lightweight concrete, which is desirable for non-structural and low-load applications.

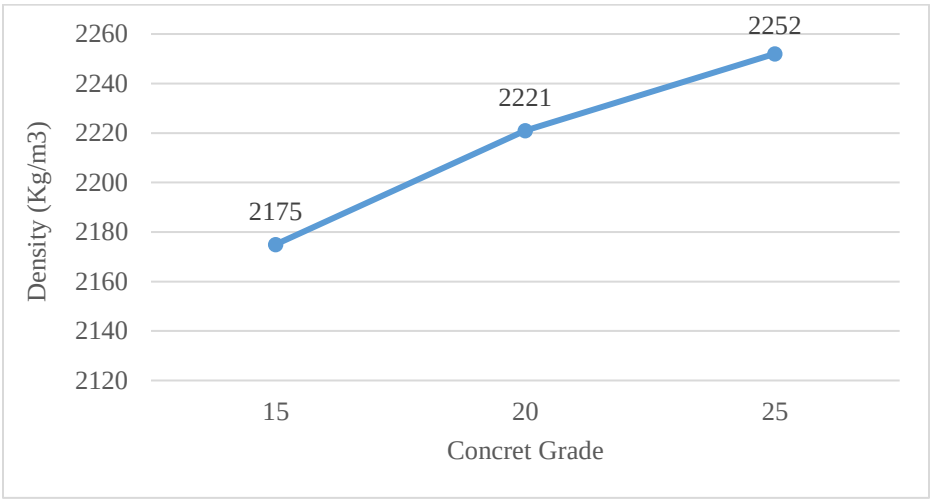

Figure 1. Density Results

3.3 Compressive Strength

Figure 2 show the compressive strength development at 3, 7, and 28 days for grades 15, 20, and 25 concrete mixes. Compressive strength increased with curing age, indicating ongoing hydration. Concrete with 5% wood ash and 15% coconut shell achieved up to 90–95% of the strength of the control mix at 28 days. The strength loss is due to the lower binding capacity of wood ash at high replacement and weaker interfacial bonding of coconut shells with the cement paste [13]. Nevertheless, mixes with moderate

replacement levels performed satisfactorily and may be used in low- to medium-strength concrete applications.

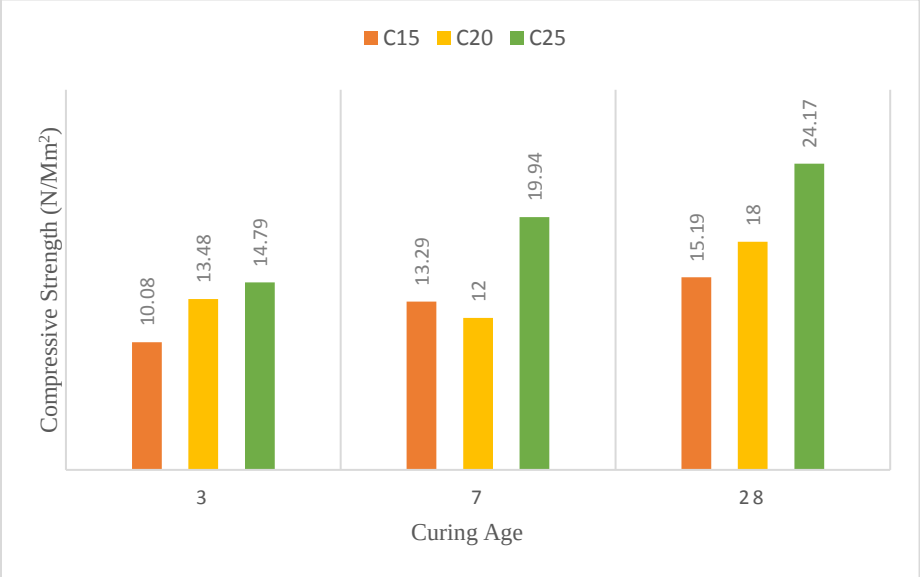

Figure 2. Compressive Strengths Test Result

4. CONCLUSIONS

This study investigated the influence of 5% wood ash and 15% coconut shell replacement on the properties of concrete grades 15, 20, and 25 MPa, focusing on workability, density, and compressive strength. Based on the experimental outcomes, the following conclusions are drawn: The workability of all concrete mixes was within acceptable ranges for construction use, with grades 15 and 20 exhibiting medium workability, while grade 25 recorded slightly lower slump but still remained workable without chemical admixtures. The density of the modified concrete showed a consistent decrease across all grades, with values approximately 8–10% lower than those of the control mixes; this density reduction classifies the concrete as lightweight, making it particularly suitable for applications where reduction in dead load is advantageous. The compressive strength of the concrete mixes incorporating 5% wood ash and 15% coconut shell remained satisfactory across all grades, with grade 15 achieving about 80–85% of the control strength, grade 20 reaching nearly 90%, and grade 25 maintaining high strength with only a marginal reduction, thus confirming the mix's suitability for structural and non-structural applications.

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