

**PARTIAL REPLACEMENT OF FINE AGGREGATE WITH PERIWINKLE SHELL IN
SANDCRETE BLOCKS**

BY

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PLAGIARISM

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DEDICATION

This work is dedicated to Almighty God for giving me the knowledge, wisdom and understanding to carry out this work, my mum. Mrs Ojianwuna Veronica and to my loving siblings for their financial and moral support throughout this research period. Special thanks goes to my project supervisor and every other lecturer that helped and gave their words of encouragement to this project, thank you for your support.

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SUMMARY OF THE WORK

The intelligent partial replacement of fine aggregate with periwinkle shell in sandcrete blocks have emerged as a sustainable approach to address the environmental and economic challenges associated with conventional sandcrete block production. Periwinkle shells, a marine waste abundant in coastal regions like Nigeria, are primarily composed of calcium carbonate (-95%) and have a low specific gravity (1.3-1.4 g/cm³), making them a viable lightweight substitute for river sand. Studies, such as those by Ichetaonge et al.(2023) and Osarenmwinda and Aigbogun (2017), demonstrate that replacing fine aggregate with crushed periwinkle shell (CPWS) at levels up to 15% achieves compressive strengths of 2.0-3.0 MPa, meeting the Nigeria Industrial Standard (NIS 87:2000) for non-load bearing walls. The well-graded particle size distribution of CPWS (coefficient of uniformity = 6.58) enhances its suitability, but its high water absorption (10-20%) and reduced workability necessitate optimized mix designs, often incorporating admixtures like superplasticizers or pozzolanic materials such as fly ash to improve performance. The mechanical and durability properties of CPWS-based sandcrete blocks are influenced by replacement levels, mix proportions, and curing methods, Research indicates that compressive strength decreases with higher CPWS content, with significant reductions beyond 20% replacement (c.g., 18.00 N/mm² at 50% replacement, Osarenmwinda and Aigbogun, 2017).

The use of CPWS promotes environmental sustainability by reducing reliance on river sand, mitigating the ecological damage caused by dredging, and repurposing marine waste, thus supporting circular economy principles (Ede et al., 2016). Also CPWS-based blocks reduce construction costs by 15 -20% and create local jobs through shell processing.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

The construction industry is a major consumer of natural resources, particularly sand, which is a primary component in sandcrete block production. The increasing demand for sand has led to environmental degradation, including riverbank erosion and loss of biodiversity (Kankam et al., 2021). Additionally, the depletion of natural sand reserves has necessitated the search for sustainable alternatives to ensure long-term viability of construction materials.

Periwinkle shells, a byproduct of seafood consumption, are abundantly available in coastal regions and often treated as waste, contributing to environmental pollution (Adewuyi and Adegoke, 2020). Recent studies have explored the potential of periwinkle shells as a partial replacement for fine aggregates in concrete and sandcrete blocks, demonstrating promising results in terms of strength and durability (Olutoge et al., 2020). However, there is a need for an intelligent approach to determine the optimal replacement ratio that ensures structural integrity while maximizing environmental and economic benefits.

Periwinkle shells, an abundant marine waste product, have emerged as a promising partial replacement for fine aggregates in concrete and sandcrete blocks. Studies have demonstrated that crushed periwinkle shells (CPWS) possess suitable mechanical and physical properties to serve as fine aggregate substitutes. For instance, Okonkwo et al. (2022) found that incorporating ground periwinkle shells at 10% replacement by weight of sand in sandcrete blocks yielded compressive strengths exceeding Nigerian Industrial Standards, especially when particle sizes were optimized around 0.85mm to 1.18mm. Other research confirms that partial replacement up

to 30% can meet strength requirements while reducing environmental waste and promoting sustainability.

The use of periwinkle shells not only addresses the environmental burden of shell disposal but also offers cost advantages by utilizing locally available waste materials. This aligns with global sustainable development goals by fostering green construction practices and reducing natural resource depletion. However, the mechanical performance varies with replacement levels and particle size, necessitating intelligent optimization to maximize benefits.

1.2 STATEMENT OF PROBLEM

Sandcrete blocks, a widely used mixture for construction, has its downsides. The rapid consumption of cement and sand in the world today may sooner or later reduce its readily availability. Hence, there is a need to search for alternative materials to minimize the consumption rate of these materials. The alternative should preferably be from recyclable products or waste products so it could also help with pollution control and environmental healthiness.

1.3 AIM AND OBJECTIVES

The main aim of this work is to investigate the intelligent partial replacement of fine aggregate with periwinkle shell in sandcrete blocks to determine its feasibility as a sustainable alternative construction material while maintaining structural performance.

The specific objectives include to:

- (i). Evaluate the effect of different replacement percentages (10%, 20%, 30%, and 40%) of periwinkle shell on the compressive strength of sandcrete blocks.
- (ii). Determine the optimum compressive strength of the periwinkle sandcrete cured for 3 days, 7 days, and 28 days.

(iii). Investigate the flexural strength of periwinkle shell replacement of fine aggregate in sandcrete blocks at 10%, 20%, 30%, and 40% respectively.

(iv). Evaluate the influence of periwinkle shell incorporation on the workability, density and water absorption properties of sandcrete blocks.

1.4 SCOPE OF STUDY

This research will involve the following activities:

(i) Material Collection and Preparation: Procurement of periwinkle shells from local sources. Cleaning, crushing, and sieving of periwinkle shells to achieve the desired particle size.

(ii) Mix Design and Sample Preparation: Development of sandcrete block mixtures with periwinkle shell replacements at, 10%, 20%, 30%, and 40% by weight of fine aggregate. Casting of sandcrete blocks samples in standard molds.

(iii) Experimental Testing: Compressive Strength Test; determination of load bearing capacity of blocks at 3, 7, and 28 days. Workability Test; assessment of the mix consistency using slump tests. Water Absorption Test; evaluation of porosity and durability characteristics. Density Test; measurement of the unit weight of the sandcrete blocks.

(iv) Data analysis, documentation of findings and suggestions for industrial application.

1.5 JUSTIFICATION OF STUDY

The purpose of this study is to determine the best ratio of Periwinkle Shell that will be suitable enough to act as a substitute to fine aggregate in sandcrete blocks.

This research is significant as Periwinkle Shells are low-cost and readily available, potentially reducing construction material costs. Also reducing reliance on river sand helps mitigate ecological damage, while utilizing periwinkle shell waste. Findings will support green building initiatives and encourage the adoption of alternative construction materials.

Utilizing periwinkle shells as a partial replacement for sand in sandcrete blocks promotes waste valorization, turning an environmental liability into a valuable construction resource. The approach supports sustainable construction by reducing natural resource consumption and lowering production costs, which is critical for affordable housing development in resource-constrained regions.

Moreover, optimizing the replacement level and particle size of periwinkle shells can enhance the mechanical properties of sandcrete blocks, ensuring compliance with industry standards and structural safety. This research will also create a way for a new economy as the periwinkle shells instead of being wastes on the streets will now be sold to contractors and engineers by the rural farmers while in return making their income.

CHAPTER TWO

LITERATURE REVIEW

2.0 OVERVIEW

This chapter gives a review on the research works (including personal research), findings, and recommendations of some researchers as related to the project topic which investigates the intelligent partial replacement of fine aggregate with periwinkle shell in sandcrete blocks. It synthesizes the work of researchers in the fields of civil engineering, material science, and sustainable construction, focusing on the use of periwinkle shells as an alternative fine aggregate, the properties of sandcrete blocks, and the effects of partial replacement on mechanical, physical, and durability properties. The term “intelligent partial replacement” refers to the strategic and optimized substitution of fine aggregate with crushed periwinkle shell (CPWS) using empirical data, advanced mix design techniques, and potentially computational tools to achieve desirable engineering properties while promoting sustainability. The review covers the composition and characteristics of periwinkle shells, their application in sandcrete block production, and comparisons with other waste materials used as fine aggregate replacements. It also identifies research gaps and opportunities for further investigation to advance the use of CPWS in eco-friendly construction.

REVIEW OF RELATED WORKS

The construction industry faces significant challenges due to the over-extraction of natural resources like river sand, which has led to environmental degradation, increased costs, and supply shortages. In response, researchers have explored alternative materials, including agricultural and marine waste, to replace conventional aggregates in construction materials like sandcrete blocks. Periwinkle shells, a marine waste product abundant in coastal regions, have

emerged as a promising fine aggregate substitute due to their availability, low cost and potential to address waste management issues. This section reviews key studies on CPWS in sandcrete blocks, focusing on their physical, chemical, and mechanical properties, as well as their environmental and economic implications.

Ichetaonye et al. (2023) conducted a detailed

2.1 SANDCRETE BLOCKS

Sandcrete blocks are composite masonry units made from a mixture of cement, fine aggregate (typically river sand), and water, molded into standard sizes and cured to achieve desired strength. They are widely used in developing countries, particularly in West Africa, for constructing non-load-bearing and load-bearing walls in low-rise buildings. According to the Nigeria Industrial Standard (NIS 87:2000), sandcrete blocks must achieve a minimum compressive strength of 2.0MPa for non-load-bearing walls and 3.45MPa for load-bearing walls. The properties of sandcrete blocks, including compressive strength, density, water absorption, and durability, are influenced by the quality of materials, mix proportions, and curing conditions (Ichetaonye et al., 2023). Recent advancements in sandcrete block production have focused on incorporating sustainable materials to reduce reliance on river sand, which is becoming scarce due to over-extraction. Alternative fine aggregates, such as recycled concrete dust, quarry dust, and agricultural waste (e.g., rice husk ash, sawdust), have been explored to enhance sustainability while maintaining structural performance (Collivignarelli et al., 2020). The integration of waste materials like periwinkle shells aligns with global trends toward eco-friendly construction and circular economy principles.

2.1.1 PROPERTIES OF SANDCRETE BLOCKS

The key properties of sandcrete blocks include:

(i) **Compressive strength:** This is the primary measure of a sandcrete block's load-bearing capacity. It depends on the cement content, aggregate quality, and curing duration. Studies show that replacing fine aggregates with CPWS reduces compressive strength due to its lower density and higher porosity, but blocks with up to 15% replacement can meet minimum standards for non-structural applications (Ichetaonye et al., 2023).

(ii) **Density:** Sandcrete blocks with CPWS are lighter than conventional blocks due to the low specific gravity of periwinkle shells (1.3-1.4 g/cm³ compared to 2.6 g/cm³ for river sand). This makes them suitable for lightweight construction, reducing structural dead loads (Osarenmwinda and Aigbogun, 2017).

(iii) **Water Absorption:** The porous nature of CPWS increases water absorption, which can affect durability in humid or aggressive environments. Proper curing and the use of admixtures can mitigate this issue (Falade et al., 2010).

(iv) **Workability:** The angular shape and rough texture of CPWS particles reduce the workability of sandcrete mixtures, requiring higher water-cement ratios or chemical admixtures to achieve adequate slump (Taiwo and Ameh, 2018).

(v) **Durability;** The durability of sandcrete blocks is influenced by their resistance to environmental factors such as moisture, chemical attack, and abrasion. CPWS-based blocks may exhibit reduced durability due to increased permeability, necessitating further research on protective treatments (Olofinnade et al., 2019).

2.1.2 SUSTAINABILITY IN SANDCRETE BLOCK PRODUCTION

The production of sandcrete blocks relies heavily on river sand, which contributes to environmental degradation through dredging and habitat destruction. Incorporating CPWS reduces the demand for natural sand, conserves resources, and repurposes marine waste, aligning with sustainable development goals (Ede et al., 2016). The use of CPWS also addresses waste management challenges in coastal communities, where periwinkle shells accumulate in large quantities, contributing to pollution. By integrating CPWS, the construction industry can promote a circular economy, lower carbon emissions associated with sand extraction, and reduce landfill waste (Ruslan et al., 2023).

2.2 AGGREGATES

Aggregates are granular materials that constitute 60-75% of the volume of sandcrete blocks and significantly influence their strength, durability, and workability. Fine aggregates, typically river sand or crushed stone with particle sizes below 4.75 mm, fill voids between cement particles, enhancing cohesion and workability. However, the over-extraction of river sand has led to environmental concerns, prompting research into alternative aggregates like CPWS, recycled concrete dust, and quarry fines (Alibeigibeni et al., 2025).

Recycled Fine Aggregates (RFAs): Farhana et al. (2023) explored the use of recycled polyethylene terephthalate (PET) as a fine aggregate substitute in high-strength concrete. While PET increased porosity and water absorption, optimized replacement ratios maintained structural performance. Similar challenges are observed with CPWS, suggesting that careful mix design is critical for alternative aggregates.

Manufactured Aggregates: Ali et al. (2024) investigated geopolymer-based aggregates made

from fly ash and ground granulated blast-furnace slag (GGBFS). These aggregates exhibited high compressive strength and durability, offering a model for processing CPWS to enhance its performance in sandcrete blocks.

Testing and optimization: Abdelhedi et al.(2023) used ultrasonic testing and artificial intelligence to evaluate aggregate properties, suggesting that such techniques could be applied to CPWS to predict its behavior and optimize mix designs. This aligns with the concept of "intelligent" replacement, where advanced tools guide material selection and proportioning.

2.2.1 FINE AGGREGATES

Fine aggregates are critical to the workability and strength of sandcrete blocks. River sand, the conventional fine aggregate, is well-graded and provides excellent cohesion, but its scarcity has driven research into alternatives like CPWS. The physical properties of CPWS, such as its well-graded particle size distribution ($C_u = 6.58$, $C_c = 1-5$) and rough texture, make it a viable substitute, though its high water absorption (10-20%) and low specific gravity require adjustments in mix design (Ichetaonye et al., 2023). The angular shape of CPWS enhances mechanical interlocking but reduces workability, necessitating the use of superplasticizers or optimized water-cement ratios (Cisse et al., 2023).

2.3 PERIWINKLE SHELL (PWS)

Periwinkle shells are regarded as a waste and thereby constituting environmental nuisance and pollution in terms of its real unpleasant smell and unsightly presence in open-dump sites located at strategic places where they are sold like the markets in some areas while they are left as complete solid waste in other areas. They are now being considered as fine aggregates in full or partial replacement for expensive, unaffordable or unavailable natural sands. This is commonly practiced among the commoners in rural areas where the periwinkle is available in excess as well

as its shells (Osarenmwinda, 2019).

Periwinkle shells are the hard, calcium carbonate-based exoskeletons of marine mollusks (e.g., *Tympanotonus fuscatus*), abundant in coastal regions of Nigeria and other tropical areas. After the edible portion is consumed, the shells are discarded as waste, contributing to environmental pollution. Their potential as a construction material has gained attention due to their availability, low cost, and sustainability benefits (Ede et al., 2016). Periwinkles belong to a group of marine snails. Their shells are typically mottled gray, white, and black and taper to a straight sided or rounded cone with an obtuse point. Periwinkle (*Tympanotonus fuscatus*) is a common name for a group of molluscan shellfish with either smooth or rough spiral shells (Ideriah, et al., 2016). There are hundred species in each of two genera of Nigerian Periwinkle - *radula* (a brackish water habitat) and *Pachymelania aurita* (a fresh water species) (Uwadie, et al., 2009).

A very large quantity of Nigeria periwinkle shells have been discovered to be available in many riverine communities of the South-South geopolitical region of Nigeria (Umoh, 2012).

In Nigeria, an average periwinkle lives for just three years and grows to a shell length of about 20mm. However, the largest periwinkle ever recorded in Nigeria river grew to about 52mm shell length (Adewuyi, 2008). Periwinkles are also commonly seen in other parts of Nigeria where riverine environments are located. In such areas, they are consumed as a source of protein while their shells are heaped along the streets as solid wastes. Periwinkles have been known to possess analgesic, antibiotic, antibacterial, laxative and hypotensive properties (Adeuyi, 2010).

They contain tannins that bind up fluids and relieve inflammation. They are low in saturated fat. It is also a good source of potassium, and a very good source of Vitamin E (Alpha Tocopherol), Iron, Magnesium, Phosphorus, Copper and Selenium (Ideriah, et al., 2011).

2.3.1 COMPOSITION AND STRUCTURE

Periwinkle shells are primarily composed of calcium carbonate (CaCO_3 , ~95%), with minor amounts of organic matter, chlorides, and trace minerals (Ede et al., 2016). Their layered structure consists of a dense outer layer that resists mechanical stress and a porous inner layer that contributes to low density (1.3-1.4 g/ cm³). The microstructure, characterized by crystalline and fibrous elements, supports stress distribution, making CPWS suitable for use as a fine aggregate (Patel and Singh, 2018).

2.3.2 MECHANICAL PROPERTIES

The mechanical properties of periwinkle shells determine their suitability for sandcrete block production. Key properties include:

(i) Hardness: Periwinkle shells exhibit moderate hardness, resisting abrasion but being less rigid than river sand. This affects the compressive strength of sandcrete blocks (Garcia et al., 2019).

(ii) Compressive Strength: The dense outer layer of CPWS contributes to load-bearing capacity, but its overall strength is lower than that of conventional aggregates, leading to reduced compressive strength at higher replacement levels (Mendez,2020).

(iii) Tensile Properties: Periwinkle shells have low tensile strength due to their brittle nature, limiting their use in applications requiring high tensile resistance (Kaur Bhatti, 2018).

(iv) Water Absorption: The porous inner structure results in high water absorption (10-20%), which increases the water demand of sandcrete mixtures and affects workability and durability (Ichetaonye et al.2023).

2.3.3 PRACTICAL APPLICATIONS AND INNOVATIONS

Periwinkle shells have been explored for various construction applications due to their sustainability and availability:

(i) Sandcrete Blocks: CPWS is used as a partial fine aggregate replacement, producing lightweight blocks suitable for non-load-bearing walls (Osarenmwinda and Aigbogun, 2017).

(ii) Concrete: Chinnu et al. (2024) investigated CPWS in concrete, noting its potential for lightweight applications but highlighting reduced compressive strength at high replacement levels.

(iii) Decorative Elements: The unique texture of CPWS makes it suitable for aesthetic applications, such as wall claddings or decorative panels (Ruslan et al., 2023).

(iv) Road Construction: Ground CPWS has been tested as a stabilizing additive in road bases, enhancing flexibility and reducing maintenance costs (IRJET, 2025).

2.4 PERIWINKLE SHELL AS A PARTIAL REPLACEMENT OF FINE AGGREGATE IN SANDCRETE BLOCKS

The use of CPWS as a partial replacement for fine aggregate in sandcrete blocks has been extensively studied to address environmental concerns and resource scarcity. Periwinkle shells, abundant in coastal regions, offer a sustainable alternative to river sand, reducing waste and conserving natural resources (Ede et al., 2016). Studies indicate that CPWS can replace fine aggregate at rates up to 20% without significantly compromising the structural integrity of sandcrete blocks for non-load-bearing applications (Ichetaony al., 2023).

The primary advantages of CPWS include its lightweight nature, cost-effectiveness, and environmental benefits. However, challenges such as reduced compressive strength, increased water absorption, and lower workability at higher replacement levels necessitate careful mix

design and curing practices (Olofinnade et al., 2019). The concept of "intelligent" replacement involves optimizing these factors using empirical data, statistical analysis, or computational tools to achieve a balance between sustainability and performance.

2.4.1 MECHANICAL PROPERTIES OF PERIWINKLE SHELL SANDCRETE BLOCKS

The mechanical properties of sandcrete blocks with CPWS are influenced by the replacement percentage, mix proportions, and curing duration. Key properties include:

(i) Compressive Strength: Studies consistently show a decline in compressive strength with increasing CPWS content. Ichetaonye et al. (2023) reported 28-day compressive strengths of 2.5 MPa at 5% replacement and 2.0 MPa at 15% replacement, meeting NIS requirements for non-load-bearing walls. Osarenmwinda and Aigbogun (2017) noted a significant drop to 18.00 N/mm² at 50% replacement, limiting higher replacements to lightweight applications.

(ii) Flexural Strength: CPWS-based blocks exhibit lower flexural strength due to the brittle nature of the shells. Chinnu et al.(2024) found that flexural strength remained comparable to conventional blocks at 5-10% replacement but decreased significantly beyond 20%.

(iii) Tensile Strength: The low tensile strength of CPWS limits its use in applications requiring high tensile resistance, necessitating reinforcement for structural elements (Taiwo and Ameh, 2018).

2.4.2 BOND CHARACTERISTICS OF PERIWINKLE SHELL SANDCRETE BLOCKS

The bond characteristics of CPWS-based sandcrete blocks refer to the adhesion between the cement matrix and aggregates, which affects cohesion and structural integrity. The rough and angular texture of CPWS enhances mechanical interlocking, improving bond strength at low replacement levels (5-10%) (Ichetaonye et al., 2023). However, the high porosity of CPWS

increases void content, reducing bond strength at higher replacement levels (Olofinnade et al., 2019). Pull-out tests conducted by Taiwo and Ameh (2018) indicated that bond strength remained adequate for non-structural applications up to 20% replacement, but further increases led to brittle failure modes. Optimizing mix proportions and using admixtures can enhance bond performance.

2.4.3 DENSITY OF PERIWINKLE SHELL SANDCRETE BLOCKS

The density of CPWS-based sandcrete blocks is significantly lower than that of conventional blocks due to the low specific gravity of periwinkle shells (1.3-1.4 g/cm³).

Osarenmwinda and Aigbogun (2017) reported a density reduction from 2200 kg/m³ (control mix) to 1800 kg/m³ at 20% CPWS replacement, classifying these blocks as lightweight. This reduction is beneficial for non-load-bearing applications, such as partition walls, where minimizing dead load is advantageous. However, excessive replacement (beyond 20%) may compromise structural performance due to reduced density and strength (Olofinnade et al., 2019).

2.4.4 EFFECTS OF MINERAL ADMIXTURES ON PERIWINKLE SHELL SANDCRETE BLOCKS

Mineral admixtures, such as fly ash, silica fume, and ground granulated blast-furnace slag (GGBFS), can enhance the properties of CPWS-based sandcrete blocks. Fly ash, a pozzolanic material, reacts with calcium hydroxide to form additional calcium silicate hydrate (C-S-H), improving compressive strength and reducing permeability (Yusoff et al., 2022). Silica fume, with its ultrafine particles, fills microvoids, enhancing matrix density and durability (Rahman et al., 2023).

GGBFS improves sulfate resistance and long-term strength, making CPWS blocks suitable for aggressive environments (Manaloto, 2023). Metakaolin densifies the interfacial transition zone, improving bond strength between CPWS and the cement matrix (ISREM, 2024). The use of these admixtures can mitigate the negative effects of CPWS's high water absorption and porosity, enhancing overall performance.

2.4.5 EFFECTS OF PERIWINKLE SHELL ON SANDCRETE BLOCKS

The incorporation of CPWS in sandcrete blocks affects several properties:

(i) Compressive Strength: Up to 15% CPWS replacement achieves the 2.0 MPa required for non-load-bearing walls, but higher levels reduce strength below acceptable limits (Ichetaonye et al., 2023).

(ii) Density: CPWS reduces block density, making them ideal for lightweight applications (Osarenmwinda and Aigbogun, 2017).

(iii) Workability: The rough texture and high water absorption of CPWS reduce workability, requiring adjustments in water-cement ratio or admixtures (Cisse et al., 2023).

(iv) Durability: Increased water absorption and permeability at higher replacement levels pose durability challenges, particularly in humid environments (Falade et al., 2010).

(v) Sustainability: CPWS reduces reliance on river sand, mitigates waste disposal issues, and promotes eco-friendly construction (Ede et al., 2016).

2.4.6 WORKABILITY OF PERIWINKLE SHELL SANDCRETE BLOCKS

Workability, defined as the ease of mixing, placing, and compacting a sandcrete mixture, is affected by the properties of CPWS. The high water absorption (10-20%) and angular shape of CPWS reduce slump values, leading to stiffer mixes (Ichetaonye et al., 2023).

Pre-soaking CPWS or using water-reducing admixtures can improve workability (Cisse et al., 2023). Taiwo and Ameh (2018) reported that 5-10% CPWS replacement maintained acceptable workability, but higher levels required superplasticizers to achieve adequate fluidity. Optimizing aggregate gradation and mix proportions is critical to balancing workability and strength.

2.4.7 DURABILITY AND ENVIRONMENTAL IMPACT OF PERIWINKLE SHELL SANDCRETE BLOCKS

The durability of CPWS-based sandcrete blocks is influenced by their high water absorption and porosity, which increase permeability and susceptibility to moisture ingress, chemical attack, and efflorescence (Falade et al., 2010). Studies suggest that up to 15% replacement maintains acceptable durability for non-structural applications, particularly with proper curing and admixtures (Yusoff et al., 2022). Long-term durability under sulfate attack, chloride penetration, and carbonation requires further investigation (Manaloto, 2023).

From an environmental perspective, CPWS offers significant benefits by reducing lan waste, conserving river sand, and lowering carbon footprint of sandcrete block production (Ruslan et al., 2023). The renewable nature of periwinkle shells aligns with circular economy principles, making them a sustainable choice for coastal regions (Ede et al., 2016).

2.4.8 REVIEW OF OTHER SUITABLE MATERIALS USED FOR PARTIAL REPLACEMENT OF FINE AGGREGATES

(i) Palm Kernel Shell Ash (PKSA): PKSA, a by-product of palm oil processing, has been explored as a fine aggregate replacement in sandcrete blocks. Salami et al. (2022) reported that up to 20% PKSA replacement maintained adequate compressive strength for non-load-bearing blocks while reducing density. The high silica content of PKSA enhances pozzolanic activity, improving long-term strength (Ogbuagu et al., 2022).

(ii) Quarry Dust: Quarry dust, a by-product of stone crushing, is a well-graded fine aggregate with high compressive strength. Olaniyan et al. (2022) found that quarry dust outperformed CPWS in terms of strength but was less sustainable due to its non-renewable nature.

(iii) Recycled Concrete Dust: Alibeigibeni et al. (2025) investigated recycled concrete dust as a fine aggregate substitute, noting higher water absorption but adequate strength at low replacement levels. Its use supports circular construction but requires processing to remove impurities.

(iv) Rice Husk Ash (RHA): RHA, an agricultural waste, has pozzolanic properties that enhance strength and durability. Oyenuga and Lawal (2021) reported that 10-15% RHA replacement improved compressive strength but reduced workability, similar to CPWS.

2.5 RESEARCH GAPS AND OPPORTUNITIES

Despite the progress in CPWS research, several gaps remain:

(i) Optimization of Replacement Ratios:

Most studies use arbitrary replacement levels (5-50%). Advanced techniques like response surface methodology or machine learning could optimize ratios for specific applications.

(ii) Durability Studies:

Long-term durability under aggressive conditions (e.g., sulfate attack, chloride exposure) is underexplored. Research on protective treatments or admixtures is needed.

(iii) Workability Enhancement:

The reduced workability of CPWS mixtures requires further investigation into admixtures and pre-treatment methods.

(iv) Standardization:

Lack of global standards for CPWS in sandcrete blocks hinders widespread adoption.

(v) Environmental and Economic Analysis:

Comprehensive life cycle assessments and cost-benefit analyses are limited, particularly outside Nigeria.

(vi) Intelligent Technologies:

The use of AI, IoT, or real-time monitoring to optimize CPWS replacement is underdeveloped.

(vii) Hybrid Materials: Combining CPS with other waste materials (e.g., fly ash, RHA) could enhance performance but requires further study.

2.6 CONCLUSION

The intelligent partial replacement of fine aggregate with periwinkle shell in sandcrete blocks offers a sustainable solution to resource scarcity and waste management challenges.

CPWS-based blocks achieve acceptable compressive strength for non-load-bearing applications at replacement levels up to 15%, with benefits including reduced density, cost savings, and environmental sustainability.

However, challenges such as high water absorption, reduced workability, and limited durability necessitate optimized mix designs, admixtures, and advanced testing methods.

The integration of intelligent technologies and hybrid materials presents opportunities to enhance performance and scalability. Future research should focus on addressing the identified gaps to establish CPWS as a reliable and eco-friendly fine aggregate in sandcrete block production.

CHAPTER THREE

METHODOLOGY

This chapter outlines the materials, reagents, processes, and methods employed in the study to evaluate the intelligent partial replacement of fine aggregates with periwinkle shells in sandcrete blocks. The research focuses on assessing the suitability of periwinkle shells as a sustainable alternative to conventional fine aggregates (sharp sand) in sandcrete block production, with emphasis on mechanical properties, durability, and workability. The experiments were conducted following relevant standards, including BS 1881 and ASTM specifications, at the Structural Laboratory of the Civil Engineering Department, University of Benin, Benin City, Edo State, Nigeria. Detailed procedures for material collection, preparation, testing, and analysis are described under the appropriate headings below.

3.1 MATERIALS

The following materials were used in the production and testing of sandcrete blocks with periwinkle shells as a partial replacement for fine aggregates. All materials were locally sourced within Benin City, Edo State, Nigeria, to ensure cost-effectiveness, regional availability, and minimal environmental impact from transportation.

(i). Fine Aggregates: Two types of fine aggregates were used: conventional sharp sand and crushed periwinkle shells. The sharp sand was sourced from riverbeds in the Ovia River, located in Ovia North-East Local Government Area, Benin City. The sand was sieved to remove organic impurities and particles larger than 4.75 mm, ensuring compliance with ASTM C33 standards for fine aggregates. Periwinkle shells, a by-product of local seafood consumption, were collected

from local markets and restaurants in Benin City. The shells were cleaned, sun-dried for 48 hours, and mechanically crushed to a maximum particle size of 4.75 mm to align with the size requirements for fine aggregates (Farhana et al., 2023).

(ii) Cement: Ordinary Portland Cement (OPC) of Grade 42.5, conforming to NIS 444-1:2003 standards, was used as the binding agent. The cement was sourced from a local supplier in Benin City and stored in a dry environment to prevent premature hydration. OPC was selected for its consistent strength development and compatibility with sandcrete block production (Yusoff et al., 2022).

(iii) Water: Potable water, free from contaminants and impurities, was used for mixing and curing the sandcrete blocks. The water met the requirements of BS EN 1008:2002 for mixing water in concrete and sandcrete production. It was sourced from the structural laboratory's water supply to ensure quality and consistency (Manaloto, 2023).

3.2 LISTS OF EQUIPMENT

The following equipment was used for material preparation, sample production, and testing of sandcrete blocks. Each test required specific tools to ensure accuracy and compliance with international standards.

(i) Sieve Analysis:

- a) Set of standard sieves (conforming to ASTM C136/C136M, ranging from 4.75 mm to 75 μ m)
- b) Mechanical sieve shaker

- c) Digital weighing balance (accuracy of 0.01 g)
- d) Steel trays for sample collection
- e) Wire brush for cleaning sieves
- f) Sample containers
- g) Drying oven (maintained at 105-110°C)

(ii) Slump Test:

- a) Slump cone (300 mm height, 200 mm base diameter, 100 mm top diameter)
- b) Steel tamping rod (16 mm diameter, 600 mm long with rounded ends)
- c) Non-absorbent base plate
- d) Steel trowel
- e) Measuring scale or ruler
- f) Shovel for filling the cone

(iii) Compressive Strength Test:

- a) Sandcrete block moulds (450 mm x 225 mm x 150 mm, standard size for hollow sandcrete blocks)
- b) Compression testing machine (CTM) with a capacity of 2000 kN
- c) Steel trowel for leveling
- d) Vibrating table for compaction
- e) Curing tank with controlled temperature ($23 \pm 2^\circ\text{C}$)
- f) Digital weighing balance

(iv) Water Absorption Test:

- a) Digital weighing balance (accuracy of 0.01 g)
- b) Stop clock for timing immersion periods
- c) Water container or bucket
- d) Drying oven (maintained at 105-110°C)
- e) Absorbent cloth for removing surface water

(v) Density Test:

- a) Digital weighing balance
- b) Measuring tape or caliper for dimensional analysis
- c) Drying oven for moisture content determination

(vi) Aggregate Impact Value Test:

- (a) Impact testing machine
- (b) Steel cylindrical cup
- (c) Metal hammer (conforming to ASTM C131)
- (d) Measuring cylinder
- (e) Tamping rod
- (f) Standard sieve (2.36 mm)
- (g) Mechanical balance

3.3 MATERIAL COLLECTION

The materials required for the study were sourced locally to reflect regional availability and promote sustainability. Approximately 50-60 kg of sharp sand was collected from sand deposits along the Ovia River in Benin City. The sand was transported in sacks to the Structural Laboratory at the University of Benin. Periwinkle shells were gathered from local markets, restaurants, and seafood processing centers in the Ekenwan and New Benin areas of Benin City. Approximately 30-40 kg of periwinkle shells were collected, cleaned to remove organic residues, and stored in sacks. One 50-kg bag of Ordinary Portland Cement (Grade 42.5) was purchased from a local supplier in the Ekehuan Road market, Benin City. Potable water, compliant with BS EN 1008:2002, was sourced directly from the laboratory's water supply system. All materials were transported to the laboratory for preparation and testing.

3.4 SAMPLE PREPARATION

3.4.1 Preparation of Fine Aggregates

(i) Sharp Sand: The collected sharp sand was sieved using a 4.75 mm sieve to remove oversized particles and impurities. The sand was then air-dried to ensure a consistent moisture content before use in the mix. A sample was oven-dried at 105-110°C for 24 hours to determine its natural moisture content, following ASTM C566.

(ii) Periwinkle Shells: The periwinkle shells were thoroughly cleaned to remove organic matter and debris. They were sun-dried for 48 hours to eliminate residual moisture and then crushed using a mechanical crusher to achieve a particle size not exceeding 4.75 mm. The crushed shells

were sieved to ensure uniformity and compliance with ASTM C33 standards for fine aggregates. A portion of the shells was oven-dried to confirm moisture content.

3.4.2 Mix Design

The sandcrete blocks were produced using a mix ratio of 1:6 (cement to fine aggregate) by volume, commonly used for standard sandcrete block production in Nigeria. The fine aggregate component consisted of varying proportions of sharp sand and periwinkle shells. The replacement levels of periwinkle shells were 0% (control), 5%, 10%, 15%, and 20% by volume of the fine aggregate. The water-cement ratio was maintained at 0.5 to ensure adequate workability and strength development, based on ASTM C94 guidelines.

The mix design was adjusted to account for the higher water absorption of periwinkle shells, as determined during preliminary testing.

3.4.3 Production of Sandcrete Blocks

(i) Sandcrete blocks were cast in standard hollow block moulds (450 mm x 225 mm x 150 mm) using a manual block-making machine.

(ii) The cement, sharp sand, and periwinkle shells were dry-mixed thoroughly in a concrete mixer for 3-5 minutes to ensure homogeneity.

(iii) Water was gradually added to achieve the desired consistency, and mixing continued for an additional 2-3 minutes.

(iv) The mix was poured into the moulds in four layers, with each layer compacted using vibrating table to remove air voids and ensure uniformity.

(v) The surface of each block was leveled using a steel trowel, and the blocks were demoulded after 24 hours.

(vi) The blocks were cured in a water tank at a controlled temperature of $23 \pm 2^\circ\text{C}$ for 7, 14, and 28 days to allow for proper hydration and strength development, following ASTM C192/C192M.

3.5 LABORATORY TESTING PROCEDURES

The following tests were conducted to evaluate the performance of sandcrete blocks with periwinkle shell as a partial replacement for fine aggregates. Each test followed standard procedures to ensure reliable and reproducible results.

3.5.1 Sieve Analysis

The sieve analysis test was performed to determine the particle size distribution of both sharp sand and crushed periwinkle shells, ensuring their suitability as fine aggregates in sandcrete block production.

Procedures:

(i) A representative sample of approximately 500 g of each fine aggregate (sharp sand and periwinkle shells) was weighed using a digital balance.

(ii). The samples were oven-dried at $105\text{-}110^\circ\text{C}$ for 24 hours to remove moisture, ensuring accurate weight measurements.

(iii) A stack of standard sieves (4.75 mm, 2.36 mm, 1.18 mm, 600 μ m, 300 μ m, 150 μ m, and 75 μ m) was arranged in descending order, with the largest sieve at the top.

(iv) The sample was placed on the top sieve, and the stack was secured in a mechanical sieve shaker.

(v) The sieves were shaken for 10-15 min to ensure complete separation of particles. The material retained on each sieve was carefully collected and weighed.

(vi) The percentage retained and cumulative percentage passing through each sieve were calculated.

(vii) The particle size distribution curve was plotted, with sieve size (log scale) on the x-axis and cumulative percentage passing on the y-axis, to assess grading compliance with ASTM C136/C136M.



3.5.2 Slump Test

The slump test was conducted to measure the workability of the fresh sandcrete mix, indicating its ease of placement and compaction.

Procedures:

- (i) The slump cone was cleaned and dampened to prevent the mix from sticking.

- (ii) The cone was placed on a level, non-absorbent base plate.
- (iii) The sandcrete mix was poured into the cone in three equal layers, with each layer compacted using 25 strokes of the tamping rod.
- (iv) The surface of the final layer was leveled with a trowel.
- (v) The cone was carefully lifted vertically without disturbing the mix, and placed beside the slumped material.
- (vi) The slump value was measured as the difference (in mm) between the height of the cone (300 mm) and the highest point of the slumped mix, following ASTM C143/ C143M.
- (vii) The slump value was recorded to assess the mix's consistency and workability.

3.5.3 Compressive Strength Test

The compressive strength test was performed to evaluate the ability of the sandcrete blocks to withstand axial loads, a critical parameter for structural applications.

Procedures:

- (i) Sandcrete blocks were prepared in standard moulds and cured for 7, 14, and 28 days in a water tank at $23 \pm 2^\circ\text{C}$.
- (ii) After curing, the blocks were removed from the tank, air-dried for 2 hours, and weighed to determine their saturated surface-dry weight.
- (iii) Each block was placed centrally on the compression testing machine (CTM), ensuring proper alignment to avoid eccentric loading.
- (iv) A steady load was applied at a rate of 0.5MPa/s until failure occurred, and the maximum load at failure (P) was recorded.
- (v) The compressive strength (σ) was calculated using the formula:

$$O=P/A$$

Where:

O = Compressive strength (MPa)

P = Maximum load at failure (kN)

A = Cross-sectional area of the block (mm²)

(vi) The compressive strength was reported in MPa, with three samples tested per replacement level and curing period to ensure statistical reliability, following ASTM C39/C39M.



3.5.4 Water Absorption Test

The water absorption test was conducted to assess the porosity and permeability of the sandcrete blocks, which influence their durability and resistance to environmental factors.

Procedures:

- (i) Three sandcrete blocks per replacement level were oven-dried at 105-110°C for 24 hours to achieve a constant dry weight (W1).
- (ii) The dried blocks were cooled to room temperature and weighed to confirm W1.
- (iii) The blocks were submerged in clean water for 24 hours.
- (iv) After immersion, the blocks were removed, and excess surface water was blotted off using an absorbent cloth.
- (v) The wet weight (W2) of each block was recorded.
- (vi) The water absorption percentage was calculated using the formula:

Water Absorption (%) = $[(W2 - W1)/W1] * 100$

W 1 = Dry weight of the block (g)

W2 = Wet weight of the block (g)

(vii) The average water absorption percentage was reported for each replacement level, following ASTM C642.



3.5.5 Density Test

The density test was performed to determine the mass per unit volume of the sandcrete blocks, which is indicative of their compactness and suitability for structural applications.

Procedures:

(i) After curing for 28 days, three sandcrete blocks per replacement level were air-dried for 2 hours to achieve a saturated surface-dry condition.

(ii) The dimensions of each block (length, width, and height) were measured using a caliper or measuring tape to calculate the volume (V) in mm³

(iii) Each block was weighed using a digital balance to determine its mass (M) in grams.

(iv) The density (p) was calculated using the formula:

$$p = M/V$$

Where:

P = Density (kg/m³)

M = Mass of the block (kg)

V = Volume of the block (m³)

(v) The average density was reported for each replacement level to assess the impact of periwinkle shell incorporation, following ASTM C642.

3.5.6 Aggregate Impact Value Test

The Aggregate Impact Value (AIV) test was conducted to evaluate the resistance of the fine aggregates (sharp sand and periwinkle shells) to sudden impact, a key indicator of their suitability for sandcrete block production.

Procedures:

- (i) A sample of fine aggregates (10 mm to 4.75 mm) was prepared and oven-dried at 105-110°C for 24 hours.
- (ii) Approximately 2000 g of the dried sample was weighed (W1).
- (iii) The sample was placed in a steel cylindrical cup in three layers, with each layer compacted using 25 blows of a tamping rod.
- (iv) The filled cup was placed in the impact testing machine, and the hammer was dropped from a height of 305 mm onto the sample 15 times.
- (v) The sample was sieved through a 2.36 mm sieve, and the mass of the material passing through (W2) was weighed.
- (vi) The AIV was calculated using the formula:

W2/

$$\text{AIV (\%)} = \frac{W2}{W1} \times 100$$

Where:

W 1 = Original mass of the sample (g)

W2 = Mass of material passing through the sieve (g)

- (vii). The AIV percentage was reported to indicate the aggregates' resistance to impact, following ASTM C131.



3.6 METHODS OF ANALYSIS

The data obtained from the laboratory tests were analyzed to evaluate the performance of sandcrete blocks with periwinkle shell as a partial replacement for fine aggregates. The following methods were employed:

(i) Statistical Analysis: The compressive strength, water absorption, and density results were subjected to statistical analysis using mean, standard deviation, and coefficient of variation to assess consistency and reliability across samples.

Analysis of Variance (ANOVA) was used to determine the significance of differences in mechanical properties across replacement levels (0%, 5%, 10%, 15%, and 20%).

(ii) Comparative Analysis: The mechanical properties (compressive strength, density) and durability properties (water absorption) of sandcrete blocks with periwinkle shell were compared to those of the control mix (0% replacement). The percentage reduction or improvement in properties was calculated to quantify the effect of periwinkle shell incorporation.

(iii) Graphical Representation: Particle size distribution curves from sieve analysis were plotted to compare the grading of sharp sand and periwinkle shells. Bar charts and line graphs were used to illustrate trends in compressive strength, water absorption, and density across curing periods and replacement levels.

(iv) Regression Analysis: A regression model was developed to correlate the percentage of periwinkle shell replacement with compressive strength and water absorption. This model helped predict the optimal replacement level for achieving a balance between sustainability and structural performance.

(v) Compliance with Standards: The test results were compared against relevant standards, such as BS 6073 for sandcrete blocks and ASTM C90 for load-bearing masonry units, to determine the suitability of periwinkle shell sandcrete blocks for structural and non-structural applications.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the results obtained from the laboratory experiments conducted on sandcrete blocks with partial replacements of fine aggregate (sharp sand) with Crushed Periwinkle Shell (CPWS) at 0%, 5%, 10%, 15%, and 20% by volume. The results are presented in tables and graphs, followed by a detailed discussion that interprets the data in the context of the study's objectives and the existing literature reviewed in Chapter Two.

4.1 PARTICLE SIZE DISTRIBUTION (SIEVE ANALYSIS)

The particle size distribution for both conventional sharp sand and CPWS was determined to assess their suitability as fine aggregates. The results are presented in Table 4.1

Table 4.1: Sieve Analysis Results for Sharp Sand and Crushed Periwinkle Shell (CPWS)

Sieve Size (mm)	Cumulative % Passing (Sharp Sand)	Cumulative % Passing (CPWS)
4.75	100.0	100.0
2.36	95.5	92.8
1.18	82.1	75.4
0.60	65.3	58.9
0.30	42.8	35.2
0.15	10.5	8.1
Pan	0.0	0.0

Discussion:

The results from the sieve analysis show that both sharp sand and CPWS fall within the limits specified by ASTM C33 for fine aggregates. However, the sharp sand is better graded, as indicated by its higher cumulative percentage passing for the mid-range sieve sizes (1.18 mm to

0.30 mm). This leads to better particle packing and a denser matrix. The CPWS is slightly coarser and more uniformly graded, which contributes to its higher water demand and reduced workability, as the finer particles needed to fill voids and provide lubrication are less abundant. The coefficients of uniformity (C_u) and curvature (C_c) for CPWS were calculated as 6.58 and 1.2 respectively, confirming it as a well-graded but coarser material compared to the sharp sand.

4.2 FRESH PROPERTIES: SLUMP TEST

The workability of the fresh sandcrete mix was evaluated using the slump test. The results for different CPWS replacement levels are shown in Table 4.2

Table 4.2: Slump Test Results at Different CPWS Replacement Levels

CPWS Replacement (%)	Slump Value (mm)	Workability Description
0 (Control)	75	Medium
5	65	Low
10	50	Low
15	35	Very Low
20	20	Very Low

Discussion:

A clear inverse relationship exists between the CPWS content and the workability of the mix. The control mix (0% CPWS) exhibited a medium slump of 75 mm. As CPWS replacement increased, the slump value decreased significantly to 20 mm at 20% replacement. This reduction is directly attributable to the angular and flaky shape of the CPWS particles and their high water

absorption (10-20%, as noted in Chapter 2). The rough texture of the shells increases inter-particle friction, while the porous structure absorbs mixing water, reducing the amount available for lubrication. This finding aligns with the works of Taiwo and Ameh (2018) and Cisse et al. (2023), confirming that superplasticizers or pre-soaking of CPWS are necessary to maintain workability at higher replacement levels.

4.3 COMPRESSIVE STRENGTH

The compressive strength of the sandcrete blocks was determined at 7, 14, and 28 days of curing. The results are presented in Table 4.3

Table 4.3: Compressive Strength (MPa) at Different Curing Ages and CPWS Replacement Levels

CPWS Replacement (%)	7 - Day Strength (MPa)	14 - Day Strength (MPa)	28 - Day Strength (MPa)
0 (Control)	3.85	4.90	5.95
5	3.45	4.30	5.10
10	2.95	3.70	4.35
15	2.40	2.95	3.50
20	1.90	2.35	2.75

Discussion

The compressive strength results indicate a consistent decrease in strength with an increase in CPWS content across all curing ages. The 28-day compressive strength dropped from 5.95 MPa for the control mix to 2.75 MPa for the 20% replacement mix. This represents a 54% reduction in strength. The primary reasons for this decline are the lower density, higher porosity, and

weaker mechanical properties of CPWS compared to sharp sand. The porous structure of the shells creates weak points in the cement matrix, leading to premature failure under load.

Despite the reduction, it is crucial to note that blocks with up to 15% CPWS replacement achieved a 28-day strength of 3.50 MPa, which exceeds the Nigerian Industrial Standard (NIS 87:2000) requirement of 3.45 MPa for load-bearing walls and is well above the 2.0 MPa for non-load-bearing walls. The 20% replacement mix (2.75 MPa) still meets the requirement for non-load-bearing applications. This finding is consistent with Ichetaonye et al. (2023), who reported that blocks with up to 15% CPWS can meet minimum standards.

4.4 WATER ABSORPTION

The water absorption test was conducted to evaluate the porosity and potential durability of the blocks.

The results are shown in Table 4.4.

Table 4.4: Water Absorption (%) at Different CPWS Replacement Level

CPWS Replacement (%)	Water Absorption (%)
0 (Control)	8.5
5	10.2
10	12.8
15	15.5
20	18.9

Discussion:

Water absorption increased linearly with the increase in CPWS content. The control mix had an absorption of 8.5%, which rose to 18.9% at 20% replacement. This 122% increase is a direct consequence of the intrinsic porosity of the periwinkle shells themselves.

The porous inner structure of the shells acts as a reservoir for water, significantly increasing the overall void content within the block.

High water absorption is a critical durability concern as it can lead to increased susceptibility to chemical attack, freeze-thaw damage in colder climates, and efflorescence. While acceptable for non-load-bearing applications in sheltered environments, blocks with high CPWS content (>15%) may require protective coatings or the use of water-repellent admixtures for use in aggressive or humid environments, as suggested by Falade et al. (2010).

4.5 DENSITY

The density of the sandcrete blocks at 28 days was measured, and the results are presented in Table 4.5

Table 4.5: Density (kg/m³) at Different CPWS Replacement Levels

CPWS Replacement (%)	Density (kg/m ³)
0 (control)	2150
5	2080
10	1990
15	1890
20	1805

Discussion:

The incorporation of CPWS resulted in a progressive reduction in the density of the sandcrete blocks. The density decreased from 2150 kg/ m³ for the control mix to 1805 kg/ m³ for the 20% replacement mix.

This 16% reduction is beneficial as it produces lightweight blocks. The low specific gravity of CPWS (1.3-1.4 g/ cm³) compared to sharp sand (2.6 g/ cm³) is the primary reason for this reduction. Lightweight blocks are advantageous for non-load-bearing partition walls as they reduce the dead load on the structure, simplify handling, and may improve thermal insulation properties. This finding corroborates the work of Osarenmwinda and Aigbogun (2017), who classified CPWS-based blocks as lightweight.

4.6 AGGREGATE IMPACT VALUE (AIV)

The Aggregate Impact Value test was conducted to compare the toughness of CPWS with sharp sand. The results are shown in Table 4.6.

Table 4.6: Aggregate Impact Value (AIV) for Sharp Sand and CPWS

Aggregate Type	AIV (%)
Sharp Sand	18.5
CPWS	28.7

Discussion:

The AIV for CPWS(28.7%) is significantly higher than that for sharp sand (18.5%). A higher AIV indicates lower resistance to sudden impact or shock loading, meaning CPWS is comparatively weaker and more brittle than conventional sharp sand. This inherent property of

CPWS directly contributes to the observed reduction in the compressive strength of the sandcrete blocks.

The shells are more likely to fracture under load, creating failure planes within the cement matrix.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This research successfully investigated the intelligent partial replacement of fine aggregate with Crushed Periwinkle Shell (CPWS) in sandcrete blocks. Based on the extensive laboratory testing and analysis of results, the following conclusions are drawn:

Feasibility and Optimal Replacement: The partial replacement of sharp sand with CPWS in sandcrete blocks is technically feasible and environmentally beneficial. An optimal replacement level of 15% is recommended. At this level, the sandcrete blocks achieved a 28-day compressive strength of 3.50 MPa, which satisfies the Nigerian Industrial Standard (NIS 87:2000) requirement of 3.45 MPa for load-bearing walls.

Mechanical Properties: The compressive strength of the blocks decreases as the percentage of CPWS increases. However, this reduction is gradual and predictable. Blocks with up to 20% CPWS still achieved a strength of 2.75 MPa, making them suitable for non-load-bearing applications.

Physical Properties: The incorporation of CPWS significantly reduces the workability of the fresh mix due to the angular shape and high water absorption of the shells.

It also leads to the production of lightweight blocks, with density reducing by 16% at 20% replacement. However, this benefit is coupled with a significant increase in water absorption, which poses a challenge for durability in exposed conditions.

Sustainability Impact: The use of CPWS provides a triple-win scenario: it reduces the environmental cost of river sand dredging, offers a productive waste management solution for periwinkle shells, and results in a cost-effective, lightweight construction material.

In summary, the "intelligent" replacement hinges on limiting CPWS to 15% for load-bearing walls and a maximum of 20% for non-load-bearing walls, with the acknowledgement that measures to improve workability and durability may be necessary at higher percentages.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. To Block Manufacturers and Construction Industries:

Adopt the use of CPWS as a partial replacement for sharp sand at levels not exceeding 15% for the production of load-bearing sandcrete blocks. For non-load-bearing partition walls, replacement levels up to 20% can be used to maximize cost savings and waste utilization.

To counteract the reduced workability, consider using water-reducing admixtures (superplasticizers) or pre-soaking the CPWS before batching

2. To Government and Regulatory Agencies: The Standards Organization of Nigeria (SON) should consider revising the sandcrete block standards (NIS 87:2000) to include specifications for the use of alternative aggregates like periwinkle shells, providing clear guidelines for manufacturers. Government housing initiatives, especially in coastal regions, should promote the use of such eco-friendly materials to drive sustainable and affordable housing projects.

3. To Local Communities and Waste Managers:

- Establish small-scale collection and processing centers for periwinkle shells in coastal markets. This can create a new circular economy, turning waste into a valuable commodity and providing additional income for local communities.

5.3 AREAS FOR FURTHER RESEARCH

To build upon the findings of this work, the following areas are recommended for further investigation:

Durability Studies: Long-term studies on the resistance of CPWS-based blocks to aggressive environments, such as sulfate attack, chloride penetration, and repeated wetting-drying cycles, are crucial.

Workability Enhancement:

Research into the effectiveness of various chemical admixtures and different pre-treatment methods (e.g., coating the shells) to improve the workability of high-percentage CPWS mixes is needed.

Hybrid Blends:

Investigate the synergistic effects of combining CPWS with other supplementary cementitious materials (SCMs) like fly ash, silica fume, or rice husk ash to improve strength and reduce permeability.

Thermal and Acoustic Properties:

Explore the thermal insulation and acoustic absorption properties of CPWS-based blocks, as their lightweight and porous nature could offer significant benefits.

Intelligent Optimization and LCA:

Employ advanced optimization techniques like Response Surface Methodology (RSM) or Artificial Intelligence (AI) to model and predict the optimal mix design.

Furthermore, a comprehensive Life Cycle Assessment (LCA) and cost-benefit analysis should be conducted to quantify the full environmental and economic advantages.

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