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THE POTENCY OF GROUND NUT SHELL IN BUILDING CONSTRUCTION: UNVEILING THE STRATEGIC ROLES AND USES FOR COST EFFECTIVENESS AND BUILDING SUSTAINABILITY.

By

Yetunde Hannah Obamoh
Department of Architectural Technology,
Federal Polytechnic Ukana
Akwa Ibom State

Solomon Emmanuel Etuk
Department of Architecture
University of Uyo

And

Arc. Enobong Bennett Equere Ph.D.,
Department of Architecture,
University of Uyo.

ABSTRACT

This study explores the potency of groundnut shells as an innovative and sustainable material in building construction, emphasizing their strategic roles in enhancing cost effectiveness and environmental sustainability. Groundnut shells, an abundant agricultural by-product, possess desirable pozzolanic and structural properties that make them suitable as partial replacements for cement and fine aggregates in concrete production. Their incorporation not only reduces construction costs but also minimizes waste disposal challenges and carbon emissions associated with conventional materials. Through a review of recent experimental findings, the study highlights the mechanical performance, durability, and eco-efficiency of groundnut shell-based composites, demonstrating their potential to support sustainable building practices, promote circular economy principles, and provide affordable housing solutions, particularly in developing economies. It concluded that by integrating groundnut shell-based materials into modern construction practices, developing and developed nations alike can promote greener infrastructure, lower carbon emissions, and advance sustainable housing initiatives—making groundnut shells a strategic, eco-friendly, and economically viable resource for the future of construction. It also recommended that technical colleges, engineering schools, and architecture programs should incorporate sustainable material technologies—particularly agro-waste applications—into their curricula to build future expertise in eco-construction.

KEYWORDS: Groundnut Shell, Building Construction, Cost Effectiveness and Building Sustainability

INTRODUCTION

The growing demand for sustainable and cost-effective materials in the construction industry has prompted researchers to explore agricultural residues as viable alternatives to conventional resources. Among these residues, groundnut shells—an abundant byproduct of peanut processing—have gained attention for their potential as a green construction material. Studies such as those by Olutoge et al. (2012) and Shobha & Rekha (2018) highlight that groundnut shells can be processed into ash or powder to serve as partial replacements for cement or fine aggregates. This innovation not only reduces construction costs but also mitigates environmental issues associated with waste disposal and cement production. Groundnut shells possess unique physicochemical properties that make them suitable for structural and non-structural applications in building projects. According to Adesanya and Raheem (2009), the incorporation of groundnut shell ash (GSA) into concrete enhances the material's compressive strength and durability up to certain replacement levels, typically between 5% and 15%. Furthermore, Bamigboye et al. (2016) report that the pozzolanic activity of GSA improves the long-term performance of concrete while lowering the carbon footprint associated with cement manufacture. These findings suggest that groundnut shells can serve as both a sustainability enabler and a functional ingredient in green construction strategies.

From an economic perspective, the reuse of groundnut shells introduces significant cost-saving opportunities for developing regions, where building materials constitute a major portion of construction expenses. Ettu et al. (2013) demonstrate that substituting part of conventional materials with groundnut shell derivatives can lower overall project costs without compromising structural integrity. This affordability makes groundnut shell-based composites particularly appealing in rural and low-income housing initiatives, aligning with global objectives for affordable and sustainable urban development. In addition to economic and mechanical advantages, the adoption of groundnut shells in construction contributes to circular economy practices by turning agro-waste into value-added materials. Joseph et al. (2020) and Ugwu & Opara (2021) emphasize that integrating such bio-based resources supports waste reduction, energy conservation, and climate resilience. As the construction sector seeks innovative methods to enhance sustainability and affordability, the strategic deployment of groundnut shells represents a promising avenue for achieving both environmental and economic efficiency in the built environment.

CONCEPT OF GROUNDNUT

Because of their high oil and protein content, groundnuts (Arachis hypogaea L.), commonly referred to as peanuts, are an essential leguminous crop that is grown all over the world. It is crucial for industrial uses, animal feed, and human nutrition. The crop is especially important in tropical and subtropical areas since it is a substantial source of edible oil, which supports the agricultural economy and household food security. As a legume, groundnut also improves soil fertility through niAtrogen fixation, making it a sustainable component of crop rotation systems (Nigam, S. N., 2014).

Groundnut botany reveals the peculiar reproductive activity known as "geocarpy," in which fertilized ovules develop underground. The plant needs a warm environment with moderate rainfall and usually grows best in sandy loam soils that drain well. Agronomic techniques that affect production and quality include seed treatment, timely planting, and pest control. According to Kumar, R., & Singh, A. (2018), the crop's adaptability to semi-arid conditions makes it a valuable resource for smallholder farmers, especially in Africa and Asia, where it supports both income generation and nutritional needs.

China, India, Nigeria, and the United States are the main producers of groundnuts, which are traded internationally. Producing value-added goods like peanut butter, roasted nuts, and oil extraction supports rural livelihoods. Breeding, molecular genetics, and biotechnology research advances have concentrated on creating drought-tolerant and disease-resistant cultivars to increase resilience and productivity in the face of changing climate conditions. Thus, the concept of groundnut extends beyond agriculture into food security, industrial use, and sustainable development (Zhang, X., 2020).

CONCEPT OF GROUNDNUT SHELL

The outer covering or protective layer that envelops the edible seeds of the groundnut plant (Arachis hypogaea) is referred to as the groundnut shell, or peanut hull. It is a lignocellulosic byproduct that is produced when groundnuts are processed for consumption or oil extraction. The primary components of groundnut shells—cellulose, hemicellulose, and lignin—give them a tough, fibrous structure. According to Olorunnisola (2019), groundnut shells account for about 20–30% of the total weight of the nut and are often discarded as waste, despite their significant potential for industrial and agricultural applications.

Groundnut shells have a high percentage of organic carbon, which makes them a promising raw material for the synthesis of activated carbon and bioenergy. They also include trace amounts of minerals, lipids, and proteins. As explained by Sharma and Pathak (2020), the high lignin and cellulose content of groundnut shells makes them suitable for use as a biomass fuel, as well as in the production of composite boards and biochar. Because of this feature, shells can be used in many industries as a sustainable substitute for traditional materials, which lowers pollution from agricultural waste in the environment.

In agricultural applications, groundnut shells are typically utilized as mulch, organic manure, or livestock bedding due to their biodegradability and nutrient content. When broken down, they increase soil fertility, and with the right preparation, they can also be utilized as roughage in animal feed. According to Eze et al. (2021), groundnut shell compost significantly enhances soil structure, water retention, and microbial activity, promoting plant growth. This demonstrates how important groundnut shells are to sustainable farming methods, particularly in rural areas.

Additionally, groundnut shells are used in the environmental and industrial domains. They are employed as fillers in polymer composites, in the manufacturing of particle boards, and in the filtration of water using activated carbon. According to Ahmed and Hassan (2022), the transformation of groundnut shells into value-added products contributes to waste minimization and economic development. Their wide range of applications underscores their importance as an eco-friendly resource in promoting sustainable waste management and industrial innovation.

Because of its potential for pollution control and adsorption processes, groundnut shell has drawn interest in scientific research and environmental management in addition to its uses in agriculture and industry. The groundnut shell's porous nature makes it a powerful bio sorbent for eliminating colors and heavy metals from wastewater. Research has indicated that growth is the source of activated carbon.

Because of their excellent adsorption capacity and chemical durability, groundnut shells can be used to filter air and purify water. As reported by Musa and Ibrahim (2023), groundnut shell-based activated carbon provides a cost-effective and environmentally friendly alternative to commercial adsorbents, thereby contributing to cleaner water systems and reduced industrial waste. This environmental significance emphasizes how crucial groundnut shells are for encouraging eco-innovation and sustainable waste valorization in a variety of industries.

CONCEPT OF BUILDING CONSTRUCTION

In essence, a building serves as a shelter to safeguard people, their belongings, and animals. In light of this, the entire evolution of building materials and construction methods is connected. In addition to offering shelter, a building must fulfill man's need for mental and spiritual fulfillment from his surroundings and serve as an enclosure so that a safe, comfortable,

and satisfactory interior environment can be created in relation to the building's intended use. (David & Isaac 2024). According to McMullan (2021), building construction is defined as the art and science of forming structures by assembling materials to meet specific functional, aesthetic, and safety requirements. It is a multidisciplinary process involving architects, engineers, builders, and clients who collaborate to translate design concepts into physical reality.

Building construction is the process of putting together materials and parts to make structures that meet human requirements, like homes, offices, learning centers, medical facilities, and entertainment venues. It encompasses planning, design, and execution phases, integrating architectural, structural, mechanical, and environmental considerations (Ching & Adams, 2020). Kibert (2022) provides a more modern and sustainability-focused definition, stating that building construction involves creating structures through processes that minimize environmental impact, optimize resource use, and ensure social and economic sustainability throughout a building's life cycle. The 21st-century construction philosophy, which requires that structures be not just long-lasting and functional but also sustainable, is reflected in this concept. It incorporates life-cycle assessment, resource efficiency, and climate resilience principles—all of which are essential elements of contemporary international building regulations and practices.Oke et al. (2017) describe building construction as an organized economic activity that transforms design concepts into physical reality through the management of materials, manpower, and machinery to achieve a functional end product. According to this definition, construction is an economic activity that plays a significant role in employment and national development. It draws attention to the resource management component, showing that building construction involves more than just putting things together; it also entails maximizing labor, time, and cost efficiency to guarantee output and profitability. Building construction is defined as the process of assembling materials and components in a structured sequence to produce buildings that fulfill functional, economic, and aesthetic requirements within the limits of available resources and technology (Illingworth & Thain, 2020).

CONCEPT OF BUILDING SUSTAINABILITY

The design, construction, operation, and maintenance of buildings in a way that maximizes efficiency, occupant well-being, and economic value over the course of their life cycle while minimizing their adverse environmental impact is known as building sustainability (Ding et al., 2023). To strike a balance between meeting human needs and protecting natural resources for future generations, it incorporates social, economic, and environmental factors (United Nations Environment Programmed [UNEP], 2022). Thus, from inception to destruction, sustainable buildings—also referred to as green buildings—are made to be resource, energy, and environmentally responsible. According to Batchman & Edem (2024), sustainability has emerged as a crucial factor in pillar construction, mirroring broader developments in green building techniques.

From an environmental perspective, building sustainability emphasizes the reduction of carbon emissions, waste generation, and resource consumption (Zhang & Wang, 2021). This entails the use of sustainable building technology, low-emission materials, water-efficient systems, and renewable energy sources. For instance, integrating renewable energy technologies such as solar panels and passive ventilation reduces dependency on fossil fuels, contributing to climate change mitigation (Rahman et al., 2020). Moreover, sustainable construction materials—such as recycled steel, bamboo, and fly ash concrete—reduce the environmental footprint associated with material extraction and processing (Tushar et al., 2023). According to Usanga & Edem, (2024), Sustainability in architecture does not only mean reducing energy use and waste. It cannot be segmented into various subcategories because it represents a fundamental and intrinsic combination of factors related to our existence on this planet.

Economically, sustainable building practices are designed to reduce operational and maintenance costs over time through energy and water savings (Azhar et al., 2021). Although the initial investment in green technology and materials can be higher, the long-term cost benefits are significant. For example, energy-efficient lighting systems, insulation, and water-recycling systems lower utility costs and increase the asset value of sustainable buildings (Al-Ghamdi & Bilec, 2020). The concept also promotes the idea of life-cycle costing (LCC), where financial analysis considers not just construction costs but also operation, maintenance, and disposal phases (Chong et al., 2022). Social sustainability in building design focuses on occupant comfort, health, and productivity (Chen et al., 2021). Sustainable buildings prioritize indoor air quality, natural lighting, acoustic comfort, and thermal regulation to ensure well-being. According to the World Green Building Council (2022), buildings with high sustainability ratings demonstrate improved occupant satisfaction and productivity due to better air quality and lighting conditions. Additionally, sustainable architecture supports community engagement, cultural identity, and accessibility, thereby fostering inclusivity and resilience (Zuo et al., 2022).

A fundamental principle in building sustainability is the life-cycle approach, which evaluates the environmental impact of a building from design to demolition (Mateus & Bragança, 2020). This perspective helps designers and policymakers identify opportunities for minimizing waste, energy consumption, and greenhouse gas emissions throughout the building's life span. Tools such as Life Cycle Assessment (LCA) and Building Information Modeling (BIM) are increasingly used to quantify and optimize sustainability performance (Oke et al., 2023). Globally, several frameworks guide the implementation of building sustainability. The Leadership in Energy and Environmental Design (LEED) and Building Research Establishment Environmental Assessment Method (BREEAM) are among the most recognized certification systems (Kibert, 2022). Sustainable building development is also closely related to the United Nations Sustainable Development Goal 11 (SDG 11), which focuses on creating inclusive, safe, resilient, and sustainable cities and human settlements (UN, 2023). In order to encourage sustainability in the public and private sectors, governments all over the world are currently implementing green construction regulations and incentive schemes.

THE ROLES OF GROUNDNUT SHELL IN BUILDING CONSTRUCTION

Groundnut shells are used as a fine aggregate in concrete and blocks or as a partial replacement for cement in building construction, mainly to increase sustainability and lower costs. Groundnut Shell Ash (GSA) functions as a pozzolan when burned, increasing concrete's durability, density, and thermal insulation. In order to reduce waste overall, unprocessed groundnut shells can also be used as a lightweight fine aggregate in concrete and masonry.

- **Partial cement replacement (groundnut shell ash — GSA)**

Mortar, concrete, and stabilized earth blocks, groundnut shell can be burned to create a pozzolanic ash (GSA), which can partially replace Portland cement, lowering the need for cement, its price, and its embodied CO_2. Several studies show that workable strength is maintained or enhanced following appropriate processing (controlled calcinations and grinding) at safe replacement ranges (typically 5–20% by mass) (Mohamed, Najma, Mohamed, 2017).

- **Fine aggregate / filler in bricks, blocks and sandcrete**

In both burnt and unfired bricks, as well as in sand Crete blocks, groundnut shell (or groundnut shell powder) has been utilized in place of some of the sand or fine aggregate. Reduced density (lighter units), reusing agricultural waste, and, when optimized, acceptable compressive strength in certain mixtures are among the advantages. For particular replacement fractions, experimental and machine-learning investigations demonstrate mechanical performance that is acceptable.

- **Thermal insulation (lightweight insulating panels / ceiling boards)**

It is beneficial for passive thermal control and as an eco-insulation filler in cavity/board products because groundnut shell, whether whole or shredded, reduces thermal conductivity when added to plaster panels, ceiling boards, or composite boards as opposed to dense concrete (Ubong, Sunday, Okechukwu et al., 2025). Peanut shell-based experimental composites exhibit encouraging heat transfer reductions and good potential for insulation and ceiling boards.

- **Soil stabilization and road sub-base additive**

When used as a pozzolanic additive or as a partial substitute for cement or lime, groundnut shell ash has been tested as a stabilizer for poor soils (such as black cotton soils), increasing Atterberg limits, strength, and bearing capacity. Mohamed L., Abdelhamid, Najma, and Mohamed (2017). This makes it appealing for inexpensive earthworks and road sub-bases in agricultural areas.

- **Reinforcement / filler in polymer and cementations composites**

In order to affect toughness, tensile behavior, and density, groundnut shell powder or particles can be used as a bio-filler in polymer composites and as fiber-like inclusions in cementations mixtures (after treatment). In certain formulations, recent composite research demonstrates enhanced modulus and thermal stability. To prevent moisture and debonding, proper size and surface preparation are crucial.

- **Acoustic panels and lightweight interior finishes**

Groundnut shell-based boards and POP (plaster of Paris) modified panels have been investigated for acoustic ceiling/partition panels with promising absorption and lightweight benefits (ideal for low-cost interior finishes) due to their lower density and variable porosity. In 2025, Ubong, Sunday, Okechukwu, et al.

- **Eco-bricks, fired bricks and ceramics (fuel/void former)**

If handled properly, groundnut shell, a flammable addition used in the production of burnt bricks, can lower firing energy and produce regulated porosity, or lighter bricks. Groundnut shell is listed as one of the feasible organic additives for sustainable brick manufacture in a number of agro-waste brick studies (Anbarasu & Karuppusamy, 2025).

- **Environmental / circular-economy role**

When replacement levels and processing are maximized, using groundnut shells can minimize the lifespan CO_2 of construction materials, redirect agricultural waste from open burning or landfills, and reduce the demand for virgin materials (sand, cement). Reviews emphasize the advantages of waste valorization and the circular economy. (Sathiparan, Anburuvel, & Virgin, 2023)

THE ROLES OF GROUNDNUT SHELL IN BUILDING SUSTAINABILITY

When correctly handled (e.g., ground or ached), groundnut shell waste can play significant sustainable roles in building materials and construction. The five functions listed below demonstrate how using groundnut shells promotes sustainability.

- **Soil Stabilization / Ground Improvement**

By strengthening, decreasing flexibility, enhancing bearing capacity, and decreasing dependence on large quantities of traditional stabilizers like cement or lime, groundnut shell ash (GSA) can be utilized to improve the engineering qualities of weak soils. This lowers embodied carbon and costs. For example, lateritic soils stabilized with GSA show improved California Bearing Ratio (CBR), reduced Atterberg limits, and improved unconfined compressive strength at optimal ash percentages (e.g., around 4% GSA) (Mmeka & Abriku, 2023). Additionally, adding lime to GSA for structural soils used in highway construction increases strength and durability while meeting highway criteria with less traditional stabilizer.

- **Partial Replacement of Cement (Pozzolanic or Mineral Admixture Function)**

Because of its siliceous content and pozzolanic activity, groundnut shell ash can be used in place of some of the cement in sand Crete blocks, mortar, and concrete. If replacement levels stay within ideal ranges (e.g., up to 20%), replacing a portion of cement with GSA lowers the volume of cement required, cutting CO_2 emissions, energy consumption, and cost, while still maintaining appropriate compressive strength (Amu et al., 2021). Additionally, concrete mixed with GSA produces significant strength results according to mix proportions, curing duration, and replacement rate, according to soft computing models.

- **Lightweight Aggregate / Fine Aggregate Replacement**

The density of concrete mixtures or blocks can be decreased by using groundnut shells (not simply ash) as fine aggregate substitutes. This lowers the load on foundations or structural frames, consumes less natural sand, and has a less environmental effect and embodied energy in transportation. Workability and compressive strength are impacted when groundnut shells are used in place of fine aggregate; however, adequate performance can be attained at specific replacement levels (Sada et al., 2020). Better waste management and less environmental stress from sand mining are two benefits of this.

- **Thermal Insulation and Improved Building Envelope Performance**

The thermal conductivity of composite boards or panels containing groundnut shell particles, whether treated or not, is lower than that of many traditional materials. By lowering heat transfer, these boards can help maintain a consistent temperature indoors and use less energy for heating or cooling. For example, composite boards with 50% treated groundnut shell particles gave thermal conductivity in the range of ~0.1545-0.1742 W/m·K, which suggests good insulating potential (Ekpenyong et al., 2023). These materials thus help in reducing energy consumption and greenhouse gas emissions and improving occupant comfort.

- **Waste Reduction, Circular Economy, and Environmental Pollution Mitigation**

By using groundnut shells (or shell ash) instead of open burning or dumping, greenhouse gas emissions are decreased, agricultural waste is turned into useable building material, and environmental contamination (air pollution from burning, leachate, or other impacts) is lessened. Additionally, using GSA to stabilize soils or substitute cement might lessen reliance on materials that require a lot of resources. Research highlights that turning groundnut shell waste into ash for use in mortar or sand Crete blocks reduces pollution and adds value to trash, supporting the ideas of the circular economy (Umar & Ali, 2023).

The hunt for affordable, environmentally friendly alternatives in construction has accelerated due to the rising expense of traditional building materials. Groundnut shells and other agricultural byproducts, which are frequently thrown away as garbage, have garnered a lot of attention as possible building materials for sustainable projects. Groundnut shells, which constitute about 20–25% of the total weight of the nut, are available in abundance across tropical regions, especially in Africa and Asia (Ogunbode et al., 2021). Their application in building construction reduces waste and reliance on non-renewable resources, which benefits the environment in addition to the economy.

- **Properties of Groundnut Shell**

Groundnut shells (Arachis hypogaea) are lignocellulosic materials composed mainly of cellulose, hemicellulose, and lignin (Usman et al., 2022). They are perfect for usage as lightweight aggregates or fillers in cementations materials because of their low density, high carbon content, and strong insulating qualities. When processed—either as ash or powder—groundnut shells can partially replace cement, sand, or coarse aggregates in concrete production (Aliyu et al., 2020). Studies have shown that the shell's ash, when burned at controlled temperatures, exhibits pozzolanic behavior due to its silica and alumina content (Eneh & Nwankwo, 2023).

ECONOMIC BENEFITS

- **Reduction in Construction Costs**

The cost of building construction is greatly reduced by using materials derived from groundnut shells. Particularly in agricultural areas where groundnut processing is widespread, groundnut shells are easily accessible for little or no cost. According to Okey et al. (2021), replacing 10–20% of sand or cement with groundnut shell ash in concrete can reduce material costs by up to 15% without compromising structural strength for non-load-bearing applications. This cost saving arises from the reduced need for expensive cement, which is a major cost driver in construction projects (Okonkwo et al., 2022).

- **Employment and Local Value Addition**

Using groundnut shells in construction materials encourages the creation of jobs and local value addition. Shells are gathered, processed, and sold to nearby block producers rather than being thrown away as garbage. This promotes the circular economy while strengthening rural economies (Ibrahim et al., 2023). It is also possible for small-scale businesses due to the cheap capital requirements for processing, such as controlled burning or grinding (Nwachukwu et al., 2024).

- **Concrete and Mortar Applications**

Groundnut shell ash (GSA) has been successfully used as a partial cement replacement in concrete mixes. Studies show that substituting up to 15% of cement with GSA yields compressive strength values comparable to conventional concrete, while providing a 10–20% cost reduction (Eze & Abubakar, 2021). In lightweight concrete applications, groundnut shell aggregates reduce the density of concrete from about 2400 kg/m³ to 1900 kg/m³, translating to reduced dead loads and lower structural costs (Ahmed et al., 2020).

- **Thermal and Acoustic Insulation**

One of the key cost-effective advantages of groundnut shell material is its superior thermal insulation. The shells' porous structure reduces heat transfer, improving energy efficiency and reducing operational costs of buildings (Adewale et al., 2022). Additionally, groundnut shell panels exhibit good sound absorption, which enhances indoor acoustic comfort at lower material costs compared to synthetic insulators (Aminu et al., 2023).

- **Environmental and Sustainability Advantages**

In addition to lowering building costs, using groundnut shells in construction helps to alleviate environmental issues associated with the disposal of agricultural waste. Large volumes of groundnut shells are typically burnt or left to decay, releasing greenhouse gases and contributing to land pollution (Babatunde et al., 2022). When incorporated into construction materials, this waste becomes a valuable resource, aligning with the Sustainable Development Goals (SDGs) 9, 11, and 12—promoting innovation, sustainable cities, and responsible consumption (UNEP, 2023).

CHALLENGES AND LIMITATIONS

The broad use of products derived from groundnut shells is hampered by a number of issues, despite the advantages for the economy and ecology. The primary issues include lack of standardized production techniques, variability in shell composition, and limited public awareness (Okafor et al., 2021). In some cases, excess substitution levels (>20%) can result in reduced compressive strength or increased water absorption (Usman et al., 2022). To overcome these obstacles, further research and development is needed to create regulatory frameworks for material certification and standardize processing techniques.

One prospective route toward economical and environmentally friendly building techniques is the usage of groundnut shells in construction. Utilizing a plentiful agricultural by-product can minimize environmental problems and drastically lower construction costs. Its applicability for the production of blocks, insulation, and lightweight concrete is supported by empirical data. Therefore, encouraging the use of groundnut shells through standardization, regulatory assistance, and technological innovation can improve the building industry's affordability and sustainability, particularly in developing nations.

HOW USEFUL IS GROUNDNUT SHELL IN BUILDING CONSTRUCTION

Growing environmental concerns, waste production, and the depletion of natural resources are driving the worldwide construction sector to adopt eco-friendly methods and sustainable materials. Previously considered waste, agricultural leftovers like groundnut (Arachis hypogaea) shells have become promising raw materials for construction. Groundnut shells are lignocellulosic by-products rich in cellulose and hemicellulose, providing useful binding and reinforcing properties when processed correctly (Ogunbiyi et al., 2021). Their application in construction materials promotes cost-effectiveness, waste management, and a smaller carbon footprint.

- **Chemical and Physical Properties of Groundnut Shells**

Because of their high cellulose (35–40%), hemicellulose (25–30%), and lignin (30–35%) content, groundnut shells have good binding and structural properties (Mekonnen et al., 2022). Because of these characteristics, they can be incorporated into cementations and polymer-based comp osites. When appropriately handled, the shells' high porosity and low bulk density (~0.7 g/cm³) make them resistant to degradation. They are also helpful in the production of pozzolanic ash and lightweight aggregates due to their calorific value.

- **Cement Replacement Material**

Ordinary Portland Cement (OPC) in concrete can be partially substituted with groundnut shell ash (GSA). Ash rich in silica (SiO_2), alumina (AlO_3), and iron oxide (FeO_3)—essential oxides for pozzolanic reactions—is produced when groundnut shells burn at 600–700°C (Onyango et al., 2023). According to studies, using 5–15% GSA in place of cement increases its durability, compressive strength, and ability to withstand sulfate attack (Aliyu & Yahaya, 2021).

- **Fine Aggregate Replacement**

Crushed groundnut shells can substitute part of the fine aggregates (sand) in concrete production. The inclusion of 5–20% groundnut shell reduces the concrete's density and enhances its thermal insulation, making it ideal for non-load-bearing walls and partition panels (Okonkwo et al., 2022). However, higher replacement levels (>25%) may decrease compressive strength; thus, optimization is key.

- **Lightweight Concrete Production**

Groundnut shell particles are used to produce lightweight concrete blocks for low-cost housing. Their low specific gravity (≈1.2 g/cm³) makes them suitable for this purpose. Studies by Adewale et al. (2020) demonstrated that groundnut shell concrete exhibited a density reduction of up to 25% compared to conventional concrete, with acceptable mechanical strength for wall applications.

- **Particle Boards and Panels**

Additionally, groundnut shells can be processed into composite panels and particle boards by employing phenolic resin or urea-formaldehyde as binders. These boards are utilized for wall panels, furniture, and ceilings. The boards show good sound absorption and moderate fire resistance when treated with flame retardants (Ismail & Abdulrahman, 2023). They are a sustainable alternative to wood-based panels, helping reduce deforestation.

- **Pozzolanic Additive in Bricks**

Compressed earth blocks and environmentally friendly burnt bricks can be made by combining groundnut shell ash with clay. It has been discovered that adding 10–20% GSA improves water resistance and thermal insulation while lowering unit weight (Ezeh et al., 2021). This invention encourages building envelopes that use less energy, especially in tropical regions.

- **Limitations and Challenges**

Despite its potential, there are obstacles to using products made from groundnut shells. Quality and performance can be impacted by changes in moisture content, particle size, and chemical composition. Furthermore, large-scale use is restricted by the lack of defined testing protocols for materials derived from agriculture (Ezeh et al., 2021). More research is also needed to determine durability under prolonged environmental exposure.

CONCLUSION

In conclusion, the utilization of groundnut shells in building construction presents a transformative opportunity for achieving cost-effective and sustainable development in the construction industry. As an abundant agro-waste material, groundnut shells can be processed into ash or powder to partially replace cement and fine aggregates, thereby reducing production costs and minimizing environmental impacts. Their pozzolanic and mechanical properties enhance the strength, durability, and energy efficiency of concrete while supporting circular economy principles through waste valorization. By integrating groundnut shell-based materials into modern construction practices, developing and developed nations alike can promote greener infrastructure, lower carbon emissions, and advance sustainable housing initiatives—making groundnut shells a strategic, eco-friendly, and economically viable resource for the future of construction.

RECCOMENDATIONS

1. Government agencies and construction regulatory bodies should create awareness campaigns and policy frameworks that encourage the inclusion of groundnut shell derivatives—such as groundnut shell ash (GSA)—in green building standards and eco-friendly construction guidelines.

2. Continuous research should focus on optimizing the processing methods, mix proportions, and chemical treatment of groundnut shells to enhance their pozzolanic activity, strength contribution, and compatibility with other building materials.

3. Technical colleges, engineering schools, and architecture programs should incorporate sustainable material technologies—particularly agro-waste applications—into their curricula to build future expertise in eco-construction.

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