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Use of Waste Ground Nut Shell in the Development of Various Construction Products

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Abstract
The construction industry will have an increasing problem in meeting increased demand, and production of construction materials such as bricks, concrete, mortar and steel will expand. Agricultural businesses, on the other hand, generate massive amounts of residues each year all throughout the world, posing concerns about the environment because the majority of these wastes are either burnt or dumped in landfills. Many agricultural waste materials Agricultural waste products have already been employed in a variety of applications such as in concrete, mortar as aggregate, or binding material substitutes. This review examines the use of groundnut shell ash in the manufacture of bricks, cement mortar, and cement concrete. various qualities of bricks, concrete, cement mortar when groundnut shell ashes are added with these materials are examined, and criteria that are related to various standards are compared. Because majority of the created materials meet the specifications, the analysis of literature revealed a visible potential for ground nut shell ash as a Substitution of a portion for materials that are commonly used. However, there is a dearth of research on durability and thermal qualities. Furthermore, existing research is insufficient to determine the wastes' potential for reuse in the manufacture of construction materials. As a result, substantial study is required to reinforce current knowledge in this subject in order to meet long-term objectives in the building business.

Keywords: Environmental pollution, Groundnut shell, Bricks, Concrete, Mortar.

1. INTRODUCTION

The population of the planet is forecast to rise, with 970 crores by 2050 to 1120 crores by the end of the century [1], resulting in a considerable demand for housing is increasing. As a result, the construction industry will have an increasing problem in meeting the increased demand, and output of building materials will increase. Traditional fired brick and concrete masonry manufacturing processes use a lot of energy [2,3], and cement production has been reported as one of the largest sources of Carbon dioxide emissions (about 5–7%) in the world [4,5], Along with other greenhouse gases, they contribute to 60% of global warming [6]. Researchers have been encouraged to produce Construction materials that are environmentally friendly as a result of this serious environmental challenge.

In Nigeria, Groundnut shell waste with up to 26.48 lakh imperial tonnes produced annually [7]. Groundnut crop were first cultivated in African Countries, particularly in Brasil, and subsequently spread throughout the America, Asia, and northern Argentine [7]. Shells of groundnuts is the outermost layer of the groundnut. It is processed as a solid waste over a longer duration. Shells of groundnuts usage in the building industry is estimated to reduce pollution while also increasing farmers' economic basis, encouraging them to boost output [7]. The groundnut shell ash (GSA) has a density of 257.78 kg per m^3 and a specific gravity of 0.60 [7]. on the other hand, GSA possesses cement qualities that are beneficial to brick manufacturing by improving the binding capabilities. GSA has a specific gravity of 2.10 to 3.20 [10,11,15,14]. GSA has some self-cementing characteristics, as evidenced by the overall oxides content (62.87–76.40) as well as the higher calcium oxide level (24.11 percent)[15,16]. According to many researches, GS waste has special properties that allows it to compete with other materials for construction. GS has already been utilised in sand-crete blocks [28], as a cement substitute [16], and as a fine aggregate replacement [8].

The utilisation of groundnut shell waste in the manufacture of bricks, concrete, and mortar is summarised in this report.

Waste Ground Nut Shells in A Burnt Brick

Fernando etc., [10] looked at the usage of GSA (2–10 percent) as a substitute material for clay in the manufacturing of light weight bricks made of clay (fired at 600 degrees Celsius 850 degrees ccelsius). The results showed that the mean sample densities continuously fell 1505 kg per m^3 to 1226 kg per m^3, while water absorption value grew (13.00 percent to 25.00 percent) from 0.00 percent to 8.00 percent replacement, and then density suddenly climbed to 1385 kg per

m^3 and At ten percent, water absorption dropped to 18.00 percent replacement. The strength of concrete of the GSA mixed samples ranged between 7.00 N/mm^2 (8.00 percent GSA) to 7.00 N/mm^2 (4.00 percent GSA), satisfying the BS:3921 standard's (>5.15 N/mm^2) requirements. GSA's greater SiO_2 content helped to stabilise the brick clay, increasing its strength. In addition, as replacement levels increased, flexural strength declined dramatically. At 2.00 % replacement, the control sample had the maximum flexural strength (0.13 N/mm^2), whereas the GSA mixed samples had the maximum flexural strength (0.11 N/mm^2).

Ground Nut Shell Waste in Mortar

Groundnut shell ash (2.00–10.00 percent) was used in place of OPC in the mortar by Ketkukah etc., [15], using a 1:5 mix proportion. The inclusion of ash reduced the mortar's setting time, indicating that it was suitable for use in hot weather concreting. The density (2285 kg per m^3 to 2150 kg per m^3), water absorption (9.20 percent to 7.81 percent), and 28-days compressive strength values (3.30 N/mm^2 to 2.70 N/mm^2) all decreased when groundnut shell ash was added. However, the strength values exceeded the Nigerian Industrial Standard [24] minimum strength requirement for sand-crete blocks (2.50 N/mm^2). The lighter composition of groundnut shell ash accounts for the drop in density.

Narayana Moorthi etc., [21] conducted studies to determine the best groundnut shell ash substitution proportion in cement (15.00, 20.00, 30.00 and 40.00 percent). The results showed that the strength of the 7-days sample achieved its maximum value (16.70 N/mm^2) at 15.00 % replacement, This was an 8.50 percent increase over the control group. The strength declined linearly when more ground nut shell ash was added, reaching 5.35 N/mm^2 at 40.00% replacement.

Ground Nut Shell Waste in Concrete

The use of groundnut shell powder in concrete was investigated by Mohamed etc,. [28] (10.00–30.00 percentage) and Tata etc,. [7] (10.00–100.00 percent). According to Tata etc,. [7], raising the ground nut shell ash ratio from 10.00% to 100.00% resulted in a decrease in density (1000 kgs per m^3) and strength (7.5 N/mm^2 to 0.75 N/mm^2), but an increase in water absorption (3.20 percent to 35.20 percent). Groundnut shell ash blended concrete was found to be suitable for insulating concrete in the investigation due to its low strength. For non-load bearing (partition) walls, 30.00–70.00 percent replacement had appropriate strength (3.65 MPa to 0.85 MPa) and density (1895 kg per m^3 to 1335 kg/m^3).

Mohamad etc,. [28] created man-made reef using varying amounts of groundnut shell ash (10.00–30.00%). The control sample would have the greatest strength (31.35 N/mm^2), whereas the increased proportion of groundnut shell ash in the concrete produced a fall in strength (25.60 N/mm^2 to 18.10 N/mm^2). Groundnut shell ash has a higher water absorption rate, This resulted in greater voids in the concrete and poor cement-aggregate bonding, reducing the concrete's strength.

In addition, Kumar at al. [12] (5.00 & 10.00 percent), Buari et al. [16] (10.00–40.00 percent), Lakshmi etc,. [18] (5.00–35.00 percent), Alabadan et al. [20] (10.00–50.00 percent), Mujedu etc,.[26] (15.00–75.00 percent), Kanchidurai et al. [9] (5.00–20.00 percent), Reddy et al. [11] (5.00–15.00%), Shubham and Khandelwal [27] (2.50–15.00%), Mahmoud et al. [13] (10.00–50.00%), Ikumapayi etc., [29] (12.00%), Nwofor and Sule[14] (10.00–40.00%), Wazumtu etc., [19] (1.00–5.00 %) substituted cement Sada etc., [7] used groundnut shell ash (5.00–75.00 %) to replace river sand in concrete.

The 28 days optimal compressive strength (41.30 N/mm^2) was recorded at 10.00% cement replacement by groundnut shell ash, according to Reddy et al. [11], and the strength indicated a falling trend beyond 10.00% replacement for cement by groundnut shell ash. Lakshmi et al, [18] (23.20 N/mm^2), Kanchidurai etc.[9] (29.85 N/mm^2), Kumar etc., [12] (28.90 N/mm^2), Buari etc.,al [16] (49.15 N/mm^2), Nwofor etc., al [14] (17.95 N/mm^2), and Alabadan etc., (20.65 N/mm^2). Mahmoud et al. [13], on the other hand, generated a sand-crete block with the maximum compressive strength of 4.00 N/mm^2 with 10.00% cement replacement. Shubham et al, [27] and Mujedu et al, [26] found the highest 28 days compressive strength as 22.15 N/mm^2 and 38.45 N/mm^2 for 15.00 percent groundnut shell ash and 7.50 percent replacement, respectively. The highest compressive strength was found by Wazumtu et al, [19] (33.55 N/mm^2) and Sada etc., [7] (40.60 N/mm^2). The maximum splitting tensile strength was determined to be 4.20 N/mm^2 (10.00 percent GSA) [11], 3.05 N/mm^2 (10.00 percent GSA) [18], 4.75 N/mm^2 (7.50 percent GSA) [27], and 8.21 N/mm^2 (10.00 percent GSA) [12]. The physical and chemical characteristics of groundnut shell ash used by different authors could explain the differences in strength values found in different studies. The mixture hydrates less because groundnut shell ash has lower cementing capabilities, resulting in decreased concrete strength [14,19]. Additionally, the w/c ratio may influence strength, as increasing the w/c ratio can improve strength [18]. Furthermore, the concrete density decreased as the ash percentage increased, ranging from 2120 kg per m^3 (15.00 percent GSA) to 1621 kg per m^3 (75.00 percent GSA) [26], 2302 kg per m^3 (20.00 percent GSA) to 2222 kg per m^3 (40.00 percent GSA) [14], and 2533 kg per m^3 (5.00 percent GSA) to 1854.00 kg per m^3 (75.00 percent GSA) [8]. The fact that groundnut shell ash has a lower specific gravity (2.03) than cement (3.05) [26] explains why there are more voids in the combination. According to

Mahmoud [13] and Sada [7], the workability of the mixture deteriorated when the GSA content was raised due to the higher water absorption ability of groundnut shell ash. GSA supplementation was also found to reduce slump and setting times [13,19]. With the addition of groundnut shell ash. however, water absorption reduced from 0.85 percent (1.00 percent GSA) to 0.45 percent (6.00 percent GSA) [19], 2.65 percent (10.00 percent GSA) to 2.25 percent (40.00 percent GSA) [16].

Kumar etc.,[25] investigated the strength qualities of Fly Ash (10.00 percent, 20.00 percent, 30.00 percent), (CA) (10.00 percent), and (GSA) (10.00 percent, 20.00 percent) mixed with cement. The peak compressive strength and flexural strength for the 10.00 percent CA + 20.00 percent GSA + 10.00 percent FA sample were 34.90 N/mm^2 and 5.90 N/mm^2, respectively, which was an 8.20 percentage and 4.00 % increase in strength over the control sample.

Kumari etc., [17] used (RHA) and GSA 2.51–12.51 percent to substitute cement in concrete. Slump decreased by 35.60 percent as the replacement quantity in the mixture was increased to 12.55 percent, and densities decreased from 2370 kg per m^3 to 2235 kg per m^3. As compared to the control mix (27.50 N/mm^2), compressive strength decreased, but improved with the adding of ash up to 10 percent (27.00 N/mm^2) until dropping to 12.55 percent (21.35 N/mm^2).

Ikumapayi etc., [29] looked at the characteristics of a GSA Concrete Mixed Sample in both water and a Solution of sodium chloride. The moisture absorption levels of the salty specimens was greater (3.27 percent) than that of the water samples, according to the findings (1.25 percent). The compressive of the sodium chloride samples (15 N/mm^2) was observed to be decreased than that of the water samples (17.50 N/mm^2).

Finally it discloses that groundnut shell waste was used to test the qualities of brick, mortar, and concrete. The selected reviewers' finding publications are presented in accordance with all relevant standards in the next section.

Groundnut Shell Wastes have an Impact on the Characteristics of Burnt Bricks

Groundnut shell ash was used to make burnt brick, The GSA brick's average maximum density was found to be 1420 kg per m^3, which meets the BS:3921 minimum criteria (1301 kg per m^3 to 2201 kg per m^3)[23]. The compressive strength was enhanced by groundnut shell ash, and the value ranged from 7.00 to 17.00 N/mm^2. These values met the Standard TS EN 771–1 [22] (7.00 N/mm^2), and Standard: SNI 15–2094-2000 (5.00 N/mm^2) [30], and Standards: BS 3921 [23], BS 5628 [31] the required compressive strength criteria for constructing applications (5.00 N/mm^2). In other hands, GSA's minimal water absorption (15.30 percent) met or exceeded industry norms.

Effects of Groundnut Shell Waste on Mortar Characteristics

Several researchers employed groundnut shell ash [15,21] to substitute cement in mortar. The setting time of mortar improved when the percentage of GSA replaced increased [15]. GSA (3.35 N/mm^2) mortar [15] met Nigerian Industrial Standard [24] for compressive strength. GS powder mortar density was reported to range from 2150 kg per m^3 to 2285 kg per m^3 [15]. The percentage of water absorbed ranged from 7.80 to 9.20 percent [15].

Concrete Characteristics as a Result of Groundnut Shell Waste

The research found that when the amount of ground nut shell ash in the combination increased, the setting time slowed down [13,19]. The low calcium contents in groundnut shell ash led the mixture's hydraulic reactivity to drop, causing the delay. The ACI [32] specifies a max slump of 100 mm, but IS 456 [34] and BS EN 12350–2 [propose a max slump of 150 mm. It can be shown that the GSA 83 mm to 80 mm [13] The slump was within the parameters of the criteria. The smaller particle size, higher carbon content, and larger specific surface area of the waste particles compared to the cement utilised result in a reduction in slump. Such characteristics cause an increase in the amount of water required, making concrete impermeable and very cohesive.

GSA's best 28 days compressive strengths were 41.30 N/mm^2 [12], 49.00 N/mm^2 [16], 38.45 N/mm^2 [27], and 40.60 N/mm^2 [8], The ASTM C 330 (17 N/mm^2 to 28 N/mm^2) and ACI 211 (15 N/mm^2 to 40 N/mm^2) [32] criteria were all met. The rise in strength can be explained by the nut shell waste granules filling capacity in the combination. Groundnut shell ash concrete had highest densities of 2533.33 kg per m^3 [8], 2125 kg per m^3 [26], and 2301 kg per m^3 (GSA) [14]. The decline in density can be explained by the reduced specific gravity of waste granules, as well as the development of voids due to particle size and shape.

CONCLUSION

This article looked into the usage of groundnut shell waste with in brick production, and in mortar and concrete production. The accompanying conclusions could be drawn based on the assessment of different qualities of the manufactured samples in compliance with relevant norms:

- Compared to concrete production, there has been little research on using groundnut shell waste in brick production. Furthermore, the most investigated physical and mechanical attributes of manufactured materials were densities, strength properties, and water content. Any building material's durability must be evaluated before it can be used in a practical setting. However, minimal study has been done on the durability of groundnut shell waste, including sulphate salts effect and acid attack tests, as well as the chloride diffusion depth test. Furthermore, the thermal characteristics of samples that have been mixed with groundnut shells have only been studied infrequently. Furthermore, only a few research compared the cost of the created materials to the cost of conventional materials.
- The high Concentration of SiO2 in groundnut shell ash particles increased strength, while the softer material characteristics resulted to less open holes in the samples, lowering the water absorbing value.
- Groundnut shell ash content of 10–15 percent was discovered to provide the highest strength for replacement of cement in concrete.
- The maximum strength was achieved by 15% of groundnut shell ash in mortar.
- This research will aid in the creation of a database for the development of ground nut shell waste-incorporated brick, mortar, and concrete, which will be beneficial to building material makers.

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