



Production of Ceiling Board using Bio Composite of Ground Nut Shell and Palm Kernal Husk with Starch as Binding Resin

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Abstract This study was carried out to seek process parameter for the Production of bio- composite Ceiling Board. This is done with a view to having alternative materials to the conventional ceiling boards that are costly and also pose health risks, reducing the cost of building material by utilizing agro- waste with disposal problems. Eight specific objectives were raised. Eight research questions was formulated to guide the study. The study employed Research and Development (R&D) design. twenty four (24) bio composite ceiling board samples were produced in different mixing ratio and tested for their properties. The test result are: Modulus of elasticity 5600N/mm, modulus of rupture 0.49N/m² compressive strength 760KPA, density 385kg/m³, thermal conductivity 0.37kw/mk, resistivity 1.28mk/w, water absorption 35.5% and Fire resistance in accordance with ASTM standards The findings revealed that the mix ratio GNS 0.040kg: PKH 0.060kg: starch 0.030kg satisfied all the parameters that were tasted and therefore has the potentials to be adopted for the production of bio-composite ceiling board. Other mix ratios were deficient in one parameter or the other. Based on the findings, cottage industries that would utilize these agricultural wastes should be built in areas where these wastes are found.

Keywords Production, Ceiling Boards, Bio-Composite, Natural fibre, Waste management

Introduction

The demand for wood products has been increasing with the increasing in the population of the world that adversely influences the sustainable utilization of forest resources into building elements. Bachman [1] mentioned some essential elements of shelter or building which include Doors, Windows, Roofs, Walls, Ceilings among others. A ceiling board is a horizontal slab between the headroom and the roof truses. Opined that it is generally not a structural element but a shell concealing the details of the structure above. According to Madu, Nwankwojike & Ani [2] ceilings are panel sheets covering the upper layer of an internal section of a building which improves its aesthetics and reduces sound and heat transmission in the house, it is an essential part in the building process which plays a key role in the thermal comfort of a building [3]. Ceiling as one of the main building elements is very important and has the main function of thermal Conductivity and thermal Resistivity which reduces or increases excessive heat in the room, Water Absorption which is the ability of the ceiling board to retain moisture in the pore or voids without releasing it and without swelled out which is called dimensional stability, Modulus of Rupture or flexural strength which is the measure of resistance to fracture or deformation under load. Modulus of elasticity, it is the tendency of an object to deform along an axis when opposing forces are applied along that axis. Compressive Strength, this is the capacity of the ceiling material to withstand loads. Density, is the relationship between the mass of the substance and how much space it takes. Fire Resistance, is the ability of the ceiling board to delay fire escalation and fire burning. There are different types of ceiling boards. These include: gypsum ceiling boards, acoustical ceiling boards, gypsum fibre ceiling boards and cement fibre ceiling boards etc. These types of ceiling boards are grouped in accordance to the raw



materials used for the production [4]. Gypsum ceiling boards are produced from gypsum, Acoustical ceiling boards are obtained from mineral wool, gypsum, small amount of paper and starch.

Adinarayana [5] confirmed that effective performance of ceiling in building depends on the types of material. Material is a mixture of substance that constitute an object from which a thing is made. According to Sandrers [6], material is generally believed to be anything used to make something. It could be raw (natural) or processed types. Seeley [7] explained further that, the common materials used for ceiling boards are asbestos, wood, polyvinyl chloride (PVC) and plaster of paris (POP). These materials posses different properties that include absorption of moisture and swelling, brittleness, fibrous and high cost [8]. Invariably materials used in ceiling board are not expected to endanger human health in any form both during construction and while dwelling in the building. The asbestos that is used in most residential buildings in Nigeria is associated with the disease of the lungs and therefore prohibited. Asbestos ceiling boards are fragile, pose health risks and relatively costly [9].

The word “waste” readily brings to mind any unwanted, unuseful item that has outlived its usefulness and needs, and usually to be disposed immediately not minding the effects of such disposal practices on the environment. Groundnut shell and palm kernel husk which are the two basic raw materials for this research work, are considered as waste materials and the commonest disposal method is incineration with its attendant effect on the environment. Isheni, Yahaya, Mbishida, Achema & Karfe, [10] pointed out that approximately 25 – 40% of municipal solid waste generated worldwide is made up of agro-waste, these waste products can however be recycled into new products of ceiling board that are more environmentally friendly and can equally add value to the economic development of any society and the building construction industry using agro -waste composite. The waste generated from the processing of agricultural produce such as Ground nut shell and palm kernel husk are already a threat to the environment and human beings because of the disposal problem. The traditional way of disposal of this wastes is by burning. The improper disposal of these wastes leads to increased level of carbon dioxide in the atmosphere, which increase global warming. Accumulated wastes release offensive odour there by contributing to air pollution. Conversion of agricultural wastes to building material offer the double benefit of shelter to the people while also helping to retain the fragile ecological balance.

The combination of ground nut shell and other agro waste materials like Palm Kernel Shell for production of building materials such as ceiling board will no doubt has the potential to make a significant contribution towards the provision of low cost building material and consequently affordable housing. Therefore the problem that this study intend to tackle, was to find ways of utilizing ground nut shell and palm kernel husk which are agro-waste into useful production of composite ceiling board using local technology, thereby converting waste to wealth and reducing the cost of housing delivery in Nigeria.

Materials and Methods

The materials that were used for this study include The groundnut shell (GNS) samples that were used for this study were collected from dump site in Gegu Beke, Koton Karfe Local Government, Kogi State where they are in large quantities and causes disposal problem. Palm kernel husk (PKH) was sourced from oil mills in Ogugu Olamaboro Local Government of Kogi State. Adhesive (Starch resin). Cassava starch was collected from *Gari (processed powdered cassava)* processing factory in Idah local Government of Kogi State. The residue was dried in the sun to get the sample in powdered form. Equipment and Tools, used for this research work include Universal Testing Machine, Thermal Conductivity Testing Machine and Tinus Olsen Universal Testing Machine were used to determine the comprehensive and mechanical properties while the Bending moment apparatus was used to determine the bending strength of the ceiling board. Electronic weighing balance was used to determine the mix ratio of the materials, Hand Trowel for mixing the materials. Measuring cylinder: For measuring the volume of water that was used during the manufacturing process, Grinding machine was used for reducing the particle size of the materials, Bags or Polythene bags was used for conveying the materials to the laboratory, Cellophane was placed on the mould before the casting of the ceiling board for easy removal. Reactor, this is the container in which all the materials used for the production was added together. Stirrer, for stirring all the materials in the reactor. Roller, this is a metallic pipe (Rammer). This was used to compress the mixture in the mould and was also used to smoothen the surface of the mixture, Other equipment used include



Local sieve, cylindrical plastic container, mortar and pestle. meter rule, vernier caliper. A wooden mould constructed by the researcher was used for casting the ceiling board as shown in Figure 1.



Figure 1: 400x400 by 12mm Wooden Mould

Results & Discussion

Table 1: The Result of Modulus of Elasticity

Property	Result	ASTM Standard	Standard Remark
Modulus of Elasticity (MOE)	4950 Nmm ²	5000-6000Nmm ²	Adequate
Modulus of Rupture (MOR)	0.03 N/m ²	0.03-0.07N/m ²	Good
Compressive strength (CS)	260 KPA	448-868KPA	Poor
Density (D)	349 kg/m ³	350-400kg/m ³	Adequate
Thermal Conductivity (TC)	0.024 Kw/MK	0.025-0.057Kw/MK	Adequate
Thermal Resistivity (TR)	0.18MK/W	17.5-19 MK/W	Good
Water absorption (WA)	0.10%	0.37-0.64%	Poor
Fire resistance (FR)	=	=	=

Table 2: The Result of Modulus of Rupture

Property	Result	ASTM Standard	Standard Remark
Modulus of Elasticity (MOE)	3965 Nmm ²	5000-6000Nmm ²	Poor
Modulus of Rupture (MOR)	0.02 N/m ²	0.03-0.07N/m ²	Poor
Compressive strength (CS)	370 KPA	448-868KPA	Poor
Density (D)	349 kg/m ³	350-400kg/m ³	Adequate
Thermal Conductivity (TC)	0.024 Kw/MK	0.025-0.057Kw/MK	Adequate
Thermal Resistivity (TR)	0.16 MK/W	17.5-19 MK/W	Adequate
Water absorption (WA)	0.19%	0.37-0.64%	Poor
Fire resistance (FR)	=	=	=

Table 3: The Result of Optimal Compressive strength

Property	Result	ASTM Standard	Standard Remark
Modulus of Elasticity (MOE)	5100Nmm ²	5000-6000Nmm ²	Adequate
Modulus of Rupture (MOR)	0.03 N/m ²	0.03-0.07N/m ²	Good
Compressive strength (CS)	580 KPA	448-868KPA	Good
Density (D)	369kg/m ³	350-400kg/m ³	Good
Thermal Conductivity (TC)	0.24w/mmk	0.025-0.057w/mmk	Adequate
Thermal Resistivity (TR)	17.23 MK/W	17.5-19 MK/W	Good
Water absorption (WA)	0.36%	0.37-0.64%	Adequate
Fire resistance (FR)	=	=	=



Table 4: The Result of Density

Property	Result	ASTM Standard	Standard Remark
Modulus of Elasticity (MOE)	5600Nmm ²	5000-6000Nmm ²	Good
Modulus of Rupture (MOR)	0.04N/m ²	0.03-0.07N/m ²	Good
Compressive strength (CS)	760KPA	448-868KPA	Excellent
Density (D)	385kg/m ³	350-400kg/m ³	Good
Thermal Conductivity (TC)	0.35KW/MK	0.025-0.057Kw/MK	Good
Thermal Resistivity (TR)	18.0MK/W	17.5-19 MK/W	Good
Water absorption (WA)	0.40%	0.37-0.64%	Good
Fire resistance (FR)	=	=	=

Table 5: The Result of thermal Conductivity

Property	Result	ASTM Standard	Standard Remark
Modulus of Elasticity (MOE)	4950Nmm ²	5000-6000Nmm ²	Adequate
Modulus of Rupture (MOR)	0.3N/m ²	0.03-0.07N/m ²	Good
Compressive strength (CS)	610KPA	448-868KPA	Good
Density (D)	450kg/m ³	350-400kg/m ³	Good
Thermal Conductivity (TC)	0.036Kw/MK	0.025-0.057Kw/MK	Good
Thermal Resistivity (TR)	18.5MK/W	17.5-19 MK/W	Good
Water absorption (WA)	0.20%	0.37-0.64%	Poor
Fire resistance (FR)	=	=	=

Table 6: The Result of thermal Resistivity

Property	Result	ASTM Standard	Standard Remark
Modulus of Elasticity (MOE)	4950Nmm ²	5000-6000Nmm ²	Adequate
Modulus of Rupture (MOR)	0.3N/m ²	0.03-0.07N/m ²	Good
Compressive strength (CS)	580KPA	448-868KPA	Good
Density (D)	450g/m ³	350-400kg/m ³	Good
Thermal Conductivity (TC)	0.24Kw/MK	0.025-0.057Kw/MK	Adequate
Thermal Resistivity (TR)	16.8MK/W	17.5-19 MK/W	Adequate
Water absorption (WA)	0.40.3%	0.37-0.64%	Good
Fire resistance (FR)	=	=	=

Table 7: The Result of water absorption

Property	Result	ASTM Standard	Standard Remark
Modulus of Elasticity (MOE)	4950Nmm ²	5000-6000Nmm ²	Adequate
Modulus of Rupture (MOR)	0.3N/m ²	0.03-0.07N/m ²	Good
Compressive strength (CS)	300KPA	448-868KPA	Poor
Density (D)	124kg/m ³	350-400kg/m ³	Poor
Thermal Conductivity (TC)	0.025Kw/MK	0.025-0.057Kw/MK	Adequate
Thermal Resistivity (TR)	16.5MK/W	17.5-19 MK/W	Adequate
Water absorption (WA)	0.10.8%	0.37-0.064%	Poor
Fire resistance (FR)	=	=	=

Table 8: The Result of Fire resistance

Property	Result	ASTM Standard	Standard Remark
Modulus of Elasticity (MOE)	5312Nmm ²	5000-6000Nmm ²	Adequate
Modulus of Rupture (MOR)	0.2N/m ²	0.03-0.07N/m ²	Adequate
Compressive strength (CS)	447KPA	448-868KPA	Adequate
Density (D)	450kg/m ³	350-400kg/m ³	Good



Thermal Conductivity (TC)	0.050Kw/MK	0.025-0.057Kw/MK	Good
Thermal Resistivity (TR)	18.5MK/W	17.5-19 MK/W	Good
Water absorption (WA)	0.20.%	0.37-0.64%	Poor
Fire resistance (FR)	=	=	=

Key:

W/mmk = Watt per millimeter

KelvinN/m² = Newton per meter squareX10³ = mili 0.00 (one thousand)**Table 9:** Engineering and material science standards for ceiling boards

%Fiber	Density (KG/M ²)	Compression strength, cs (KPA)	Modulus of elasticity (N/mm ²)	Modulus of rupture (N/m ²)	Water absorption WA (%)	Thermal conductivity (W/M.K)	Thermal resistivity (W/M.K)
Standard	350-400	448-868	5000-6000	0.03-0.07	0.32- 0.64	0.052-0.057	17.5-19

Source: Standard Organization of Nigeria. (SON)**<http://www.sciencedomain.org/review-history.php?iid=713&id=5&aid=6578>****Key:**

Standard

Min	Mix	Remark
75	- 100%	Excellent
50	- 74%	Good
25	- 49%	Adequate
0	- 24%	Poor

Test Result

The bio- composite ceiling board produced from the mix ratio of GNS 0.040kg: PKH 0.060kg: starch 0.030kg Table 4 has Modulus of elasticity of 5600N/mm², Modulus of rupture of 0.4N/mm² is good enough to resist deformation under load and opposing forces. This attribute does not alter the size and shape of the ceiling board, the mix ratio has excellent compressive strength of 760KPA which makes the ceiling board rigid to support fastener load sustaining the total roofing system. The density of the mix ratio also yielded good result of 385Kg/mm². This attribute makes the ceiling board well compacted and does not contain air space which is not liable to collapse or breakage during storage, transportation and usage. Good thermal conductivity of 0.35kw/mk, thermal resistivity of 18.0kw/mk respectively this attribute of the bio-composite ceiling resist heat penetration and help provide comfort in the building. water absorption of the composite ceiling board produced from the mix ratio is 25.5% which is within the accepted standard this ceiling board has good water holding capacity. This result agrees with that of Ataguda [3], The flexural strength of 0.03360N/m² was obtained, which is good enough to withstand wind forces. In a study conducted by [11]. Akinyemi, Afolayan, & Oluwatobi [11] and Ataguda [3], got flexural strength of 0.054N/mm², 0.03N/mm² and 0.05N/mm² respectively. The composite ceiling board from GNS: PKH: Starch as binder: has adequate flexural strength than that produced by Ataguda [3]. However, the one produced by Banjo et'al and Obam yielded more strength [11]. The water absorption of the composite ceiling tile is 19.22% which means the composite ceiling tile is impervious; this means that it will maintain dimensional stability. Dorostkar *et al* [12] investigated the water absorption property of wood plastic composite and got 12% water absorption, Banjo et'al got water absorption of 49.85% while Ataguda [3] got water absorption of 14.5%. The result of Banjo et'al exceeded the specified standard therefore the ceiling board will absorb water, the thickness will swell up. The researchers, Dorostkar *et al* [12] and Ataguda [3] obtained, water absorption values that are within the accepted standard. These results indicate that the composite ceiling board produced from GNS and PKH has a higher resistance to fracture than that of Obam. This mix ratio has satisfied all the physical properties investigated and therefore ideal for production of bio-composite ceiling bo





Figure: 2. Bio- composite of Groundnut Shell & Palm kernel Ceiling Board

Conclusion

This study was carried out to solve the problem of high cost of building materials especially ceiling board. The study was to proffer solution to the challenge of agricultural waste disposal particularly Groundnut shell and palm kernel husk by utilizing these wastes for the production of bio-composite ceiling board. The eight different mix ratios were tested. Only one had all the properties of ceiling board within the accepted standard of ASTM. That is GNS 0.040kg: PKS 0.060kg: starch 0.030kg. The rest of the mix ratios were deficient in one property or the other. Based on the findings it is recommendations that.

- The findings of the mix ratio that satisfy all the parameters be used by ceiling board manufacturing industries for massive production of bio-composite ceiling board.
- The Nigerian Building and Roads Research Institute (NBRRI) should recommend this ceiling board to Architects, prospective house owners and contractors.
- Production Factories for bio-composite ceiling boards be established as part of the development programmes of higher institutions creating jobs for both skilled and unskilled personnel in the midst of locally available raw materials.

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