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Production of Ceiling Board Using Bio Composite of Arachis Hypogaea and Eleas Guinessis Waste with Amylum As Adhesive.

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ABSTRACT: *This study focused on 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 In four phases: Phase I: Access needs to identify goals Phase II: Development of New concept Phase III: Description and development of ceiling board using bio-composite ofArachis Hypogaea (Groundnut shell) and (Eleas Guinesis) Palm kernel husk with Amylum (starch) as Adhesive. Phase IV: Test Techniques and Decision on the study task.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% 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: *Ceiling Boards, Bio-Composite, Arachis Hypogaea, Eleas Guinesis, Adhesive.*

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I. 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 (2008) 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. Obam (2016). Opined that it is generally not a structural element but a shell concealing the details of the structure above. According to Madu, Nwankwojike & Ani (2018) 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. (Ataguba, 2016). 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. 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 (Ajayi and

Fuwape, 2005). Gypsum ceiling boards are produced from gypsum, Acoustical ceiling boards are obtained from mineral wool, gypsum, small amount of paper and starch.

Adinarayana (2015) 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 (2011), material is generally believed to be anything used to make something. It could be raw (natural) or processed types. Seeley (2010) 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. (South African Building Interior System Association SABISA, 2013). 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.(Koleoso 2019).

An adhesive is a substance used to hold other materials together. Adhesives can be produced from natural rubber, and starch, (Bart, 2005) starch or Amylum is abundant in nature and renewable and can be used to produce glue (Gidde, 2007). It is a carbohydrate containing large number of glucose units linked by glycosidic bonds. It is the most common carbohydrate in the human diets and is found in great amounts in staple foods as such potatoes, wheat, maize, rice, and cassava. Pure starch is a white, tasteless and odorless powder that is insoluble in cold water or alcohol.Reddy, & Yang, (2005) states that a good adhesive must have proper viscosity, which is the thickness of a liquid or its resistance to stirring.

Bio composite is a composite material formed by a reinforcement of natural fibers. Bio fibers are the principal components of bio composites, which are derived from biological origins.In the context of this study, the matrix is the starch.Holbery, & Houston (2006). Asserted that the matrix is important to protect the fibers from environmental degradation and mechanical damage, to hold the fibers together and to transfer the loads on it. Due to its great benefits, it is renewable, cheap, recyclable, and biodegradable. Advocates of bio composites state that the use of these materials improve health and safety in their production, are lighter in weight, have a visual appeal and are environmentally superior**.** (Şafak, Ahmet, Mustafa, & Hasan, 2018).

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 also known as Arachis hypogaea and palm kernel husk (Eleas Guinesis)which are the two basic raw materials for this research work. Isheni, Yahaya, Mbishida, Achema & Karfe, (2017) 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.

II.MATERIALS, EQUIPMENT, TOOLS AND METHODS

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. As shown inFigure 1, 2, 3 & 4.

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 reseacher was used for casting the ceiling board.

Fig:1 Palm Kernal Husk

Fig: 2 Ground nut shell

Fig: 3 Ground nut shell Powder

Fig: 4 Cassava starch

III.PREPARATION OF MATERIALS

The groundnut shells and palm kernel husk was collected in sacks of 50kg separately, washed with water to remove the sand and other impurities. The washed groundnut shells and palm kernel husk were solar dried and hammer milled to reduce the size to smaller ones and then ground in a machine and the particles were sieved through 0.5mm, 1mm and 1.5mm BS sieves respectively to obtain fine uniform particles. The purpose of reducing the particle size is to prevent balling when mixing with other composite materials. Waste liquid from raw cassava in Gari (processed powdered cassava) processing factory was collected in buckets and allowed to settle and decanted. The residue was dried in the sun to get the sample in powdered form. This served as adhesive to the composite.

3.1Mix Ratio Ground nut shell powder and palm kernel husk fibre were mixed in the prescribed proportions by weight. (Table 1) The mixing was carried out in a plastic bucket and stirred to a homogenous mix. The two matrices were mixed differently to prevent segregation of materials after mixing, starch was mixed with the Ground nut shell powder and palm kernel husk separately before the entire mixture was brought together, the matrix and composite fibre were measured by weight according to the stated ratios. The scoopand measuring scale were used in measuring the quantity of materials mixed. The starch was prepared and mixed with the groundnut shell in a separate plastic container thoroughly to a homogeneous state. Themixture of ground nut shell and starch were then emptied in the palm karnal husk and the mixing progressed until a uniform consistency of the whole mixture was achieved before moulding began.

Mix ratio %								
GNS(kg)	0.020	0.015	0.030	0.030	0.040	0.020	0.015	0.040
PKH(kg)	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
Starch(kg)	0.015	0.025	0.030	0.015	0.030	0.020	0.020	0.025
Sample	A	B	C	D	E	F	G	H
24 Samples	A1 A2 A3	B1 B2 B3	C1 C2 C3	D1 D2 D3	E1 E2 E3	F1 F2 F3	G1 G2 G3	H1 H2 H3

Table 1: Population Distribution Table.

3.2 Moulding of Specimen

The composite materials having been thoroughly mixed with binder and water, was cast in a wooden mould of size 400x400 mm with a thickness of 12mm, using manual compaction by hand and rod. A trowel was used to smoothen the exposed top surface. Polyethylene sheet was used to seal the inside of the mould to prevent the board from sticking onto the mould Samples were cast using different mix ratios, the mix ratio of 0.030kg: 0.020kg: and 0.015kg were fed into the mould with the aid of hand trowel to give a smooth surface finish. The speciemens were allowed to set and dry by exposure to the sun. Demoulding the samples was done as soon as the samples have gained enough strength to support themselves. After demoulding, the boards edges were trimmed with circular saw to avoid edge effect and cut into the required sizes for testing


Fig. 5. 400x400x12mm wooden mould **Fig 6. Bio- composite of Ground nut shell and Palm kernel Ceiling Board**

3.3 Testing of the Specimen

3.3.1Modulus of Elasticity

Modulus of elasticity (MOE) is defined as the ratio of tensile stress to tensile strain; it is the tendency of an object to deform along an axis when opposing forces are applied along that axis

MOE of the samples were calculated using the formula:

$MOE = PL^3/4bdH$

where: MOE = modulus of elasticity (N/mm2): P = Ultimate failure load (N): L= the span of board sample between the machine supports (mm): b = width of the board sample (mm): d = thickness of the board sample (mm) and H = Increase in deflection (mm).

3.3.2 Modulus of Rupture (MOR)

Modulus of Ruptureorflexural strength is defined as the stress in a material just before it yields in a flexure test. The flexural strength represents the highest stress experienced within the material at its moment of yield. The bio-composite boards were cast to size 100x100x500 mm sample beam. The hardened samples were subjected to flexural (bending) stress

(MOR) was calculated using the formula:
MOR=3PL/2bh²
where: MOR = Modulus of rupture (N/mm2): P= the ultimate failure load (N): L = the board span between the machine supports (mm): b = width of the board sample (mm) and h= thickness of the board sample (mm).

3.3.3 Density

The density of a substance is the relationship between the mass of the substance and how much space it takes (volume) It is a measure of mass per unit volume. This was carried out according to Standard Specifications ASTM C1186-08(2012)
Density =M/V. where M is the weight of the test pieces in kg: and V is the volume of the sample in kg/m3**3.3.4 Compressive Strength (CS)**
This is the capacity of a material to withstand loads tending to reduce its size. It is also the maximum load per cross sectional area of the material. This was carried out using, Instron 4260 universal testing machine.

3.3.5 Water Absorption Test

Water absorption is defined as the ratio of mass of water absorbed over the dry mass of material**.** This refers to the uptake of liquid into the fibre of a substance, it is used to determine the amount of water absorbed under specified conditions. Factors affecting water absorption include the type of material and additives used, temperature and the length of exposure to humid condition. Water absorption was calculated using the formula; W1W2/W2 X 100% in accordance with international method Standard Specification ASTMD 570 for composite material.The calculation formula to determine the percentage moisture content (MC) is as follows:
Percentage MC: Wo X
= percentage moisture content.

3.3.6 Thermal Conductivity

is the ability of a material to conduct heat. The bio-composite ceiling board sample was cast to a size of400mmx400mm and thickness 12mm. A hardened sample was placed between hot and cold surfaces of thermal conductivity test machine. The hot surface was heated while cold water was made to pass through the cold surface continuously through out the period of heating. The temperatures at the hot surface (T_1) and cold surface (T_2) were noted as soon as steady temperature readings were observed. The thermal flux (p) was noted in the electric power of the heater.

$$K = \frac{pt}{A(T_1 - T_2)}$$

3.3.7 Thermal Resistivity (TR)

This is the reciprocal of thermal conductivity, denoted by Psi with unit of Kelvin-meter per watt.

$\Psi = 1/_K$

Ψ = thermal resistivity

Ψ = thermal conductivity

IV. RESULTS & DISCUSSION

Table 2. The Result of Modulus of Elasticity

Property	Result	ASTM Standard	Standard Remark
Modulus of Elasticity (MOE)	4950 Nmm²	5000-6000Nmm²	Adequate
Modulus of Rupture (MOR)	0.03 N/m²	0.03-0.07N/m²	Good
Compressive strength (CS)	260 KPA	448-868KPA	Poor
Density (D)	349 kg/m³	350-400kg/m³	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 3. The Result of Modulus of Rupture

Property	Result	ASTM Standard	Standard Remark

Modulus of Elasticity (MOE)	3965 Nmm²	5000-6000Nmm²	Poor
Modulus of Rupture (MOR)	0.02 N/m²	0.03-0.07N/m²	Poor
Compressive strength (CS)	370 KPA	448-868KPA	Poor
Density (D)	349 kg/m³	350-400kg/m³	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 4: The Result of Optimal Compressive strength.

Property	Result	ASTM Standard	Standard Remark
Modulus of Elasticity (MOE)	5100Nmm²	5000-6000Nmm²	Adequate
Modulus of Rupture (MOR)	0.03 N/m²	0.03-0.07N/m²	Good
Compressive strength (CS)	580 KPA	448-868KPA	Good
Density (D)	369kg/m³	350-400kg/m³	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 5: The Result of Density

Property	Result	ASTM Standard	Standard Remark
Modulus of Elasticity (MOE)	5600Nmm²	5000-6000Nmm²	Good
Modulus of Rupture (MOR)	.04N/m²	0.03-0.07N/m²	Good
Compressive strength (CS)	760KPA	448-868KPA	Excellent
Density (D)	385kg/m³	350-400kg/m³	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 6: The Result of thermal Conductivity

Property	Result	ASTM Standard	Standard Remark
Modulus of Elasticity (MOE)	4950Nmm²	5000-6000Nmm²	Adequate
Modulus of Rupture (MOR)	0.3N/m²	0.03-0.07N/m²	Good
Compressive strength (CS)	610KPA	448-868KPA	Good
Density (D)	450kg/m³	350-400kg/m³	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 7: The Result of thermal Resistivity

Property	Result	ASTM Standard	Standard Remark
Modulus of Elasticity (MOE)	4950Nmm²	5000-6000Nmm²	Adequate
Modulus of Rupture (MOR)	0.3N/m²	0.03-0.07N/m²	Good
Compressive strength (CS)	580KPA	448-868KPA	Good
Density (D)	450g/m³	350-400kg/m³	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 8: The Result of water absorption

Property	Result	ASTM Standard	Standard Remark
Modulus of Elasticity (MOE)	4950Nmm²	5000-6000Nmm²	Adequate
Modulus of Rupture (MOR)	0.3N/m²	0.03-0.07N/m²	Good
Compressive strength (CS)	300KPA	448-868KPA	Poor
Density (D)	124kg/m³	350-400kg/m³	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)	=	=	=

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 5**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 (2016) and Obam (2012), The flexural strength of 0.03360N/m^2 was obtained, which is good enough to withstand wind forces. In a study conducted by Banjo, Afolaya & Ogunji in 2016 and Ataguda in 2016, Obam in 2012 got flexural strength of 0.054N/mm^2, 0.03N/mm^2 and 0.05N/mm^2 respectively. The composite ceiling board from GNS: PKH: Starch as binder: has adequate flexural strength than that produced by Ataguda. However, the one produced by Banjo et'al and Obam yielded more strength. 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. Alireza, Ali & Mehrab (2014) 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 (2016) 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, Alireza et'al (2014) and Ataguda (2016) 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

V. 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.

1. 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.
2. The Nigerian Building and Roads Research Institute (NBRRI) should recommend this ceiling board to Architects, prospective house owners and contractors.
3. 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.

REFERENCES

[1]. Adinarayana, M. (2015) Construction and building materials Retrieved from www.vigyanprasal.gov.in> brief>building.pdf.

[2]. Allen E. (2005) Fundamentals of Building materials and methods (5th ed) New York. John Willey and Sons Inc.

[3]. ASTM C367/C367-09 Standard Test Method for strength properties of prefabricated architectural acoustical tile on lay in ceiling panels. 2014 ASTM International West Conshocken P.A.

[4]. ASTM D7433-13 Standard Test Method for Measuring Surface Water Absorption of overlaid Wood based Panels. 2013 ASTM International West Conshocken, P.A.

[5]. ASTM E 119-00 (2014). Standard test methods for fire Tests of building construction and materials.

[6]. ASTM international, West Conshohocen PA 2014.

[7]. Ataguba, C.O. (2016), Properties of ceiling board produced from a composite of waste paper and rice husk. International journal of advanced in science engineering and technology.117-120

[8]. Atiqah, A. Jawaid, M. Ishak, M & Sapuan, M. (2017). Moisture Absorption and Thickness Swelling Behaviour of Sugar Palm Fibre Reinforced Thermoplastic Polyurethane, Procedia Engineering 184 581-586.

[9]. Bachman, R. & Dowty, S. (2008). Non-structural components and none building structures, Retrieved from www.skghoshassociates,com/.../Bachman.

[10]. Bart, J. C. J. (2005) Adhessive in polymers: Industrial analysis and applications England: John Wiley and Sons ltd.

[11]. Beghezan, C.T., (2015), "Fabrication and Performance of Natural Reinforced Composite Materials", Journal of Polymer Engineering and Science, 35, 970 - 978.

[12]. Bergman, T. I. & Bourell, D. L. (2013). Material and Processing Retrieved from www.wtec.org>addditve>report,pdf.

[13]. Holbery, J. & Houston, D. (2006). Natural-fiber-reinforced polymer composites applications in automotive. Jom, 58(11): 80-86.

[14]. Koch, J. D. Glassley, M. R.& Cunnningham, R. N. (2011) Process for the mixture of ceiling Tiles Retrieved from http://www.google.com/patents/USS194206.

[15]. Koleoso A. O, Edmond O. A, Godwin K. O & Hyginus O. O. (2019) Production of Ceiling Tile with High Density Polyethylene (HDPE) and Polyethylene Terephthalate (PET) Plastic Wastes as Main Ingredients. Retrieved from https://www.researchgate.net/publication/336811257

[16]. Madu. Nwankwojike & Ani, (2018). Optimal Design for Rice Husk-Saw Dust Reinforced Polyester Ceiling Board"American Journal Of Engineering Research (AJER), 7, 6. 11-16.

[17]. Mantia, F. & Morreale, M. (2011). Green composites: A brief review. Composites Part A: Applied Science and Manufacturing 42(6): 579–88, Doi: 10.1016/j.compositesa.2011.01.017.

[18]. S.O. Obam (2016) "Properties of saw dust, paper and starch composite ceiling borads". American Journal of Scientific and Industrial Research Vol. 3 pp300- 304.

[19]. Sandrers, P. (2011). Types of building materials Retrieved from htt://www.lawyerment.com/library/article/RealEstate/General/3624:html.

[20]. Seeley, I.H. (2010). Building technology: fifth edition. London: Palgrave Macmillian Press Ltd

[21]. South African Building Interior System Association (SABISA) (2013) General specification for suspended ceiling. Retrieved from www.superteceiling.co.za>2013/02

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