Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2017, 4(6):208-212**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Production of Agro Waste Composite Ceiling Board (A Case Study of the Mechanical Properties)

Isheni Yakubu[1], Yahaya B. S[1], Mbishida M. A.[2], Achema Felix[1], Karfe Gayus S[1]

[1]Engineering Materials Research Department, Nigerian Building and Road Research Institutes, KM 10 Idiroko Road, Ota, Ogun State, Nigeria
[2]Building Research Department, Nigerian Building and Road Research Department, Nigeria

Abstract The word waste readily brings to mind any unwanted item that has outlived its usefulness and needs to be disposed immediately which might have negative effect on the environment. Agricultural waste such as saw dust, palm kernel shell, rice husk, maize husk, etc are available in large volume but there mode of disposal is causing a great menace to the environment. The use of agricultural waste such as rice husk, maize husk and saw dust can be beneficial in its usage as ceiling board to eliminate the health hazard which asbestos presents. This research work seeks to present process parameter for the production of agro waste composite ceiling board. The specimens were produced and cast into rectangular and squares shapes in different mixing ratio, polyvinyl acetate was used as a binder. A total of twenty-eight (28) specimens were formed and allowed to cure naturally in the laboratory, there average values were reported. The produced ceiling boards were tested for percentage of water absorption, flexural strength, modulus of elasticity, thermal conductivity, and density in accordance with ASTM and British standards. From the obtained results, the water absorption properties ranges from 12.30% to 23.35%, the thermal conductivity ranges from 0.098 to 0.065, the flexural strength ranges from 0.05N/mm^2 and 0.1N/mm^2, the density of the composite material exhibited a decreasing trend with increase in saw dust content ranges between 103kg/m^3 and 190kg/m^3.

Keywords Agro waste, mechanical properties, ceiling board, composite

Introduction

Nigeria is an agricultural country with annually wastes of over ten millions ton of agricultural wastes such as: rice husk, straw, bagasse, coconut fiber, banana, maize, bean cover etc. Most of these waste materials are mostly poorly discarded causing pollution by two main forms:

- Discard uncontrolled caused pollution in the canals, river banks, village roads
- Burnt caused CO_2 emission to the environment, smoked impacted to the life of the people. [1]

Figure 1: Uncontrolled disposal of agro-waste at the river banks and burnt caused pollution [1]

Some of these agro-waste products can however be recycled into new products that are more environmentally friendly that can equally add value to the economic development of Nigeria. Reports have it that approximately 25 – 40% of municipal solid waste generated worldwide is made up of agro-waste [2]. Similarly, nearly 140 million tons of rice husk are generated from the annual 700 million tons of paddy rice harvest worldwide with its disposal posing a serious environmental problem [3, 4]. In Nigeria, about 3 million tons of paddy rice is produced yearly giving rise to an annual rice husk generation of 600,000 tons [5]. The major disposal technique utilized for these agro-wastes is burning (incineration) which results in serious air/environmental pollution. [1, 3]

Ceiling boards are required in houses to reduce sound and heat and they give additional aesthetics. A ceiling with its upper surface highly reflective, having a good heat insulation and low thermal capacity is recommended in hot climates [6]. As a performance standard, it is recommended that thermal conductivity of ceiling boards should be within 0.50-0.15 W/mK [7]. All types of asbestos fibers are known to cause serious health hazards to humans. Amosite and crocidolite are considered the most hazardous asbestos fiber types; however, chrysotile asbestos has also produced tumors in animals and is a recognized cause of asbestosis and malignant mesothelioma in humans, and mesothelioma has been observed in people who were occupationally exposed to chrysotile, family members of the occupationally exposed, and residents who lived close to asbestos factories and mines [8, 9]. Asbestos ceiling boards are fragile, pose health risks and relatively costly. Therefore, there is a compelling need to produce alternative products that are cheap, using local organic materials that could pose little or no health hazards. [10]

Rice husk, Saw dust and Maize husk are the main basic raw materials for this research work and are considered as waste materials and the commonest disposal method is incineration. The main focus of this study is to further explore the potentials in the use of inexpensive and locally available waste materials in the production of low cost building materials that are environmentally friendly as well as enhance waste-to-wealth principle.

Materials and Methods

The main agro-waste that were employed during the cause of this research work are

i. Maize husk
ii. Rice husk
iii. Saw-dust

And white gum serves as the binder.

The raw materials for this composite material were obtained locally from Tafawa Balewa Local Government Area of Bauchi State, Nigeria. The rice husk was obtained from the rice mill; saw dust was obtained from the saw mill and the maize husk from the maize plantation. The saw dust was sieved to the required particle size (600µm), Maize husk and rice husk were also crushed using crushing machine to the desired grain size. The maize husk, rice husk and sieved saw dust were packed in sealed polythene to prevent contamination. The mould for this research was made from 10mm thick plywood to form a 270mmx270mmx23mm with a 3mm thick plywood was used to cover the bottom of the mould. The Jig (Rammer) is from a 10mm thick plywood to form a square of 268mmx268mm. The outside of the rammer is projection was fixed for the pressing process.

The rice husk, maize husk, saw dust and white gum were mixed in different proportion with binder/composite ratio of 0.6 and cast into the prepared mould for water absorption, thermal conductivity tests as well as 75mm x 75mm x 450mm for flexural strength and modulus of elasticity tests. Four samples each were prepared for each test at the composite mix percentages and openly dried in the laboratory 7 days. This gives a total of 28 samples and the average values were presented in this report.

The process for the production of ceiling boards

Rice husk, Maize husk, Saw-dust, and the binder (top gum) were mixed at arbitrarily selected ratios. A known weight of the mashed waste paper and the starch were mixed. Selected ratios of Rice husk, Maize husk and Saw dust were mixed. The rice husk-maize husk-sawdust mix was mixed with the binder in a container. It was thoroughly stirred to a homogenous mix. A mould of size 270x270 mm with a thickness of 3mm was cleaned and oiled lightly with petroleum lubricant. The mix was then cast into the mould with manual compaction by hand and rod. A trowel was used to smoothing the exposed top surface. Twenty eight samples of the boards were produced. The boards were demoulded at the seventh day. Removing the moulds from the samples was done as soon as the samples have gained enough strength to support themselves.

Tests Carried Out on the Ceiling Board Samples

Water Absorption, (P): The dry boards were weighed and immersed in water for 24 hours. They were allowed to surface-dry then weighed. The water absorption was calculated according to [11]

$$p = \frac{(w_s - w_d)100}{w_d} \quad (1)$$

P is the percentage water absorption

W_s of the surface-dry sample

W_d dry sample

Thermal Conductivity, (K): The composite was cast to size 400mmx400mm and thickness 3mm. 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 throughout 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, the thermal conductivity was then calculated according to [11]:

$$K = \frac{pt}{A(T_1 - T_2)} \quad (2)$$

K is thermal conductivity

Flexural Strength, (σ_f): The composite for the flexural strength was cast to the size of 100x100x500 mm sample beam. The hardened samples were subjected to flexural (bending) stress according to BS 1881: part 118, 1983 (11). Flexural stress was calculated thus [11]:

$$\sigma_f = \frac{pl}{bd^2} \quad (3)$$

p is the maximum load on the beam

l is the span of beam

b is the width of the beam

d is the depth of the beam

Result and Discussion

Table 1: Water Absorption Test Result

Specimen	Dry Mass (g)	Saturated Mass (g)	Percentage Water Absorption
A	100.00	112.80	12.80
B	83.10	101.80	22.50
C	67.40	76.40	13.35
D	86.40	100.90	16.78
E	76.40	85.80	12.30
F	76.00	87.40	15.00
G	71.20	83.80	17.70

Table 2: Physical Test Results From the Composite Material

Sample	Density (Kg/m^3)	Flexural Strength (N/mm^2)	Thermal Conductivity (kw/mk)	MOE (N/mm^2)
A	190	0.05	0.098	1250
B	185	0.07	0.082	1265
C	162	0.09	0.075	1288
D	153	0.1	0.071	1320
E	135	0.09	0.07	1315
F	123	0.07	0.068	1312
G	103	0.05	0.065	1301

Discussion of Results

From Table 1, it was observed that all the samples water absorption properties were within the acceptable values with percentage ranging from 12.30% to 23.35%. The highest water absorption capacity was observed in average value of sample G and the lowest values were observed in average value of sample E, the high value of the absorption capacity varies across the mix ratio with the sample having more of rice husk exhibiting higher values. The composite exhibited a declining thermal conductivity with samples that have more of rice husk. The samples have an average thermal conductivity ranging from 0.098 at highest value to 0.065 at lowest. Asbestos have thermal conductivity value of about 0.096 [11], which shows the samples have great insulating properties and this proof its shows good potential as ceiling board. A flexural strength ranging from 0.05N/mm^2 and 0.1N/mm^2 indicate a fragile board. Asbestos board has average flexural stress of about 1.00 N/mm2 [11]. The density test showed that the density of the composite material exhibited a decreasing trend with increase in saw dust content ranging between 103kg/m^3 and 190kg/m^3, the modulus of elasticity shows good quality of the produced composites as shown in Table 2 above (physical properties of the produced composite)

Conclusion

The ever increasing cost of building materials makes the search for cheaper materials very necessary. In many developing countries, including Nigeria, asbestos products are dominant in the building industry, but this has great health hazards on the occupants. In this paper agro-waste such as saw-dust, rice husk and maize husk have been convert into useful ceiling board products. The composite sample boards were subjected to thermal conductivity test, water absorption, flexural test and modulus of elasticity test. The composite board shows good characteristics in the entire test it was subjected to. The composite boards were successfully nailed with firm grips. The boards show good potential as ceiling boards. This composite material compares favorably with other commercially available ceiling board materials. This study has equally shown that waste materials can be recycled into other useful materials, such as agro-waste ceiling boards.

Recommendation

The recommendation from the research work is that the composite boards need to be impregnated with bituminous materials to reduce its water absorption or permeability. The commercial production of the board can be mechanized to enhance its properties. Nails could be substituted with bolts and rivets when fixing the boards. It is also highly recommended that production factories for composite ceiling boards be established as part of the entrepreneurship development programmes of our higher institutions and research institutes for both skilled and unskilled personnel in the midst of locally available raw materials. More research is also encouraged in the area of composite ceiling materials from recyclable waste materials with different binding material.

Reference

[1]. Vo Chi Chinh and Hoang An Quoc, Manufacturing Heatproof Ceiling from Agricultural Wastes, 2013, *J. Eng. Technol. Educ.* 10(2): pp: 111 – 117

[2]. R.W.J. McKinney, Technology of paper recycling. Blackie, London. 1995.

[3]. FAO Rice market monitor 2010. Vol. 8(2) www.fao.org/docrep/012/al307e/al307e00.pdf Accessed April 2017

[4]. M.R. Gidde, and A.P. Jivan "Waste to wealth: Potentials of rice husk in India, A literature review". International Conference on Cleaner Technologies and Environmental Management, Pondicherry India January 4-6 2007 pp586-590

[5]. J.A. Chukwudebelu, C.C. Igwe, and E.I. Madukasi, "Prospects of using whole rice husk for the production of dense and hollow bricks', African Journal of Environment, Science and Technology 2015 Vol 9(5) pp493-501.

[6]. Badejo, S. O., (2001); Saw-dust utilization for building materials production in Nigeria-Technical report, No. 50, forestry research institute of Nigeria, Ibadan

[7]. Ebeh, S. E., (1997); Recycling of solid domestic and agricultural wastes for use in building industry as alternative to asbestos ceiling boards; thesis, University of Agriculture Makurdi

[8]. Straif, K; Benbrahim-Tallaa, L; Baan, R; Grosse, Y; Secretan, B; El Ghissassi, F; Bouvard, V; Guha, N; Freeman, C; Galichet, L; Cogliano, V; WHO International Agency for Research on Cancer Monograph Working Group (2009). "A review of human carcinogens—Part C: Metals, arsenic, dusts, and fibres" (PDF). The Lancet. Oncology. 10 (5): 453–4. doi:10.1016/S1470-2045(09)70134-2.

[9]. Kanarek, M. S. (2011). "Mesothelioma from Chrysotile Asbestos: Update". Annals of Epidemiology. 21 (9): 688–97

[10]. Badejo, S. O. and Giwa, S. A., (1985); Volume assessment and economic importance of wood wastes utilization in Nigeria- Technical report, No. 50, forestry research institute of Nigeria, Ibadan

[11]. Obam, Sylvester Ogah, 2012, Properties of saw-dust, paper and starch composite ceiling board, American journal of scientific and industrial research, pp: 300-304 ISSN: 2153-649X