International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 13, Issue 2 [February. 2024] PP: 51-56

Suitability of Environmental Waste in Production of Non-Asbestos Ceiling Board Using Paper Pulp

[1] Ibikunle, O. A, [2] Aderinto, S. J [3] Olawoore, W. A, [4] Oyedokun, O. M and [5] Hassan, K M

[1,2,3,5] Civil Engineering Department, Adeseun Ogundoyin Polytechnic, Eruwa, Oyo State Nigeria
[4]Electrical and Electronics Engineering Department, Adeseun Ogundoyin Polytechnic, Eruwa, Oyo State Nigeria
Corresponding Author: ibks76@gmail.com

ABSTRACT: *Asbestos ceilings were used because of their fireproofing and heat resistance properties. In houses, asbestos ceilings are most commonly found in interior rooms where ta fire may start unattended. Thus, asbestos ceilings were used to reduce the risk of fire spreading through the ceiling. This study revealed the production of a locally made ceiling boards using non-asbestos materials, specifically waste paper. The main aim was to reduce the environmental impact of the waste and as well as removing the health risk involved with the use of asbestos materials through recycling for the utilization and benefit of our man. The fibres used for the ceiling boards are cellulose fibre obtained from pulped carton. The raw materials used are Cement, Calcium, Kaolin, Starch, and Water. Ceiling boards with unique designs were produced from pulped carton or paper. The new ceiling board was subjected to performance evaluation tests. The analyses of the experimental tests conducted on paper specimens showed that its qualities and properties meet up to standard without dangerous side effect unlike the convectional ceiling board. Cement to paper ratio is 3:5 in making the ceiling boards. The results show that the ceiling board made from recycled paper is a good alternative to asbestos-based ceiling board. This is because it has a high bursting strength of 39.2N.*

Keywords: *Asbestos, fibre, cement, environment, ceiling, fire, waste paper.*

Date of Submission: 26-01-2024 Date of acceptance: 08-02-2024

I. INTRODUCTION

A ceiling board is a horizontal slab covering the upper section of a room or internal space. A ceiling board is generally not structural but is a shell concealing the details of the structure above. However, the ceiling might be holding up building materials such as heat or sound insulation. In modern buildings, electric lights, smoke detector, security cameras and signage are commonly attached to ceilings.

This paper is based on the production of ceiling board from local raw materials. These local raw materials include cement, fibre cellulose, fibre obtained from ground paper, mainly waste paper, water and some other additives. The grouping of these types of ceiling boards are in accordance to the raw materials used for their production. For instance, Gypsum ceiling boards are produced from gypsum, Acoustical ceiling boards are obtained from mineral wool, gypsum and small amount of paper and starch. Gypsum fibre ceiling boards are produced from gypsum and fibre to reinforce the ceiling board.

However, this study is on the production of fibre cement ceiling boards which consist essentially of an inorganic binder usually calcium silicate formed by the chemical reaction of a siliceous material and a calcareous material and is reinforced by organic fibres (saw dust), fillers and pigment compatible with the fibre-reinforced cement to form a ceiling board.

In the past, ceiling boards were produced using Asbestos, a fibre present naturally in rocks. It was used because of its high tensile strength, poor heat conductivity and high fire resistance. However, asbestos causes asbestosis, which leads to cancer. As a result of this problem, manufacturers of ceiling boards went into research to find out substitutes that can be used in the production of ceiling boards.

This substitute includes shredded wood (saw dust), cellulose fibre agricultural waste etc. Rather than industrial products (glass-fibre, iron fillings) and man-made materials, the fibres best suited to the socio-economic circumstances of developing countries are natural fibres.

Construction materials like concrete, bricks, blocks (hollow, solid or pavement), and tiles are manufactured from existing natural resources which directly or indirectly damage our environment because of its continuous exploration and depletion. Also, some toxic substances like high concentration of carbon (1) oxide, Sulphur (iv) oxide, nitrogen (iv) oxide, and suspended particulate matters are directly released into the

atmosphere when these construction materials are being produced which affects living standard of man. As a result of these, matters related to conservation of our environment have recently gained great importance in our society. (Adhikary et al 2008)

The government and individuals globally are now paying serious attention to the issues relating to our environment and major changes regarding the conservation of resources and recycling of wastes are putting into consideration in our ways of living and working. For this purpose, extensive research and development works towards exploring new ingredients are required for the manufacturing of sustainable construction material. (Clyne and Tanovic 2009)

Composite materials possessed several benefits amongst which are excellent lightweight, heat resistance to heat, mechanical and control characteristics. Thus, the rate at which they are use as materials of structures in many engineering fields for production purposes increased rapidly. One way of addressing the problem of waste recycling is to decide on how to make useful and profitable material from wastes; which was why products such as particleboard, wood panel, sawdust concrete and tiles were developed. Sawdust concrete-based products can be classified as a light weight concrete building material that exploits organic elements being waste wood like sawdust, chip, and other cuttings with concrete-based material, which are cement and other aggregates. (Harris 2009)

In the present investigation sawdust is considered as a composite member for retrofitting of composite ceiling tiles with body mix for clay-silica cement tiles. A mixture of sawdust, sand and cement was successfully used in the past for making wall panels as a non-load bearing construction material (Hayes 2005). The significance of this study is to analyze the properties of tiles which utilize wood waste (sawdust) as a recycled resource material to produce potentially economically viable ceiling tiles when 50% of the clay is being replaced with sawdust (Olusegun et al 2009).

Due to the issues of environmental pollution, air pollution caused by waste materials like pulped paper and sawdust, there has been a quest for a means to recycle some of these materials and still make them useful in construction work leading to economic benefits which has inspired the researcher to put forward the production of non-asbestos ceiling board. This will not only reduce the pollution and environmental effect associated with it but also remove the health threat of the existing asbestos production material, which is known to be cancerous.

This study aimed at ensuring environmental waste management by turning waste to wealth and reducing health hazards through the following:

- to determine the possibility of making use of local raw materials for the production of ceiling board.
- to produce a board with good acoustic and thermal insulating properties.
- to produce a board with reduced cost to discourage importation and promote building industry in Nigeria
- to reduce environmental pollution caused by indiscriminate littering of papers and the pollution of the air resulting through burning this waste.

Years ago, asbestos was used in the production ceiling boards, a fibre naturally found in rock formations throughout the world. Its usage was due to the fact that it has high tensile strength, high resistance to fire, and a poor conductivity of heat (Adekunle et al 2006). However, asbestosis, that caused cancer is caused by asbestos, as a result of this, producers of ceiling boards carried out research to find substitute materials to be used in the production of ceiling boards. These substitutes are agricultural wastes, shredded wood etc. However, the use of shredded wood as re-enforcement for inorganic binders points back to the genesis of the nineteen century (Oladele et al 2014)

According to the production materials, ceiling boards are classified into five different classes namely asbestos cement ceiling board, acoustic ceiling board, gypsum ceiling board, gypsum fibre ceiling board, and cement fibre ceiling board.

Asbestos Cement Ceiling Board

Asbestos cement ceiling boards is mainly a product from cement where about 10 to 15% asbestos is added for reinforcement (Ogundele 2007). Asbestos cement ceiling boards is weatherproof in that even though it absorbs water, the moisture does not get into the product which had a surface richly mixed with cement. The asbestos fibres were coated within; thus, people inside the building with asbestos cement ceiling boards were likely to be even safe than people outsidein the open space. (Olorunmaiye et al 2015)

Acoustical Ceiling Board

Acoustical ceiling board is a low waste production process which majorly consist of mineral wool, gypsum, paper, starch, as well as other mixed materials. The recycled contents in ceiling boards vary from approximately 20% to 80%, depending on the type of the product, manufacturer, and plant site. Wool used in board is made from slag which is a by-product of steel production, it consists of sulphur and other impurities.

The slag is meted in coke-fired copulas or electric meters and spun into fibres, which are incorporated into the production process. The use of slag reduces the need to mine naturally occurring materials such as basalt rock and also decreases landfill waste. Ceiling boards that are chipped or broken during the manufacturing process are recycled and returned to the process. (Sheni et al 2017)

Acoustic ceilings tend to be made from fibrous materials that absorb sound energy, unlike plaster and gypsum ceilings. They do not necessarily reduce the transmission of sound between spaces, rather they reduce the amount that reflects back into the space and so can be used to tailor the acoustic character of a space. (Spurny 1982)

The sound absorption performance of a ceiling material is expressed in terms of its noise reduction coefficient (NRC). An NRC of 0.85 means that a ceiling material absorbs 85% of the sound that reaches it, and reflects 15% back into the room. NRCs for most acoustical ceilings range from 0.5 to 0.9, compared to values below 0.10 for plaster and gypsum ceiling board materials.

Where acoustic privacy is required, heavier ceiling materials such as plaster or gypsum board are more effective. (Daramola 2016)

Gypsum Ceiling Board

Gypsum is non-toxic to humans. In fact, it can be helpful to animal and plant life and the environment in a variety of applications, such as a soil additive to improve the workability and nutrient level of the soil. It is also acceptable for human consumption and is used as dietary source of calcium. Gypsum, the primary raw material occurs naturally like salt or limestone and is one of the most abundant minerals on the planet. It is neither rare nor endangered. Gypsum ceiling boards scores extremely high on nearly all sustainable design criteria. Apart from the natural source, gypsum ceiling boards manufacturers also rely increasingly on "synthetic" gypsum as an effective alternative. Synthetic gypsum is a by- product or waste material, from other manufacturing processes, primarily the desulphurization of flue gases in fossil-fueled power plants and the manufacture of titanium dioxide used in plant. (Sheni et al 2017)

Gypsum board is the generic name for a family of panel products that consist of a noncombustible core, composed primarily of gypsum, and a paper surfacing on the face, back and long edges.

Decorative gypsum board has many properties such as light weight, high strength, fire proofing, sound insulation and high ductility etc. It can be processed in such ways as sawing, planning, nailing, drilling and sticking. It's convenient in application and installation. The right side of decorative gypsum board should not have such defects to weaken its decorative effects as pores, blots, crackles, unfilled corners, disproportion of colors and incomplete patterns etc. (Leigh 2002)

Gypsum board is the most common indoor building material in the United States. In the United States and Canada, gypsum board is manufactured to comply with ASTM Specification C 1396 which was designed to replace several existing ASTM specifications, leaving one reference standard for all gypsum board products. This standard is to be applied whether the core consists of natural ore or synthetic gypsum. (Boreman et al 1986)

Advantages of gypsum board include its low cost, ease of installation and finishing, fire resistance, nontoxicity, sound attenuation, and availability. Disadvantages include: difficulty in curved-surface application and low durability when subject to damage from impact or abrasion.

Gypsum Fibre Ceiling Board

The gypsum fibre manufacturing process combines gypsum and cellulose paper fibres to create a variety of high-performance ceiling boards. They are made from 95% recycled material. Specially, 85% of the content in these ceiling boards come from post-consumer recycled ceiling boards and this offers an excellent sustainable alternative to other wood- based ceiling boards (Sheni et al 2017)

Cement Fibre Ceiling Board

In general, cement fibre ceiling boards is a 50/50 mixture of cement and wood or other lignocelluloses fibre. The cement fibre ceilings do not easily burn but are resistant to termite damage, rotting, and warping. (Ohijeagbo 2005)

In fibre cement there is a fibre reinforcement, which contributes to making the fibre-cement material even stronger. Together with a carefully planned production process, fibre cement makes it possible to develop strong and long lasting construction materials. Today fibre cement is considered as a material physically suited for construction products such as cladding and roofing. It is primarily due to its function, performance and commercial value.

Fibre cement is a main component of long-lasting building materials. The main application areas are roofing and cladding. Fibre-cement products have found a wide usage in various sectors of construction: industrial, agricultural, domestic and residential buildings, mainly in roofing and cladding applications, for new constructions and refurbishment projects. (Haigh 2006)

Overview of Thermal Properties of Ceiling Boards

Ceiling materials being overhead interior surfaces that can cover the upper limits of the room, are not generally considered as structural element but finished surfaces concealing the underside of room structure or the floor of store above.

In some places, zinc-made roofs without ceilings are very common, thus there is intense heat transfer to the internal environment, which may cause thermal discomfort to the inhabitants. One way to reduce the thermal discomfort is by the use of radiant barrier (i.e. ceiling board) which reduce the heat flux. However, the knowledge of thermal properties of different materials is very important in the choice of the types of materials to be used as a radiant barrier since the heat flow through any building depends on the thermal properties of the materials used in the building. The study of the thermal properties of materials will help one to know whether materials are suitable to use as Ceiling materials in our houses, schools and industries. (Clarke 2000)

II. MATERIALS AND METHOD

Materials

Materials used for the non-asbestos ceiling boards are

- Cement: This is the main binding element of the ceiling board.
- Saw dust: This is the fibre used in the production of the ceiling board, in place of the common asbestos.
- Gypsum: It allows the cement to dry fast but must be added with caution.
- Calcium carbonate: It is a colourless or white inorganic compound occurring as chalk, limestone, marble etc. It helps to strengthen the sheet during and after drying and prevent cracking.
- Kaolin: It is a fine clay rich in kaolinite. When kaolin is mixed with water in the range of 20 to 35 percent, it becomes plastic (i.e., it can be moulded under pressure), and the shape is retained after the pressure is removed. With larger percentages of water, the kaolin forms a slurry, or water suspension. The amount of water required to achieve plasticity and viscosity varies with the size of the kaolinite particles and also with certain chemicals that may be present in the kaolin.Kaolin helps the sheet to exhibit the properties of plasticity and shrinkage.

Tools

The following tools were used for the production of ceiling sheet: Frame, Weighing balance, Mortar and pestle, Mixer, Rod Square, Cellophane, Roller, Hack saw and Hand Trowel

Method For the production of ceiling board using carton pulp, Ordinary Portland Cement o f 3kg, 5kg of paper, 1kg of gypsum were measured using the weighing balance and they were kept in different containers. The ratio of cement, pulped paper and gypsum is 3:5:1 respectively and this measurement was used in the production of four 2ft by 2ft ceiling boards.

Preparation of Cellulose Fibre (Paper Pulp)

Paper was size reduced by cutting it into small sizes and then, it was soaked in enough volume of water for 48 hours. This was done for better absorption of water for softening to enable easy pulping of the carton. After 48 hours, it was removed from water after much absorption and softening. It was thereafter pulped manually with the aid of mortar and pestle. However, milling machine could be used for industrial or mass production.

Starch Preparation

A 100g of starch of locally made starch obtained from cassava was used. It was put in a container and dissolved in water to obtain a smooth paste. Boiled water was then added to the paste and stirred continuously until it become a sticky gel.

Production Procedures

The same procedure can be used to produce the different types of ceiling boards the only variation will be in their compositions, as well as the type of fibre that was used. Since all the raw materials that will be used has been prepared and made ready for used, production was commenced. The ceiling board produced from paper pulp cellulose fibre was produced.

All the raw materials used for the manufacturing of this ceiling board were assembled and their respective weights were rechecked. Then, the fibre was poured into the reactor, followed by the cement. Both were mixed properly to make sure that it had the same consistency all over the reactor. Next, the 1 table spoon of kaolin and calcium carbonate was added and mixed thoroughly as well. Water was then added gradually and sparingly to obtain a smooth mixture and the starch was then introduced into the mixture, finally, gypsum was added and mixed thoroughly until the same consistency had been obtained throughout the reactor.

The mixture poured into the mould (using hand trowel) which had been prepared for casting on spread sheet of thick cellophane. It was then spread all over and within the mould, compressed, smoothened out until the surface becomes desirably smoothened. The edges were then smoothened with aid of the rod square.

Drying and Trimming

The sheets of ceiling board produced were thereafter dried after demoulding under the sun for about a week for total drying. As part of finishes, the sheets were trimmed using a hack saw for the neatness and smoothness of the edges.

III. FINDINGS

A dried sample of the prepared sheets was subjected to Bursting Strength testing manually to know the maximum weight of load that would break it. This was done by supporting the sheet at both ends on cube blocks and thereafter applied weight of different mass central until it breaks. Consequently, the result of the test showed that the maximum load before breaking of this Non-Asbestos Cement Fibre Ceiling Board is 4kg (39.2N)

Samples	Applied Mass (kg)	Force (N)
Cement fibre ceiling (Non-Asbestos ceiling board)	4	39.2

This shows that the produced board has a high bursting strength which means that it has a higher tensile strength and of better quality when compared to asbestos.

Plate 1: Sample of Ceiling board with a unique design after drying

IV. CONCLUSION AND RECOMMENDATION

Conclusively, Non-asbestos materials such as waste paper, which is a solid waste with environmental pollution issues, was could be used to make ceiling boards. In addition, the paper composite specimens used for the production of these boards with 5:3 paper cement ration is adequate and appropriate in producing high quality sheets resulting from its high bursting and tensile strengths and these could serve as alternatives to the known asbestos which contain cancerous materials.

Lastly, Ceiling Boards made from non-asbestos materials are cheaper when compared to Asbestos which is expensive to get consequently leading to high cost of ceiling boards produced from it.

It is therefore recommended that construction industry should accept the use of non-asbestos ceiling boards in other to encourage its production, reduce environmental pollution and reduce cost of housing.

Further studies should be encouraged on the suitability of non-ceiling boards made from saw dust and comparison between two non-asbestos materials could also be made to promote its usability.

REFERENCES

[1]. Adekunle, A. S. Dimensional stability and mechanical behaviour of environmental wastes composites based on recycle 2006

[2]. Adhikary, Kamal, B., Shusheng Paing and Mark P, Dimensional stability and mechanical behaviour of wood-plastic composites based on recycle and virgin high- density polythylene(HDPE) Composites, 2008, pp. 807-815.

[3]. Bornemann P and Hildebrandt U. 1986. The question of environmental pollution by material removed from asbestos cement by weathering. Staub Reinhalt der Luft, 41(11), 486–489.

[4]. Brown SK 1998. Physical properties of asbestos-cement roof sheeting after long-term exposure. J. Occup. Health Safety-AustNZ 14(2), 129-134.

[5]. Clyne, and Tanovic, 2009. [Online]. Available:http://www.matter.org .uk/matscicdrom/manual/co.html. [Accessed 17 july 2009].

[6]. P. G. Harris, "microsoft encarta," lumber industry, [Online]. Available: http://en.wikipedia.org/wiki/woodcomposite. [Accessed 2009].

[7]. B. Hayes, in infrastructure: the book of everything for the industrial landscape, 1st ed., New York City, Norton: ISBN 978-0393329599, 2005.

[8]. Clarke RM (unknown date). The significance of asbestos cement building productsas a source of airborne asbestos. Mineral Science Laboratory, Chemistry Centre. Western Australia.

[9]. Daramola E.S "effect of chemical treatment on the mechanical properties of fibre reinforced polyester composite,," vol. 18, no. 2, pp. 96-102, 2016.

[10]. Fasooto, S ., "effect of chemical treatment on the mechanical properties of fibre reinforced polyester composite,," 2014
[11]. Haigh G 2006. Asbestos House. Scribe Publications (Melbourne). ISBN 1 92076962 5.
[12]. Kelly TD and Matos GR (2006). Historical Statistics for Mineral and Material Commodities in the United States. U.S. Geological Survey Data Series 140.
[13]. Leigh J, Davidson P, Hendrie L and Berry D 2002. Gypsum ceiling properties, 1945-2000. Amer. J. Ind. Med. 41, 188-201.
[14]. Lohrer-W, Heide H and Konig R 1979. Roofing properties and Floor Coverings Staub Reinhaltung Luft, 39(11), 417-422.
[15]. Merck Index. 2006. The Merck Index: An Encyclopedia of cellulose fibre. 14th. Edition. Eds.: O'Neil MJ, Heckelman PE, Koch CB, Roman KJ. Merck & Co. Inc. Whitehouse Station, NJ. 2006. ISBN 978-0-911910-00-1.
[16]. Ogundele, S.O "Physical characteristics of Latterite and Granite composite tiles," no. 7, pp. 127-138, 2007.
[17]. Ohijeagbon I. O "extrinsic characteristics of Latterite and Granite composite tiles, no. 7, pp. 127-138, 2005.
[18]. Olusegun, H. D., Ohijeagbon, I. O., Adekunle, A. S. and Ogundele, S. O, "modelling characteristics of Latterite and Granite composite tiles," no. 7, pp. 127-138, 2009.
[19]. Oladele, I. O., dARAMOLA O. O., Fasooto, S., "effect of chemical treatment on the mechanical properties of fibre reinforced polyester composite,," vol. 18, no. 2, pp. 96-102, 2014.
[20]. Olorunmaiye J. A., Ohijeagbon I. O.,, "Retrofiting composite ceiling boards with jatropha curcas seedcake materila," vol. 18, no. 2, pp. 96-102, 2015.
[21]. Sebastien P, Bignon J, Martin M. 1982. Indoor airborne asbestos pollution: from theceiling and the floor. Science 216(4553):1410-1412
[22]. Sheni, Y., Yahaya, B. S., Mbishida, M. A., "production of agro waste composite ceiling board(a case study of the mechanical properties)," vol. 4, no. 6, pp. 208-212, 2017.
[23]. Spurny KR 1989. Properties of Acoustical ceiling board. IARC Sci Publ 1989;(90): 367-371.
[24]. UK DETR 1999. 'Asbestos in the Home' Nottingham City Department of Environment, Transport and the Regions (DETR) Accessed online 10 June 2007.http://www.nottinghamcity.gov.uk/nchl_home/nchl-asbestos.htm
[25]. Yahaya, B. S "production of agro waste composite ceiling board(a case study of the physical properties)," vol. 4, no. 6, pp. 208-212, 2016.