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Manufacturing of Non-Asbestos Ceiling Board

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Abstract

This project reports the manufacturing of a locally made ceiling board using non-asbestos materials, such as waste paper and saw dust. These are solid wastes which cause environmental pollution and can be recycled and utilized for the benefit of our society. Three different ceiling boards were produced based on difference types of fibre. The fibres used for the ceiling boards are cellulose fibre obtained from pulped carton and sawdust. The raw materials used are Cement, Calcium Trioxocarbonate (iv) ($CaCO_{3)}$, Kaolin, Starch, and Water. Ceiling boards were produced from pulped carton and sawdust. The two new ceiling boards and a convectional existing ceiling board were subjected to performance evaluation tests such as moisture content test, density test and bursting strength test. The analyses of the experimental tests conducted on paper and sawdust composite specimens showed that their qualities and properties depend on the ratio of constituent materials respectively. Wood to paper ratios of 1:1, 1:2, 1:3, 1:4, and 1:5 were considered in making the ceiling boards. The results show that the ceiling board made from recycled paper and saw dust ratio l:4 is a good alternative to asbestos-based ceiling board. This is because it has the highest bursting strength of 56.2 N, among others.

Key words

Ceiling Board, sawdust, Calcium Trioxocarbonate (iv), Cement and Cellulose fibre

1. Introduction

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 [1]

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 [2].

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. [3]

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 [4]. 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 [5].

The significance of this project is to control wastes through recycling process (waste management technique) and to provide better alternatives to timbers and ordinary paper. Low cost and light weight ceiling chips are produced instead of the old expensive and heavy asbestos. The environmental pollution caused by disposed paper will be reduced if not totally eradicated. Air pollution from burning of sawdust in sawmills and paper wastes on dump ground or incinerator will be prevented and investors and manufacturers of wood-paper composites will be provided with some basic researches to help them boost their business.

2. Literature Review

History of Ceiling Boards

Some years ago, asbestos were 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. 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 [6].

Types of Ceiling Boards

There are five different classes of ceiling boards which are: asbestos cement ceiling board, acoustic ceiling board, gypsum ceiling board, gypsum fibre ceiling board, and cement fibre ceiling board. Classifications are based on the materials used for their production.

Absestors Cement Ceiling Board

Asbestos cement ceiling boards is mainly a product from cement where about 10 to 15% asbestos is added for reinforcement. 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 outside in the open space. [7]

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. [8]

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. [8]

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 [8]

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. [8]

Typical Thermal Properties of Some Ceiling Board Materials

Table 1: Thermal properties of some ceiling board materials

Materials	Density kg/m^2	Thermal conductivity	Thermal resistance
Asbestos cement	1600	0.36	2.78
Concrete ball	1200-1400	1.0-2.0	0.5-1.0
Cork board	140-320	0.03-0.04	25-33
Fibre board	460	0.05	20.00
Hard board	640	0.1	10.00
Plywood	530	0.14	7.14
Wood wool slab	470-800	0.08-04	7.14-12.5
Plaster board	960	0.16	6.25

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3. Materials and Method

Here, the procedure involved in the production of ceiling board is described and discussed. It focuses on the evaluation, effect of wood plastic ratio on the mechanical properties of wood plastic composite (WPC) produced from wood dust, and paper wastes, and the formulations used in compounding as well as the list of apparatus and materials used.

Materials used for the non-asbestos ceiling boards

Cellulose fiber - obtained from carton waste.

Saw dust – obtained from the size reduction of log of wood into planks. This is the small particles of wood that falls off during the reduction. It is usually in powdery form. The other raw materials used for the production of the three different types of ceiling board are: Kaolin powder, Calcium trioxocarbonate (iv) powder ($CaCO_3$), Cement, Starch, and Water

Composition of material used for the product of different types of ceiling board

A. Using Cellulose Fibre (5000g) = 5kg

35% Cement = $\frac{35}{100}$ x 5000 = 1.75kg

40% Carton pulp = $\frac{40}{100}$ x 5000 =2.0kg

10% Kaolin = $\frac{10}{100}$ x 5000 = 0.5kg

10% $CaCO_3$ = $\frac{10}{100}$ x 5000 = 500g = 0.5kg

5% Starch = $\frac{05}{100}$ x 5000 = 250g = 0.25kg

B. Using Sawdust (5000g) = 5kg

30% Cement = $\frac{30}{100}$ x 5000 =1500g= 1.50kg

40% Saw dust = $\frac{40}{100}$ x 5000 =2000g= 2.0kg

5% Kaolin = $\frac{05}{100}$ x 5000 = 250g = 0.25kg

10% $CaCO_3$ = $\frac{10}{100}$ x 5000 = 500g = 0.50kg

15% Starch = $\frac{15}{100}$ x 5000 = 750g = 0.75kg

C. Using Paper and Sawdust

% 30Cement 30% = $\frac{30}{100}$ x 5000 = 1.50kg

20% Carton pulp = $\frac{20}{100}$ x 5000 = 1.00kg

20% Saw dust = $\frac{20}{100}$ x 5000 = 1.00kg

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5% Kaolin = $\frac{05}{100}$ x 5000 = 250g = 0.25kg

10% $CaCO_3$ = $\frac{10}{100}$ x 5000 = 500g = 0.50kg

15% Starch = $\frac{15}{100}$ x 5000 = 750g = 0.75kg

D. Using Paper and Sawdust

30% Cement = $\frac{30}{100}$ x 5000 = 1.50kg

30% Carton pulp = $\frac{35}{100}$ x 5000 = 1.50kg

10% Saw dust = $\frac{10}{100}$ x 5000 = 0.5 kg

5% Kaolin = $\frac{05}{100}$ x 5000 = 250g = 0.25kg

10% $CaCO_3$ = $\frac{10}{100}$ x 5000 = 500g = 0.50kg

15% Starch = $\frac{15}{100}$ x 5000 = 750g = 0.75kg

E. Using Paper and Sawdust

30% Cement = $\frac{30}{100}$ x 5000 = 1.50kg

10% Carton pulp = $\frac{10}{100}$ x 5000 = 0.5kg

30% Saw dust = $\frac{35}{100}$ x 5000 = 1.50 kg

5% Kaolin = $\frac{05}{100}$ x 5000 = 250g = 0.25kg

10% $CaCO_3$ = $\frac{10}{100}$ x 5000 = 500g = 0.50kg

15% Starch= $\frac{15}{100}$ x 5000 = 750g = 0.75kg

Materials preparation

Preparation Of Cement For Production

For the production of ceiling board using carton pulp, 1.75kg of cement was weighed using the weighing balance and this was done by placing an empty container on the weighing balance, the balance is zeroed, the cement is poured into the container until the pointer gets to the 1.75kg mark. This is brought down and the same procedure was used to measure 1.50kg of cement which was used for the production of ceiling board using saw dust and rice husk these were kept in three different containers and was identified using a cellotape on which was written carton, saw dust and rice husk.

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, the size reduced carton was pulped. This was done by pounding with mortar and pestle since there was no available milling machine. 200g of pulp was measured using a weighing balance and poured in a container.

Preparation Stage For Saw Dust

The saw dust from saw mill contained many impurities ranging from stone, larger wood materials and sand. First, the saw dust was sieved by screening to separate the fractions. The saw dust free from impurities was soaked in water for 24 hours to leach out low molecular weight carbohydrates that could inhabit the normal settling of cement. After 24 hours of soaking in water it was sieved to separate the sawdust from water. 200g of saw dust was then measured using a weighing balance and put in a container.

Preparation Of Starch

The starch used is the locally made starch obtained from cassava. It was put in a container and dissolved in water is obtain a smooth paste. Boiled water was then added to the paste and stirred continuously until a sticky gel was obtained. The weight of the various mass of starch

Production Procedures

The same procedure was used to produce the different types of ceiling boards the only variation were 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 first.

All the raw material used for the manufacturing of this ceiling board was gathered and confirmation was made for the weight used. First, 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. The mixing was done using a stirrer. Vext, the kaolin and calcium carbonate was added and mixed thoroughly as well. Water is then applied gradually and sparingly to obtain a smooth mixture, once that has been done, starch is then added to the mixture and mixed thoroughly until it is noticed that the same consistency has been obtained throughout the reactor.

This is then poured into the mould which has been prepared for casting by spreading a sheet of thick cellophane on it. The mixture is spread all over the mould using a roller and compressed as this is done when the mixture covers the whole mould, it is smoothened out using the roller until the surface becomes as smooth as possible. This same procedure was followed using saw dust and rice husk.

Drying

The various sheets of ceiling board formed in the mould were dried with solar energy from the sun which took about three days-one week to dry totally. For the ceiling board produced from Cellulose fibre it took about one week for it to dry totally that produced from saw dust took a shorter period of about three days and it took about five days for the ceiling board produced from rice husk to dry totally.

Trimming

This is the finishing process, the sheets formed were trimmed using a hack saw to make the edged smooth and neat. This was done after the drying of the samples.

Analysis of the Samples

Three different types of ceiling boards was produced. Each of these samples consist of different compositions of raw materials used for the production of these boards are waste paper, cement, calcium trioxocarbonate (iv), starch, kaolin, and local fiber. Starch acted as the binder, the cement served as filler which also added to the strength of the board.

Sample used for various tests

Sample A – 40% Waste paper (cellulose fibre) + cement+ starch + kaolin + water+ $CaCO_3$

Sample B – 40% saw dust + cement + starch + kaolin + $CaCO_3$ + water.

Sample C – 20% saw dust + 20% waste paper + cement + starch + kaolin + $CaCO_3$ + water

Sample D – 30% saw dust +10% Waste paper+ cement + starch + kaolin + $CaCO_3$ + water

Sample E –10% saw dust + 30% Waste paper + cement + starch + kaolin + $CaCO_3$ + water

Table 2: Constituent Materials Mixing Ratio

Samples	Mixing Ratio	Percentage by Mass (%)	
		Recycled Paper	Sawdust
A	1:1	40%	0%
B	1:2	0%	40%
C	1:3	20%	20%
D	1:4	30%	10%
E	1:5	10%	30%

Densities and relative densities of the samples were calculated and shown in Table 3 below:

Volume = Length x Breadth x Thickness

$$\text{Mass (kg)} = \frac{\text{Mass (g)}}{1000} \quad (1)$$

$$\text{Density } (\rho) = \frac{mass\ (kg)}{volume\ (cm)^3} \quad (2)$$

$$\text{Relative Density (R)} = \frac{density\ of\ the\ samples}{density\ of\ water} \quad (3)$$

Density of water is taken to be $1000 kg/m^3$

Table 3: Density and Relative Density of the Samples with different Mixing Ratios

Sample	Volume (m^3)	Dry weight (kg)	Density (kg/m^3)	Relative Density
A	0.005400	5.002	926.296	0.926296

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B`	0.005403	5.006	926.522	0.926522
C	0.005407	5.010	926.577	0.926577
D	0.005400	5.000	925.926	0.925926
E	0.005400	5.004	926.666	0.926666

4. Results and Discussion

Bursting Strength

A smaller sample of each mixture was prepared and cut into uniform size and set for the testing on a "Bursting strength tester". The sample sheets were cut by the sides at the middle way leaving 10mm in the middle. Each sample was then fixed on the bursting strength tester", and weight were added gradually until the sample snapped. At this point this applied weight was recorded. This applied weight was then converted to force

Table 4 Bursting Strength Test

Samples	Applied Mass (g)	Force (N)
A	4.33	42.5
B	3.82	37.5
C	3.05	30.11
D	5.76	56.2
E	3.3	32.37

Sample D has the highest bursting strength which means that it has a higher tensile strength than others. Therefore, it has a better quality; it has a bursting strength of 56.2 N, and next to it is sample A with bursting strength of 42.5N

Moisture Content

A standard specimen sample was cut and weighed on a scale balance then dried in an oven at a temperature of 107°C. This sample was allowed to cool in a desiccator, to avoid absorption of moisture before re-weighing. Below is the result obtained.

Table 5 Moisture content

Sample	Weight before drying (g)	Final Weight after drying for 3hours`(g)	% Moisture Contained
A	6010	5002	16.77
B	6004	5006	16.62
C	6040	5010	17.05
D	6005	5000	16.74
E	6007	5004	16.60

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Products after drying

The ceiling board after drying are shown in Figure. 1 to figure 5

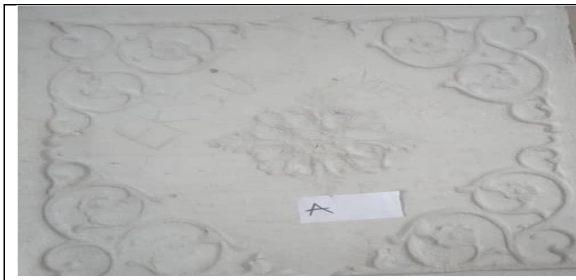

Figure 1 Sample A

Figure 2 Sample B

Figure 3 Sample C

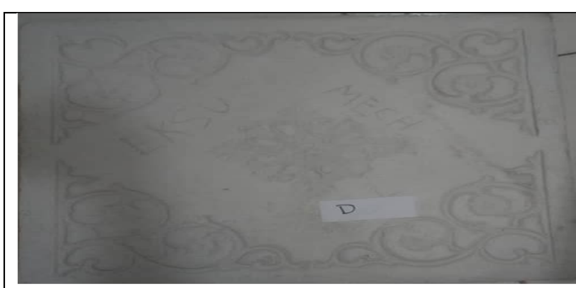

Figure 4 Sample D

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Figure 5 Sample E

5. Conclusion

Two non-asbestos materials, namely: waste paper and saw dust, which are solid wastes with environmental pollution issues, were used to make ceiling board. The analysis of the experimental tests conducted on paper and saw dust composite specimens showed that the qualities and properties of a wood and paper composite depend on the ratio of its constituent materials (i.e. wood and paper components). With reference to the scope of this project, the wood to paper ratio of 1:2 ,1:3 ,1:4 and 1:5 were considered and investigated experimentally; while sawdust ratio l:4 was preferred to others due to its highest bursting strength and tensile strength.

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