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PRODUCTION OF CEILING BOARD USING WASTE MATERIALS

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ABSTRACT
The Production of Ceiling Board from waste Materials was carried out basically using waste paper and sawdust materials which was sourced locally. These raw materials were found to be in abundance and constitute environmental hazard. The other raw materials used includes cement, calcium carbonate ($CaCO_3$), Kaolin, starch and water. The quantity of each material used, was weighed out sawdust fibre (40%), Cement (10%), Kaolin (10%), $CaCO_3$ (15%), starch (10%) and water (15%) while for waste paper material composition of fibre (40%), Cement (35%), Kaolin (10%), $CaCO_3$ (10%), starch (10%) and water (15%) was used to obtain the best mix. The deflection and fire resistance test shows that the produced ceiling boards are better in terms of rigidity and fire resistance ability. It was then recommended that the used of local materials in the production of ceiling board should be encourage to create job opportunities for Nigerians and to sanitised the environment from waste material.

Keywords-: Ceiling board, waste materials, cement, $CaCo_3$, kaolin, starch.

1 INTRODUCTION

Engineering infrastructures are said to be combination of fundamental system that support a community, region or country (Hayes, 2005*)*. Civil infrastructures system involves the design, analysis and management of infrastructures supporting human activities, including e.g electric power, oil and gas, water and waste water communication, transportation and the collections of building that make up urban and rural communities (Huler, 2010). Civil infrastructures system emphasizes on, how different structures behave together as a system to serves community's need. It can be defined generally, as set of interconnected structural elements that provide a frame work supporting an entire structure of development, aiming at making life better for the people. The engineers are usually responsible for design, construction and maintenances of building infrastructure. A building is a structure that has a roof and walls and stands more or less permanently in one place. The fundamental purpose of buildings is to provide man with a comfortable working, living space and protection from extreme of climate. The components of building are element which uses industrial products that are manufactured as independent units capable of been jointed with another element are beam, column, roof e.t.c. The other finished building components are doors and windows, floors, covering of rough walls and ceilings.

A ceiling board is horizontal slab covering the upper section of a room or internal space. A ceiling board is generally not structural element but it a shade (covering), concealing the details of the structure above. Provision of ceiling covering is an essential stage in the building process. The use of asbestos ceiling board is been discouraged because of its hazardous effect on human. Though demand for ceiling board and other panel products have been on the increase in recent time due to increased activities in the building industries.

Recent research effort is focused on how to use the waste generated from paper and wood products for ceiling board production, these waste has been a major source of solid waste problem in Nigeria and only a small percentage of the discarded waste paper e.g newsprint are kept in the achieves as reference material and a small portion of sawdust is been used and difficult to dispose.

The Production of Ceiling Board from waste Materials was carried out basically using waste paper and sawdust materials which was sourced locally and could serve as a very good fibre (Oladele, *et al*, 2014). These raw materials are found to be very much in abundance and constitute environmental hazard (Callister, 2001).

It is aimed that this waste paper product and sawdust can be reuse into a more permanent usage in the production of ceiling board for building and hence be able to solve the disposal problem of waste generated from these papers and wood, these will in turn reduce the cost of building construction and make the material for the production of ceiling to be locally sourced.

2. METHODOLOGY

The Production of Ceiling Board from waste Materials was carried out using the following raw materials: waste paper, cement, calcium carbonate ($CaCO_3$), Kaolin, starch and water, all are sourced locally. These raw materials are found to be very much in abundance.

2.1 Methods Adopted for Study

The under listed method was adopted for this research work in order to meet the set of aim and objectives.

i. Material sourcing
ii. Equipment used
iii. Production of ceiling board / manufacturing process

iv. Test on produced ceiling and available ceiling

2.2 Material Sourcing

The materials in Table 1, were used in the production of the ceiling board

Table 1: Materials used, form and source.

S/No	Materials	Form	Source
1	Waste paper	Plain and white Mostly	Minna
2	Sawdust	Powdery and Brown	Minna
3	Cement	Grey and Powdery	Minna
4	Calcium carbonate	Powdery	Ibadan
5	Kaolin	Powdery	Minna
6	Starch	White powder	Minna

2.3 Equipment Used

The underlisted equipment was in the production of the ceiling board

i. Measuring Cylinder
ii. Thermometer
iii. Weighing Balance
iv. Reactor
v. Stirrer
vi. Mould
vii. Cellophane
viii. Bucket
ix. Roller

2.4 Production of Ceiling Board/ Manufacturing Process.

There are different ways ceiling boards can be manufactured and this depends on the availability of raw materials used for the production. This study was based on the use of cement and different fibres for the production of ceiling board. The manufacturing process discussed includes:

1. The manufacturing of ceiling board from sawdust
2. The manufacture of ceiling boards from paper.

The production processes for the above are similar, the different only depends on the fibre type (paper or sawdust) been included as the raw material especially the type of re-enforcement that will be used but they are all cement composite ceiling boards**.**

2.5 Ceiling Board Production process

The Production of the ceiling was group into seven (7) major steps.

Step1: Material Collection

Waste paper and sawdust were collected from different places. e.g printing houses, schools, hotels, saw mill e.t.c.

Step 2: Sorting

Sorting involves the selection of waste paper from other solid waste in order to prevent contamination that could prevent the recycling of this waste paper, while the sawdust was also sieve to remove every large wooden particles.

Step 3: Soaking

After sorting out some few coated and strong paper that cannot be easily re-pulped by the beater from the collected sample, some quantity of these paper was soaked in enough volume of water for 2 days. The essence of soaking these papers is to allow easy blending. While enough quantity of the sawdust was soaked in enough volume of water for 24hrs (1days).

Step 4: Beating

The paper was then blended with the grinding machine to achieve a smooth finish. The used paper was from the wet paper which was soaked. The sawdust needs not to be blended.

Step 5: Mixing

A total of 5kg of various components for the production of ceiling board were then mixed. These components include; (i) Water (ii) Waste paper (iii) sawdust (vi) Calcium carbonate ($CaCo_3$), (v) Kaolin and (iv) cement in various percentages. They were all mixed together thoroughly with the machine to enhance proper blending. The chemical additive ($CaCo_3$) of 3% concentration in water dilution was used for each specimen, and the water containing the additives was added to the mixture while blending in the mix. The ceiling board production was divided into two (2) Categories (i) The paper fibre and (2) The Sawdust Fibre. The fibre (paper and sawdust) was used because it was the structural back bone of the product. It contributes to the strength, optics, stiffness and smoothness of the ceiling board. Cement and $CaCo_3$ was added to improve the texture and opacity, brightness of the board. It also contributes to the smoothness and more uniform surface of the board. Starch was added to increase the forces required to tear or rupture a board. Finally, the addition of water enables easy mixing of the slurry and to make the mixture mouldable.

(a) The paper Fibre

Three different composition was chosen for paper ceiling production as stated in Table 2 and the best selected as the final production mix.

(b) The sawdust Fibre

Three different composition was also chosen for sawdust ceiling production as stated in Table 2 and the best selected as the final production mix.

Table 2: Waste Paper and Sawdust Fibre Composition

Material composition	Sawdust (%)			Waste Paper (%)		
	Sample A	Sample B	Sample C	Sample A	Sample B	Sample C
Fibre	40	40	40	40	45	40
Cement	5	15	10	10	10	5
Kaolin	10	10	10	10	10	15
$CaCO_3$	15	10	15	10	10	15
Starch	15	10	10	15	10	10
Water	15	15	15	15	15	15

Step 6: Mould

The mixed component was then poured into a 600mm by 600mm square mould designed for the production of ceiling board. The mix component was then spread across the mould in order to take the shape of the mould. It must fill every part of the mould, vibrated and the levelled using a trowel. It was then compress together to remove some water content. This process is also known as expression. It was used to separate liquid from a mixture of liquid and solid. This was done by compression under the condition that permits liquid to escape while the solid is retained between the compressing surfaces. pressure of $1.23Nm^2$ to form the required thickness of 1inch for a period of 24 hours setting was applied. The boards were removed from press and from the mould.

Step 7: Drying

The board was then allowed to set and to dry in the mould for about two days after which is removed from the mould and dried naturally in conducive environment usually it is dried with solar energy. They are stacked under a controlled laboratory environment to allow for 7 days curing.

Step 8: Trimming

The sheets formed from the mould undergo trimming to get rid of the rough edges.

3. RESULT AND DISCUSION

3.1 Material Composition

After careful observation of the mix composition for various samples sample A of waste paper was selected while sample C for sawdust was selected as the best mix composition. The two selected mix were outstanding in their performance against the common ceiling board in the market. Table 3 shows the selected composition in Kilogramme (Kg) for 5kg production quantity.

Table 3: Selected Production Composition

Material composition	Sawdust (Kg)	Paper (Kg)
Fibre	2	2
Cement	0.5	0.5
Kaolin	0.5	0.5
$CaCO_3$	0.75	0.5
Starch	0.5	0.75
Water	0.75	0.75

3.2 Sample drying period

Table 4, present the rate of drying for each sample composition. It was observed that the composition of waste paper for sample A dries faster than others while in the composition of sawdust, sample C dries faster than others after 24hrs of drying in an open air, the curing continues after then.

Table 4: Drying Period per Sample

Duration	Waste Paper (Days)			Sawdust (Days)		
	Sample A	Sample B	Sample C	Sample A	Sample B	Sample C
Number of the days	4	7	5	5	4	3
Rate of drying	Fast	Very Slow	Slow	Very Slow	Slow	Fast

After drying, sample B and C did not bind properly as a result there were lots of cracks. More starch was thus used to produce a latter ceiling board. For drying the ceiling board, solar energy was used in place of even drying. This is because when high temperature is used for drying, the surface of the board dries up while the inner part is still wet as a result; there were lots of cracks on the board. This was notice when the board was dried using an oven. Therefore, drying is better when done at a low temperature to avoid the development of micro-cracks due to quick setting of cement. During the drying process, it was notices that sample A dries faster than all the others. It took 4days for it to dry totally while it took sample B seven days to dry and sample C it took 5days for it to dry totally.

After drying, it was noticed that sample B has the smoothest surface, next to it is sample A then finally is sample C. This is because, the Starch is minimal. The colour of sample B was found to be ash colour, this is because of the percentage of cement which is 5%. sample A and C however are result obtained from analysis, of the ceiling board, it was noticed that the dry weight of the ceiling board from at (sample C) was higher than others, the dry weight was found to be 15.43g, next to it is sample B with dry weight of 11.6g is sample B with dry weight of 11.6g and finally is sample A with dry weight of 11.00g.

3.4 Load Bearing Test

The results load test in Table 5, shown that all the samples resisted more load than the existing ceiling board of same size. Indicating a better deflection ability when suspended. Sample A 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 42.50 N, next to it is sample B with bursting strength of 37.50 N then sample C of bursting strength of 56.20 N.

Table 5: Loading Bearing Test

Loading	Waste Paper (Days)			Sawdust (Days)			EXISTING CEILING BOARD
	Sample A	Sample B	Sample C	Sample A	Sample B	Sample C	
Applied mass(kg)	4.33	3.82	5.76	2.05	3.3	2.4	2.09
Force (N)	42.5	37.5	56.2	20.11	32.37	23.72	20.5

3.5 Fire Resistance Test

All the samples were subjected to fire test, it was clear that both the waste paper ceiling and the sawdust ceiling board has higher fire resistance than the existing ceiling board. Table 6 present the results of the fire resistance test.

Table 6: Burning Resistance Test

Burning Time Interval (min)	Waste Paper (Time)			Sawdust (Time)			EXISTING CEILING BOARD
	Sample			Sample			
	A	B	C	A	B	C	
1	No effect	No effect	No effect	No effect	No effect	No effect	No effect
2	No effect	No effect	No effect	No effect	No effect	No effect	No effect
3	No effect	No effect	No effect	No effect	No effect	little effect	little effect

3.6 Costing

The costing carried out on this project is a rough estimate of the cost of production. That is it depends on or based on cost of materials used in production not including the equipment cost. This is to show the economic viability of the production of these ceiling boards here in Nigeria.

In this project, three different types of ceiling board were produced from different quantity of the samples. The difference being in the quantity of the material used for the sample of ceiling board produced from cellulose fibre. The different raw materials used include fibre, cement, CaCo3, kaolin, starch and water, which all had their function in the ceiling board.

Finally, from the costing it was observed that, sample B is the cheapest which cost ₦145.38 next is sampling C which cost ₦149.94 and finally is sample A which cost ₦154.94. Table 7 showing Specification of the Overall Cost of the Production of ceiling board.

Table 7: Cost of Production

		Cost of materials		Cost of material used	
S/N	Materials	Quantity(kg)	Cost (#)	Quantity (kg)	Cost (#)
1	Waste paper	20	0.00	2	0.00
2	Cement	50	1850.00	0.5	200.00
3	Kaolin	4	1000.00	0.6	90.00
4	$Caco_3$	10	150.00	0.5	7.50
5	Starch	2	250.00	0.5	31.25
6	Cellophane yield	_	150.00	_	150.00

Table 8: Cost of each samples Produced

Samples	Cost of materials	Transportation Cost (#)	Total Cost (#)
A	22.88	132.06	154.94
B	13.38	132.06	145.44
C	17.88	132.06	149.94

4. CONCLUSION

It was observed that the paper fibre ceiling of sample A has a better quality and properties and its composition was chosen as best for production while Sample C, for sawdust was chosen for production. The selected composition for paper and sawdust as in Table 3, shows superiority over the available ceiling board in the market in term of strength, fire resistance ability, cost and been able to sanitise the environment after used. Finally, our waste instead of dumping them should be recycled and re-used like in this case; paper and sawdust should not be dumped but recycled and used for the production.

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