Production of Roof Ceiling Boards from Wasted Paper

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ABSTRACT

The need for human being is shelter. In the entire world the population is increasing day to day for that the human need shelter for living.

Building is permanent or temporary structure enclosed with in exterior wall, roofs, and including all attached structures that cannot be removed without cutting in to ceiling, floors or walls. Building serve societal needs primarily as shelter from weather, security, living space, privacy, to store belongings and to comfortably live and work now a day. The house construction of our country is very difficult due to many reason one of those are the cost of finishing materials. Among the finishing materials, roof ceiling is one of them. Most of the product is imported from abroad having a high cost.

This research work investigated the potential applicability of waste paper in the production of ceiling boards with focus on achieving: environmental sustainability, safe disposal of waste paper and more cost effective production of materials. The main aim was to provide locally produced and environmental ceiling board that are cost effective. Four mix designs were formulated and used for the casting (1:0:6, 1:1:5, 1:2.5:3.5 and 1:2:4) Ordinary Portland cement, Sawdust and waste paper ratios respectively, varying in regards of the weight of the waste paper components. exhausted Cereal powder (maize, barely, sorghum, wheat) was added to the mix as an additive to aid binding. The mix design was satisfactory for the production of roof ceiling prototype having size of 40cm in length, 40 cm in width and 1.5 cm in thickens, and laboratory experiments were conducted to determine the properties and suitability of the produced boards. Properties such as water absorption, abrasion, modulus of rupture, pull-out and cutting test, and flexural strength and ultimate loads were considered for comparison. The boards with 1:2:4 mix ratios displayed the best results of the test properties hence, its mechanized manufacturing was recommended.

Key words: Wasted Paper; Cereal Powder Additive; OPC; Ceiling Board; Water Absorption, Flexural Strengt

1. INTRODUCTION

Waste includes all items that people no longer have any use for, which they either intend to get rid of or have already discarded. Those wastes are hazardous both to man and the environment. Majority of these waste emanate from households, commercial activities, and industries giving rise the waste production. Then the need for proper management is of greater essence in other to prevent the harmful effects of some of these wastes. Paper is an essential commodity in line with its socio-economic importance in the overall development of the country. which is directly linked with the industrial and educational growth in the country. This increase in both industrial and education sector development, as well results to increase in demand of paper in the country. With this excessive demand of paper, its abuse is inevitable hence the need of waste paper management. For once a substance or an object has become a waste, it will remain a waste until it has been fully recovered and no longer poses a potential threat to the environment or to human health. Among many methods of waste management, recycling and prevention is the best method of waste paper management. Waste paper is the unneeded by products (used paper) that discarded away or dispose to the community. This waste paper can pollute our environment while burning. Waste paper has usually nothing to contribute to the environment other than pollution, so we need to minimize this pollution by recycling the waste paper. Recycling paper is a method of recovering waste paper and remaking them into new paper products. The recycling of waste paper is the process by which waste paper is turned in to new paper product. Waste paper can be recycled into useful materials like paper boards, roof ceiling etc. Paper waste prevention is a practice of reducing or eliminating paper use; so that the potential for paper to be ineffectively used or disposed is prevented. The use of waste paper to produce paper products is a good economical across the world. The reuse of waste paper is a waste minimization strategy which includes reclaiming activities as various human activities result to the production of significant amounts of waste of different materials.

Waste materials can be used directly or recycled to produce the same or another product. This has the benefit of not only reducing the amount of waste paper but can also provide significant cost reduction for the production of roof ceiling.

1.1. STATEMENT OF THE PROBLEM

Where do we begin to solve the affordable housing problem? Among the most basic of human is a place to call home .One of the biggest issues, all over the world is addressing affordable housing. This fact is strengthening in developing countries like Ethiopia .As many developing countries,

Ethiopia is facing a lot of problems a high population growth with a huge release of wastes and erosion caused by deforestation can be considered the most serious one the need for housing is increasing with the increment of populations.

A challenge facing the Ethiopian government and society is thus to give a growing population opportunities to obtain decent ,suitable and affordable housing because conventional and modern housing components or

their constitutes are imported ,their prices are beyond the reach many, their manufacturing plants and transportation consumes lots of energy and also characterized by high carbon emission in their production and their high costs and low affordability are still major challenges .With the current trend of the economic growth in Ethiopia , the construction sector is in need of transformation to meet the national demand especially of housings.

The other challenges, the country facing is a high volume of waste released to the environment .Among the waste, paper waste takes the second largest volume .According to the World Bank report, global waste to grow by 70 percent by 2050 unless urgent action is taken. [12]. One way to overcome this challenge is to adapt and study on the use of locally available materials and wastes as alterative construction materials for production of roof ceilings.

This paper aims in producing roof ceiling majorly from waste papers. This wasted paper is obtained in office, municipality office, colleges, lower grade school, higher educational level and the like by product (waste) paper. The problem and the local availability of the raw material enforced us to produce a new finishing material (roof ceiling).

2. MATERIALS AND METHODS

2.1. Instruments

This research was done by using different instruments for the production of the board from the initial to the product (ceiling board)

Balance: It was used for measuring all measurable ingredient quantities of the produced board and was applicable in electric power and battery source.

Meter: it was used to measure the every dimension of the prototype.

Container: This instrument was used for soaking the waste paper. The container could be used up to 0.385$m^3$of waste paper.

Sieve: The sawdust was allowed to pass through 2.36mm sieve. This was done to get rid of some unwanted materials such as stones, pieces of metals and woods,etc

Measuring cylinder: It was used to measure the amount of fluid ingredient (water and cereal powder paste)

Stove: This instrument was used for boiling the cereal powder to form paste and the stove was applicable by electric power.

Mixer: An electric power machine rotated an average of three revolutions per second used for mixing the ingredients.

Molding equipment: Those instruments were used for casting the mixed paper in the desired shape and size. The mold was fixed by metal (40cm*40cm*1.5cm) and flat timber (15cm*15cm*1.5cm) length, width, depth respectively.

Oven: Drying instrument used to remove moisture in the sample and know the amount of water has been contained in the sample. It adjust its temperature according to variation of room temperature and amount of power supply to the machine at 105±5o^c

2.2 Materials

Waste Paper: Waste papers were collected and unwanted materials such as stencil papers, office pins, cenotaph, etc...,
were carefully removed manually from the sample papers. The paper served as sources of main constituent for the

composite. The paper samples were shredded manually. They were then soaked in water at room temperature for about three hours

Cement: The cement used in the mixture was ordinary Portland cement (OPC) and used as a binder when it was mixed with water to form paper-cement paste.

Saw-dust: Saw-dust samples were collected from saw mill, timber shade. The samples were dried in the open at room temperature. It was then sieved through 2.36mm sieve. This was done to get rid of some unwanted materials such as stones, pieces of metals,

woods and etc… Saw-dust serves as both filler and source of fiber in the matrix.

The sawdust was also soaked in water to allow for softening before further processing. The saw-dust was also soaked for about three hours in a separate container. After soaking and pounding, the pulp was collected in a container to ensure an eventual proper and uniform mixing with the pulp.

Water: to accomplish every activity of the product

Cereal powder paste: the cereal powder was manually cleaned and boiled using stove at 100 o^c for ten minutes then this would form jelly like character and used as a binding agent called paste. The paste would be used according to the sample mix ratio .The paste would be effective when mixed with other input ingredients at a temperature of 60^{o}c.

2.3 Methods

2.3.1 The Process for the Production of Ceiling Board

Saw-dust and cement were mixed at arbitrarily selected ratios. A known weight of the mashed waste paper and the cereal powder paste were mixed. Selected ratios of Saw-dust and cement were mixed. The paste-paper mix was mixed with cement-sawdust mix in a bucket. It was stirred to a homogenous mix. A mold of size 400x400 mm with a thickness of 15mm was cleaned and oiled lightly with petroleum lubricant. The mix was casted into the mold with manual compaction by hand and rod in three layers each of five mm thickness. A trowel was used to trim and smooth the exposed top surface. Four mix ratio samples of the ceiling boards each having three specimens were produced. Removing the molds from the samples could be followed by attaining seven days strength. This was done due to the reason that, the samples have gained enough strength to support themselves at the end of seventh day air drying. The moisture content was measured from the ratio of the weight of the moist sample to the weight of dry sample, and the value was 75%.

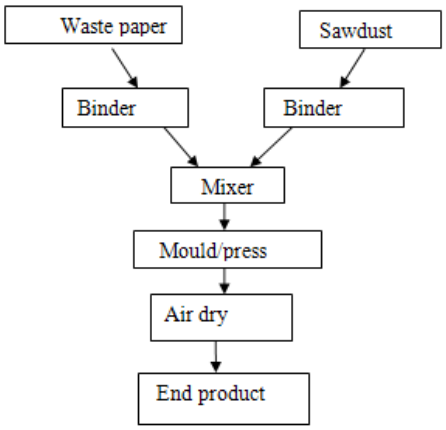


figure 1 Process of production

2.3.2 Pilot Tests

Accordingly, conducted both physical and mechanical properties test that could be done. As described above, we used ordinary Portland cement (OPC), waste paper (WP), cereal powder paste (P) and saw-dust (S) The arbitrarily testing ratio for each of the materials described in the ratio of OPC : S : WP.

a) Physical property tests

These test methods covered some of the physical tests of waste paper ceiling board; Machines aid and manually testing procedure were used for those properties tests.

I. Water absorption

The entire sample at the end of soaking in water and before soaking was weighted as W_2 and W_1 respectively. Its variation with different mix ratio was conducted as [10];

$$WA = \frac{(W2 - W1)}{W1} * 100\%$$



Figure 2 Water absorption

Abrasion test

Abrasion Test tends us to know the ability of a ceiling board to resist the relative movement of the board in contact with other solid bodies. For the purpose of this test, a dried sample of the board was weighed (W_1). A hard shoe brush was used to rub against the two surfaces of the board. 50 strokes of forward and backward movements each were made against the surfaces. The flaked particles from the surfaces were collected and weighed. The flaked board was also weighed (W_2). This procedure was repeated for all the four samples of three specimens. Flaking concentration (Fc) was determined using the expression in;

$$FC = 100\% - \frac{(W1-W2)}{W1} * 100$$



Figure 3 Abrasion test

II. Density (D)

The average density of sample was tasted

$$D = \frac{\text{weight}}{\text{volume}}$$

b) Mechanical property tests

The mechanical properties have been conducted were flexural strength test, MOR test, MOE test, and pull out and cutting test [6].The tests were summarized according to the respective mixing ratios.

I. Flexural strength test

Flexural properties of each ceiling boards were evaluated by supporting the specimens

near the ends and applying a transverse

load midway between the supports [7]. The testing result were recorded just when the board fails to resist those loads presented below according to the mixing ratio. The four samples had different mixing ratio and the respective flexural (bending) strength of each sample was tasted and described.

II. Modulus of rupture (MOR)

This was used to determine the peak load that can carried, it is calculated with the formula [8]

$$MOR = \frac{P.L.C}{6.I} \quad ,$$

Where:

$I = \frac{b.h^3}{12}$, I is moment of inertia in mm^4

P is the applied load in N

L is length of the sample in mm

C is half of the thickness of the sample in mm

b is width of the sample in mm

h is thickness of the sample in mm

All parameters remain the same as above and c=half thickness of the board

III. Pull-out and cutting test

This test was run to perform the fixing capacity of the board when nailing by hammer. Four specimens of each three specimens had a size of 15cm x 7.5cm x 0.15cm were prepared with the same

dosage used in the manufacture of

prototype boards. These specimens, after 7 days open air hardening were subjected to the pull-out test.

Nails of 2.50 mm in diameter and 32 mm in length were introduced into the specimens, shown in the fig. below. Two nails were inserted in the lateral face, two on the longitudinal side, and one at each end side of the piece. Beside the pull-out test cutting the sample using saw was also conducted. Accordingly the entire sample had different mixing ratio and had different strength that have been observed by visualization the effects. The effect of both pull-out and cutting test was summarized as follows.

IV. Impact test

This measures the amount of energy absorbed by a material during failure. This test was needed whenever something from the roof could be dropped to the ceiling panel for instance Un- bolted purlin, cracked side wall etc...And so the ceiling should resist such kinds of sudden loads. This test was carried out using spherical steel ball which is used for loss angels abrasion test those ball have different failure loads. According to the NTC 4335 standards have been conducted for impact load dropped from a height of one meter above the sample by suspending the ceiling[8]. And different failure load was observed for each sample and specimens.

Energy absorbed=mgh.

Where; m=mass of spherical wheel

g=acceleration due to gravity ($9.81 m/s^2$)

h=1m height above the suspended sample

3. RESULTS AND DISCUSSIONS

All tests outcome were conducted in accordance to the research design described. Now, laboratory test outcomes were presented for both physical and mechanical property of ceiling board. Various percentage tests have been considered in order for focusing the thesis with the improved property of samples which satisfied for the production of

ceiling board. And those test outcomes were evaluated and compared with standards and previous research results. So the applicability of this ceiling board could be identified for use of as construction material.

a) Physical property tests

I Water absorption (WA) value of the tests

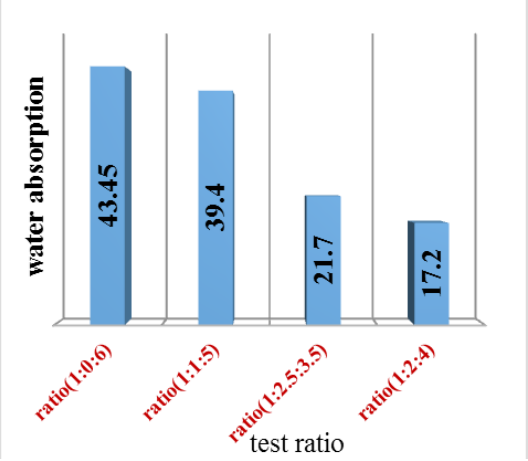


chart 1. water absorption test result

Out of the four samples tested for water absorption, it was found that test 4 with the mix ratio of 1:2:4 absorbed the least quantity of water and its average percentage water absorptive was 17.2% unlike the other tastes. Based on the results shown, it was noted that the mixing proportion has significant effect on the water absorption. This shows that more water is absorbed with decreasing quantity of cereal paste. Hence, there is a need to treat the mix with cereal powder paste to be used in ceiling boards in order to reduce its affinity for water.

According to the water absorption of previously produced ceiling type fiber cement flat sheet, trilite board ,and waste paper ceiling with rice husk <35%,<35%,16.83-18.3% respectively. Therefore, test 4 with mixing ratio of 1:2:4 (cement: sawdust: waste paper) had water absorption of 17.2% which had comparatively best result than the above described ceiling types. [3]

II. Abrasion test result

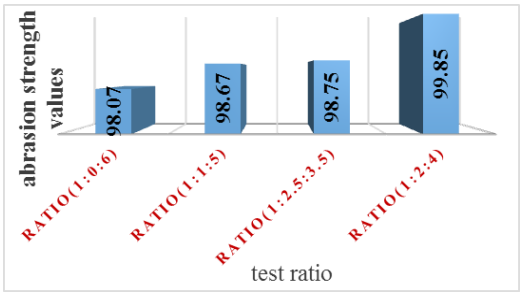


Chart 2 . Abrasion test result

According to the Abrasion strength of previously produced ceiling type fiber cement flat sheet, trilite board, and waste paper with rice husk ceiling 99.31%, 98.6%, and 98.07% to 99.85% respectively. So, the mean values of the abrasion strength obtained from the experimental board samples ranged from and from this study test number 4 had strength of 99.85 %.This showed that the ceiling boards with this mixing ratio, the quantity of the sawdust was in optimized ratio and the additive agent, cereal powder paste resist the board for prone to flaking. From the above graph indication, our study result had optimized value. [2]

III. Density test result

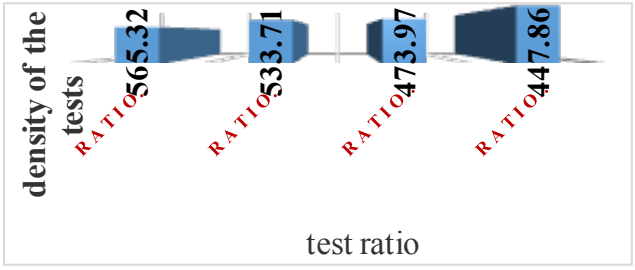


chart 3 Density test result

It was observed that the density of the samples decrease as the composition of paper decrease. The density of sample 1, which is purely made of waste paper (100% pulp), is 565.32 kg/ m^3, while that of sample 4, which is

80% paper and 20% sawdust, is 447.86 kg/ m^3. This indicated that wood waste and the waste paper had the minimum density as compared with using paper waste only. But, using more than the specified ratio of sawdust, the density of the board would increase due to higher density of wood than paper.

b) Mechanical property tests

I. Flexural strength test

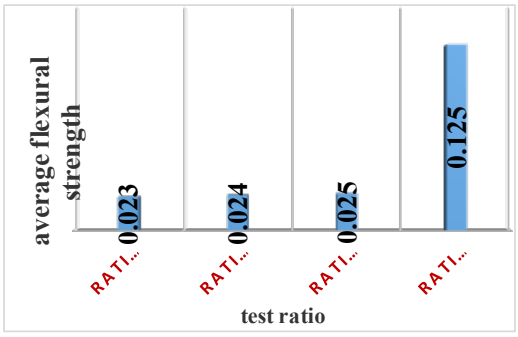


Chart 3 Flexural strength test

The highest flexural strength value 0.125 N/ mm^2 was achieved on the board sample with mix ratio 1:2:4. Other values are 0.023 N/mm^2, 0.024 N/mm^2 and 0.025 N/mm^2 for samples produced from mixes 1:0:6, 1:1:5 and 1:2.5:3.5 respectively. It was found that sample 1 failed on the application of more than 37.441N load, sample 2 failed after the load applied was more than 39.669N, sample three failed after the load applied was more than 42.24N, and sample 4 failed on the application of load more than 200.60 N. Test 4 indicated the ability of ceiling board to withstand flexural stresses during the handling or use of the material. . Based on the results shown, it was noted that the mixing proportion has significant effect on flexural strength test. This showed that as the amount of waste paper and sawdust increase the flexural strength of ceiling board decrease [7].

I. Pull-out test and cutting test results

Table 1 effect of crack and fracture

Test	1	2	3	4
Mix ratio	1:0:6	1:1:5	1:2.5:3.5	1:2:4
Pull-out effect				
(crack occur-rence)	Oc-curred	Occurred	Partially Occurred	Didn't. Occurred
Cutting effect				
(frac-ture occur-rence)	Oc-curred	Occurred	Partially Occurred	Didn't. Occurred

This indicated the ability of ceiling board to withstand Crack and fracture during the handling or use of the material, from the above result test 4 resisted fracture and crack while cutting and nailing the ceiling board. This was achieved due to the optimal amount of sawdust with additive cereal paste in the sample.

Therefore, the ease of handling of the plates was noted, given their low weight and flexibility of assembly with screws, without generating fractures at the edges.

II. Impact strength (Nm)

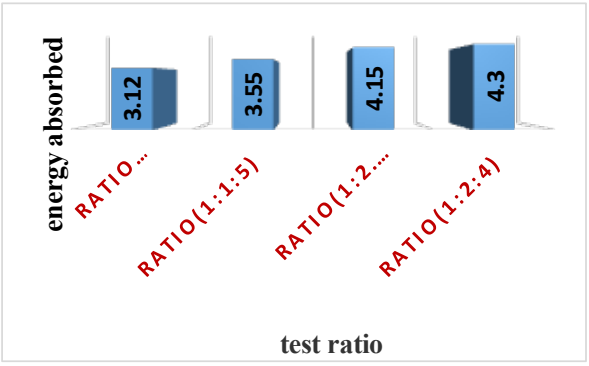


chart 4. Impact strength (Nm)

According to the Impact strength (Nm) of previously produced ceiling type fiber cement flat sheet, trilite board, and waste paper with rice husk ceiling 5.2-6, 4.9-4and 4.29-4.31 respectively.

It was observed that our research study board had an average impact strength value of 4.3 Nm which in turn indicated that it had optimized value among the three tests conducted. This was due to the presence of 20% of sawdust and 80 % of paper with cereal powder paste gave best outcome and increasing the amount of sawdust would decrease the result. And it was observed that the test outcome had optimized result than the other type of ceilings described in the above [4]

III. Modulus of rupture (MOR)

The results of the flexural strength test were used to compute both the MOR of the boards as a result the modulus of rupture just before fail when load was applied during flexural test was recorded for each tests conducted and test four (4) shows higher average result, 0.783 N/mm^{2}the optimized value was due to the presence of 20% of sawdust in the mix, this sawdust

increase the bondage of the mix when additive agents (paste) were used because sawdust have course texture and would increase the binding capacity ,which intern increase the sample strength and MOR value. Therefore, from the values of MOR it can be seen that the maximum MOR is satisfactory with the ASTM 208-72 requirement of not exceeding 2 N/ mm^2 [9]

4. CONCLUSION

From the results of the boards produced from waste paper, it was found that the boards had a good impact strength, abrasion strength, flexural strength, MOR, pull out and cutting strength, density, and a special water resistant property which can find usage in humid areas because of its low value of percentage water absorption. So, this study concluded that the board attained good physical and mechanical properties as compared to other previously manufactured ceilings.

The paper ceiling board attained its optimum value of the specified physical and mechanical tests with a mixing of ordinary Portland cement, sawdust and waste paper in ratio of 1:2:4 respectively. All the test outcome were the 7 days air dry value but, as the day increase up 28 days the maximum test value would be obtained.

From the research low cost composite ceiling boards has been made from environmental waste materials (sawdust) and waste paper which were considered and treated as waste materials exposed for disposal. This composite material compared favorably with other commercially available ceiling board materials. This study has equally shown that waste materials has been recycled into ceiling boards which can still be useful to man thereby protecting the environment to an extent, from waste disposal challenges.

5. RECOMMENDATION

It is highly recommended that production factories for composite ceiling boards be established as part of the entrepreneurship development programs of our higher institutions creating jobs for both skilled and

unskilled personnel in the midst of locally available raw materials.

Further researches have to be done for determining the chemical properties of those ingredients while mixing. And thermal

conductivity test have to be done.

To meet the demand of consumers, machineries that can produce large amount of ceiling have to be implanted.

Finally, by studying further tests and increasing the amount of the additive partition wall board and paper brick with the optimized ratio (1:2:4) of constituent materials will be produced.

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