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BUILDING MATERIALS MADE FROM AVAILABLE RAW MATERIALS IN NIGERIA

By

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Abstract

The level of manufacturing of a country or continent is an indication of the level of the development of the country or continent. This paper identifies the most important factors affecting the production of building materials using locally available raw materials in developing countries. Work that has been done in this area of the building industry was .looked at and the improvement provided by this work in areas of manufacturing method, raw materials and their sources are identified. Also, the locally available raw materials to manufacture the building materials were identified – fibre, waster paper, cement and water. This is followed with the analysis of test results. The products were tested to ascertain their reliability, porosity and impact the result showed that our products were very much better and cheaper than the conventional ones. Again a detailed cost analysis is included to establish the usefulness of this project. An example is included for comparison and finally comments were made and conclusions were drawn on the project. The final conclusion is that the project is feasible and very viable for the manufacture of building materials from locally sourced raw materials in Nigeria, so government and individuals of developing countries should invest in this research work to create jobs for young technologist for their respective countries.

Keywords: Housing, Building materials, Local raw materials, Cost, Benefits.

Introduction

The three main needs of human beings have been identified to be food, clothing and shelter. The importance of shelter to human existence cannot be over-emphasised because even God provided shelter for man in the Garden of Eden as recorded in Genesis 2:8 of our Holy Bible. This makes it very clear that housing is a necessity and not a privilege.

Again every society wants to improve the welfare of her people through technological advancement and developing countries cannot afford to be exceptions. Good food, roads,

rural infrastructure, housing, water and electricity are the yardsticks used in the measuring of societal development or growth. With improvement generally in health facilities in the world population has been increasing progressively, hence the demand for accommodation has increased tremendously. This in turn leads to increase in demand for building materials. One of the main raw materials required in the building industry is cement. In Nigeria the demand for cement in 1975 was 4,950,000 metric tons, in 1978 it was 7,220,000 metric tons, in the year 2000 the demand was over 16,000,000 metric tons, for the same period cement production within the country moved from 1,200,000 metric tons to 5,000,000 metric tons, hence the country produce less than 30% of its demand. For this reason the Nigerian economy is termed "import dependent' as most materials have to be imported to satisfy demand, this importation is the cause of the high price of many materials in the country including building materials that have very high demand in the country. In summary some of the factors that cause the high prices are;

i) Instability of the economy of the country due to frequent change of government.

ii) Lack of political will as universities findings are not put into practical use.

iii) Monopoly due to capital intensiveness in production. As Nigerians are not rich, capital for investment is a problem.

iv) Nigeria technologists are not encouraged, because leaders tend to believe so much in foreign goods and foreign personnel.

v) Assumed lack of raw materials base, this not true because the country has many raw materials not put into use.

To bring down cost of materials required in the country, the materials must be produced within the country using available local raw materials. In pursuance of this government of Nigeria established Directorate of Food, Road and Rural Infrastructure (DFFRI) in 1980s (1) to encourage the utilisation of local raw materials for the provision of building materials to assist the rural people to improve their accommodation at a cheaper price. DFFRI (1) produced several types of building materials ranging from roofing sheet, roofing tiles etc but the products produced had series of problems which we need to look at to improve the quality of products

The roofing with its structure, ceiling, the walls and partitions in a building account for more than 51% of the total cost of setting up the building, so if the cost of these items are reduced the total setup cost of the building will be reduced. This is where this research work comes in. Therefore the main aims of this research work are summarized below;

i) Improve on the work done by DFFRI

ii) Specifically produce roofing sheets, ceiling tiles, to be used for constructing walls and partitions of buildings from locally available materials at cheap cost.

iii) State the possibility of setting up small scale industries to provide job opportunities.

Required Raw Materials and Sources in Nigeria

The work at this stage will be divided into two parts;

(i) Production of roofing sheets from local raw materials.

(ii) Production of building walls and partitions using local raw materials.

Production of Roofing Sheet

DFFRI used a combination of local sand, sawdust, and fibre to produce roofing sheets; but the products did not conform to specified standards and had the following problems;

(i) The sheets produced cannot be carried about easily because they are very heavy.
(ii) The thickness of the product is not uniform.
(iii) The production moulds are very heavy hence cannot be easily carried about.
(iv) Finally the sheets break and fall off easily

To solve these problems stated above in this research work series of experiments and productions were made and the following decisions were taken.

i) Reduction of mould weight – To achieve this, fibre glass is used for the construction of the mould for the production of the roofing sheets. Fibre glass is almost weightless hence the mould can be carried about easily.

ii) Reduction of weight of produce roofing sheets – To tackle this problem the sand used by DFFRI as one of the constituents of the product is replaced with waste paper. Paper is almost weightless and tests showed that the waste paper improved the nail ability of the product.

iii) Ease of carrying the finished product – To solve this problem the sheets are produced at half the normal size of asbestos sheets. The production size is 1.2m x 1.2m and of 3.00mm thickness that is two our product in size is equal to a standard asbestos sheet, hence many can be transported or carried at a time.

iv) Producing uniform thickness – This achieved easily because of the fibre glass mould as its thickness is designed to give the exact requirement thickness of 3mm.

The major raw materials required for the mould production which are locally available are fibre-glass mat, mould removed wax, fibre-glass mat binders (resin and jell-coat), accelerator and plywood. Other materials are asbestos roofing sheet, nails, and hinges, painting brush, batons, trowel, planks and plane. For the production of the roofing tiles, the raw materials required and their sources are stated in table 1;

S/No	Raw Materials	Source of Raw Materials
1	Fibre	From Palm Kernel and Coconut
2	Waster Paper	From Cartons Sold in Market
3	Cement	Bought From Local Market
4	Water	From Taps, Stream or Rain Water

In the above table only cement constituent that is bought from any local market that has a bit of foreign component. The tools and equipment used for the production of the tiles are polythene, mixing tray (head pan), leveller wood (of 800mm long) and measuring cup.

Production of Building Walls and Partitions

In a standard building its walls and partitions account for 30% of the local cost of constructing the building, so if this cost is reduced the overall cost of the building will be reduced.

From our studies we have confirmed that acoustic tiles produced from locally available raw materials can be used for ceiling, walls and partitions of the building like the production of the roofing sheets, production of mould for the tiles is required. The mould assembly consists of three parts – the mould cover, the feed tray and base of the mould. The materials required are plywood, lining wood, glue, waterproof, tracking and positioning nails etc.

For the production of acoustic tile the same materials used for the production of roofing sheets shown in table 1 are used. Therefore it is the method of production that gives a different product. Other materials required are for the construction of a roller and they are rod and pipes.

Manufacturing Stages of the Building Materials

As done previously the manufacturing stages of the roofing sheets will be separated from that of the ceiling, partition and wall tiles.

Manufacturing Stages of Roofing Sheets

The production process can be divided into two distinct stages and the stages are production of the mixture box mould and production of the roofing sheets.

Again the first stage is divided into two parts – production of the mould and the mixing box. The mould is constructed so as to obtain the exact shape and convolution of the asbestos sheet. The asbestos roofing sheet is cut to the required size (1.2m x 1.2m) and placed on the ground, this is followed with the application of the mould removal wax on the sheet then a mixture of jell, resin and accelerator (in the ratio 2:17:1) is applied to the surface of the cut sheet which has been treated before. Then after some time about five minutes the fibre mat is place on the cut asbestos surface with the aid of painting brush, also batons are used as reinforcement on the mould. After about three hours the mat conforms to the shape of the convolutions of the asbestos sheet. This whole process is repeated on the other side of the sheet.

The mixture box is constructed using batons, planks, plywood and nails. The batons are placed in such a way as to give the correct thickness of the sheet while the plywood used is (1.2m x 1.2m) of the roofing sheet. The next stage is the treatment and preparation of the raw materials required for the mixture for the production of the roofing sheets.

Figure 1 shows in block diagram the required processes.

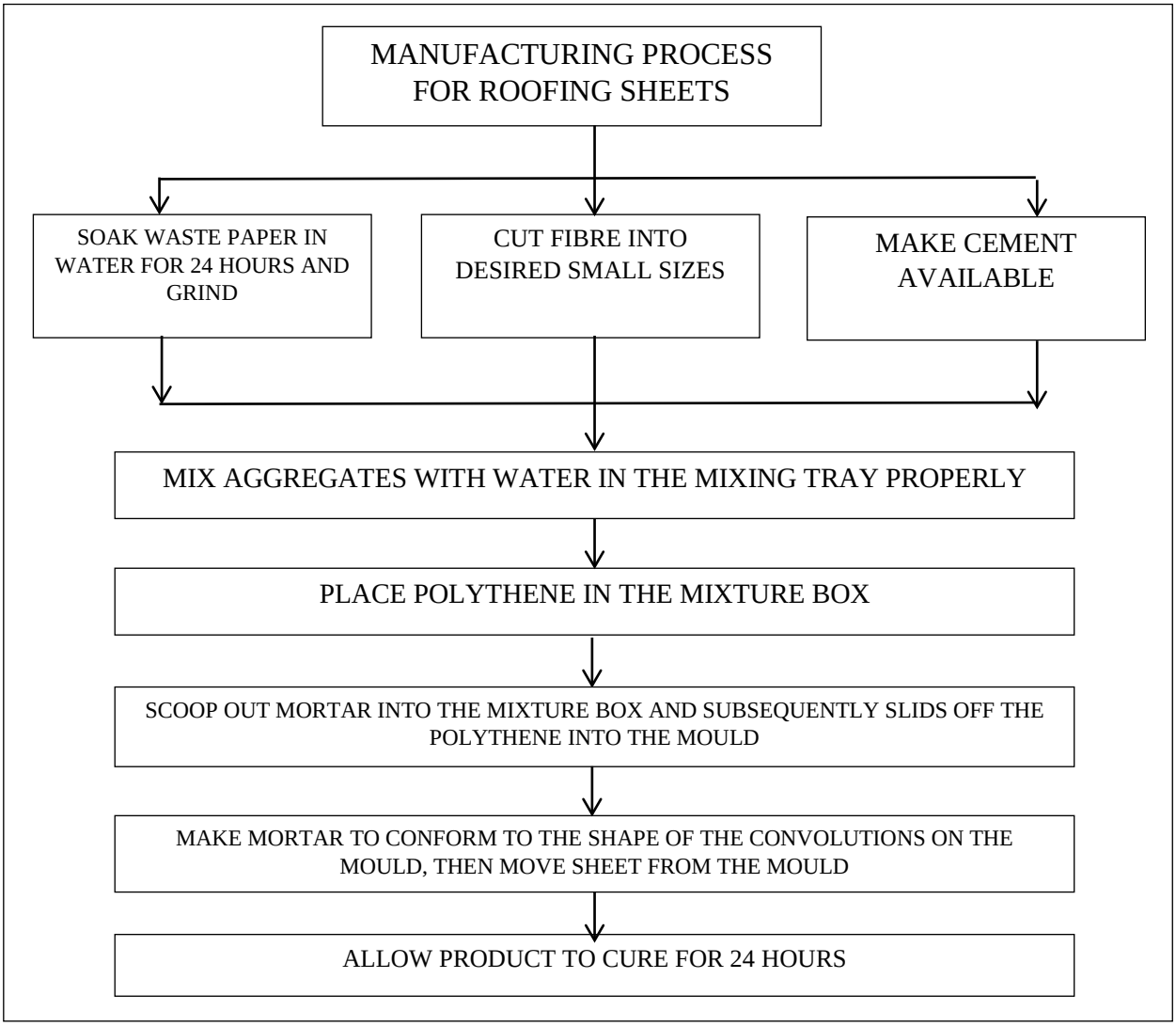


Figure 1: The block diagram showing the different manufacturing processes for roofing sheets.

The cement to be used is flat sieved using 600m laboratory sieve pan and kept in a polythene bag. The required waste paper is obtained from cartons broken into pieces, soaked in water for 24 hours and grinded to dine grains using locally available grinding machines. The processing of palm kernel fibre is quite cumbersome and it is time consuming because of its oil content. The fibre is subsequently rinsed in fresh water and allowed to dry. On the other hand the coconut fibres are then obtained from the bark of the coconut fruit, the fibres are carefully pilled off and reduced to fine strands, finally both palm kernel and coconut fibres are carefully are subsequently mixed together in one bag. The water to be used is available everywhere.

The final stage is the manufacture of the roofing sheet. The mixture of the raw materials takes place in a mixing tray using a hand trowel. The constituents are measured in an approve ratio say 40 cups of cement, 5 cups of waste water, 8 cups of fibre and 4 litres of water. Then after

thoroughly mixing the constituents the mortar is scooped out from the tray using the hand trowel unto polythene placed inside the mixture box. The mortar is then distributed evenly and smoothened using the hand trowel and the leveller. The cut asbestos sheet is placed on top of the female part of the mould. The polythene that contains the mortar is then gradually and carefully slides off from the mixture box unto the asbestos sheet placed on one part of the mould; then polythene is placed on the mortar this is followed with the mating of the parts of the mould firmly. After this the mould is then opened and the asbestos sheet that carries and contained the product is carefully removed. The finished product is then allowed to cure and set properly.

MANUFACTURING OF MATERIALS FOR CEILING, WALLING AND PARTITION

The manufacturing of the acoustic tiles locally using the locally available raw materials involves series of steps are shown in figure 2.

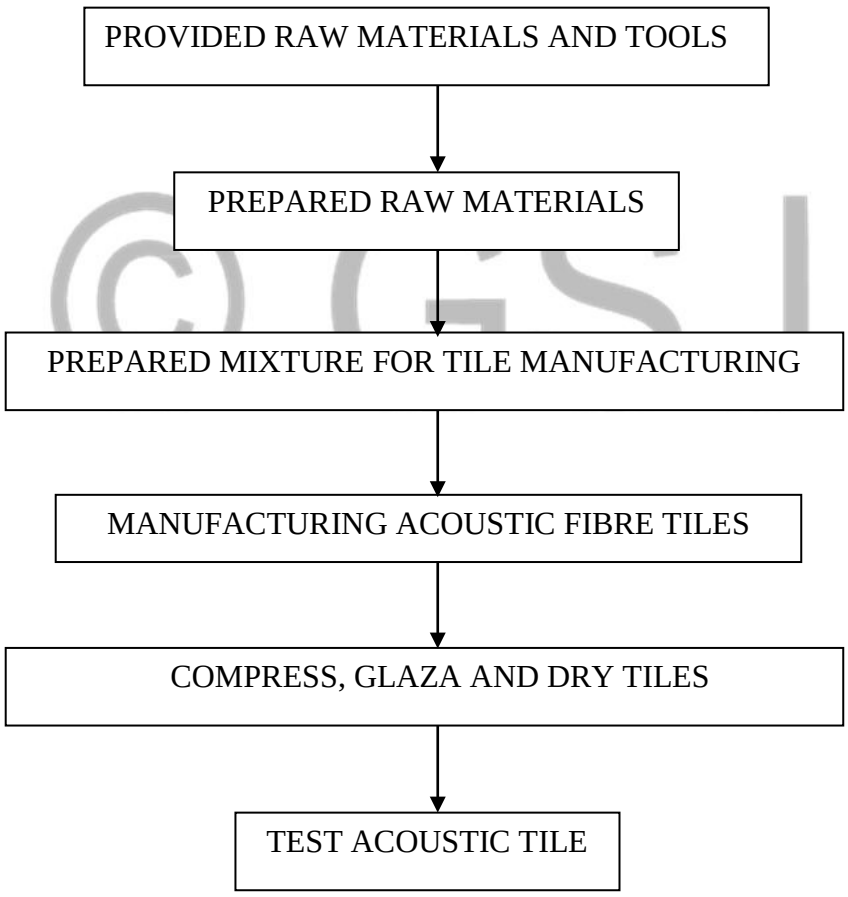


Figure 2: The Manufacturing Process of Acoustic Tiles

Now we shall look at each of the manufacturing process starting with the preparation of the mould and equipment. Here the two major assignments are the manufacturing of the mould for the smooth and uniform surface for the tile and manufacture of the tile itself. The acoustic tiles for ceiling purpose are produced 600mm x 600mm, while the walls and partition tiles are

produced 1.2m x 1.2m, each of a thickness of 20mm. Therefore manufacture of two mould cover, the feed tray and the base of the mould.

First the size of the tile to be produced is fixed as 0.6m, this is for the ceiling. For the construction of the mould cover 15mm thick plywood, lining wood and tracking and positioning nails are used.

The final assembly of the mould cover has the dimensions: 650mm x 650mm (External), 600mm x 600mm (Internal) and its height is 40mm.

For the construction of the feed tray 3.2mm thick plywood, lining wood, glue, waterproof and tracking nails are used. The final assembly of the tray is 600mm x 600mm; the difference of 500mm on one edge served as its handle. The same materials for the mould cover are used for the mould base. The finished mould base will have an internal dimension of 600mm x 20mm thickness (height).

The materials required for the construction of the roller are 100mm diameter pipe of length 680, 15mm diameter rod of 800mm length, cement, sand, water and waterproof. A mixture of sand, cement and water is prepared and poured into a pipe, then the rod is moved and finally the waterproof is removed from the rod. The rod serves as a handle for the roller.

This process is repeated for the mould and the roller for the wall tiles with all dimensions doubled as required. The next stage is the preparation of all the required raw materials. Here we start with the preparation of the coconut fibre. The coconut barks are dried and the fibres are removed in the form of strands and cut into very small bits, then they are stored in a polythene bags. This is followed by the preparation of the waste paper. This is the main constituent of the tile and it is obtained from used cartons. The cartons are cut to very small pieces, soaked in water for two or three days and grinded into paste form with aid of a local hand grinding machine, finally the paste is stored in a container. After that cement and dried starch are bought from local market. Then they are separately sieved and kept in separate polythene bags. The next stage is the preparation of tile production mixture. First two types of binding elements – starch and cement were used. The research work showed that the cement has better binding properties so it is used for all other tests in this study. First the grinding moist paper and cement are measured out and thoroughly mixed using trowel in a head pan. This is followed with the spreading of the coconut fibre evenly on the mixture and constituents mixed again with the aid of the trowel. Then water is gradually added to the mixture and fully mixed until the mixture is even.

The final stage is the manufacture of the acoustic tile. First the feed tray is covered with polythene and placed inside the mould base. Then the mixture is scooped out of the head pan into the feed tray until it is full to the brim, this is followed by the use of the roller on the mould to provide smooth surface and compact the mixture. This process if repeated with the addition of more mixture until no reduction is noticed in the mould again, then it is covered with polythene and the top cover of the mould is carefully placed and fitted over the mould. The rolling process is repeated on the top cover with the exertion of pressure several times.

After this both top cover and polythene are removed, and then the top of the mixture is carefully painted with fine watery cement to provide the finest surface finish. With the aid of feed tray the tile is removed and allowed to dry. Finally the surface is sprayed with white oil pain to give it the desired white surface finish. Again this process is repeated for the

manufacturing of wall and partition tiles which are double in dimension when compared to the ceiling tiles.

ANALYSIS OF TEST RESULTS

After series of tests and analysis we decided to restrict our raw materials for all the required building materials to cement, waste paper, fibre and water only. At this stage some product of different sets of constituent aggregate mixture were produced to determine which aggregate gives the best production of any product. To do this a couple of trial tests were carried out on the finished products. The tests were nail, porosity and impact or crack. The detailed analysis of the tests and their corresponding results are discussed below.

The analysis of the production tests results for roofing sheet are shown in table 2.

Table 2; Result of Test

Sample No.	Cement No. of Cups	Paper No. of Cups	Fibre No. of Cups	Water No. of Cups	Weight in Kg	Nail Test	Porosity Test	Impact Test
1,	36	8	8	4	5.28	Passed	Passed	Passed
2.	40	6	8	3	5.72	Passed	Passed	Passed
3.	40	5	8	3	5.66	Passed	Passed	Passed

For the nail test a roofing nail was used on the product and it was observed that the nail passed it smoothly without any fracture. For the porosity test the product was placed under a water tap for five hours and no water permeated through it. For the impact test the product was raised to 1.5m above the ground and released and no cracks were observed. In general, sample 3 gave the best the best result so its use is recommended.

The three tests were repeated on the ceiling tiles as well as on the tiles on the walls and partitions. This is done to confirm if they adhere to established standards set for tiles. The analysis for the ceiling tiles manufacture is shown in table 3.

Table3; Result of Tests

Sample No.	**Cement No. of Cups**	**Paper No. of Cups**	**Fibre No. of Cups**	**Water No. of Cups**	**Weight in kg**	**Nail Test**	**Porosity Test**	**Impact Test**
1,	4	30	10	2	3.81	Passed	Passed	Passed
2.	4	25	14	2	3.47	Passed	Passed	Passed
3.	3	25	14	2	3.24	Passed	Passed	Passed

Sample 1 failed the nail test because of lack of porosity. In sample 2 there is decrease in paper content, increase in fibre content while the sample passed all the tests. For sample 3 only the cement content is reduced in the case of sample 2 and the sample failed the crack test. The tests showed that cement to some extent assisted in the inter-locking of the fibre. In reality sample 2 produced relatively the smoothest surface, but is however very difficult to mix because of the presence of the fibres.

The test results for the wall tiles (1.2m x 1.2m) were exactly the same with those of the ceiling tiles as the only difference is that the wall tile is double the ceiling tile in dimension.

Analysis of Manufacturing

For this research work to be useful to government and private investors a no manufacturing cost analysis is necessary. The cost analysis will provide an opportunity for comparison (5), (6). The analysis will be divided into three (3) parts;

(i) The manufacturing cost of roofing sheet
(ii) The manufacturing cost of ceiling tiles
(iii) The manufacturing cost of wall or partition tiles.

The Manufacturing Cost of Roofing Sheet

The analysis will be divided into two parts.

(i) The cost of constructing the mould and the mixing box
(ii) The cost for the purchasing of the required raw materials.

The cost of construction of the mould and the mixture box is shown in table 4 below;

Table 4: Cost of Constructing Materials for Mould and Mixture Table

S/No	Description of Materials	Quality	Unit Cost (₦)	Total Cost (₦)
1	Resin	6 litres	500.00	3,000.00
2	Fibre glass Mat	3 yards	400.00	1,200.00
3	Catalyst/ Accelerator	1 litres	700.00	700.00
4	Jell Coat	1 litres	1,500.00	1,500.00
5	Mould Remove Wax	1 tin	1,500.00	1,500.00
6	Asbestos Sheet	1 sheet	600.00	600.00
7	Batons	2	70.00	140.00
8	Nails (2” x 4”)	1 bn	200.00	200.00
9	Hinges 4”	1 pair	150.00	150.00
10	Plywood (8” x 4”)	1 sheet	1,600.00	1,600.00
11	Planks (2” x 4”)	4 pieces	300.00	1,200.00
Total				**11,790.00**

The cost of the raw materials required for producing the mixture for the roofing tile production is shown in table 5.

Table 5: Cost of Raw Materials for Roofing Sheet Production

S/No	Description of Materials	Quality	Unit Cost (₦)
1	Eagle Cement	1 bag	2,500.00
2	Waste Paper Cartons	5 cartons	200.00
3	Fibre from Palm Kernel/Coconut	1 bag	300.00
4	Polythene	1 roll	800.00
5	Transportation		500.00
Total			**4,300.00**

Next we shall calculate the production cost of one unit of the roofing the using sample 3 in the test cases.

A bag of cement weights 50kg and costs ₦2500.00 therefore the cost of 40 cups of cement used with be (₦2500 x 0.135 x 40)/50 = ₦270.00 A bag of fibre weights 1.35kg and costs ₦300.00 hence the cost of 8 cups of fibre used = (₦300/1.35) x 0.01 x 8 = ₦17.78. If 5 grinded paper cartons weigh 0.9044kg and cost ₦200.00 then 5 cups of paper will cost = (₦200/0.9044) x 0.04795 x 5 = ₦43.36. Let the cost of labour per unit = ₦2.50. Therefore the total cost of manufacturing a roofing tile = ₦270.00 + N43.36 + ₦2.50 = ₦315.86. The cost of locally manufacturing a roofing sheet is less than 45% of the price of an imported one. If it is mass manufactured the cost will be further reduced.

The Cost of Manufacturing One Acoustic Tile

The cost of manufacturing one unit of a ceiling tile is shown below:

The cost of a standard bag of cement (50kg)	=	₦2, 500.00
A cupful of cement weights	=	225gm
Therefore its cost = (₦2, 500/225)	=	₦11.1

Coconut fibre is not bought but is gathered from places for its cost will be the cost for labour on gathering and treating them. 1.35kg weight of coconut fibre cost = ₦300.000; but a cupful of fibre weights = 35gm

Five (5) grinded paper cartons weighs = 0.9044kg and it costs	=	₦200
A cup of paper weighs	=	80gm
Therefore the cost of one cup of grinded paper	=	
(₦200/0.9044) x 0.04795	=	10.60

The cost analysis of manufacturing one acoustic tile is shown in table 6.

Table 6: Cost of Constructing Materials for Mould and Mixture Table

S/No	Description of Materials	Quality (Cups)	Unit Cost in Naira (₦)	Total Cost in Naira (₦)
1	Paper	25	10.60	265.50
2	Cement	4	11.1	44.4
3	Fibre	14	2.59	36.26
4	Labour			2.00
Total				**348.16**

The cost of locally producing an acoustic tile is less than 40% of cost of an imported one. If it is mass produced the cost will be further reduced.

The Production Cost of Wall or Partition Tile

The ceiling tile is half in size when compared to the wall or partition tile. Therefore, the maximum cost of production of the wall tile will be twice the value of the ceiling tile and it is equal to N696.32.

Cost Analysis of a Prefabricated House

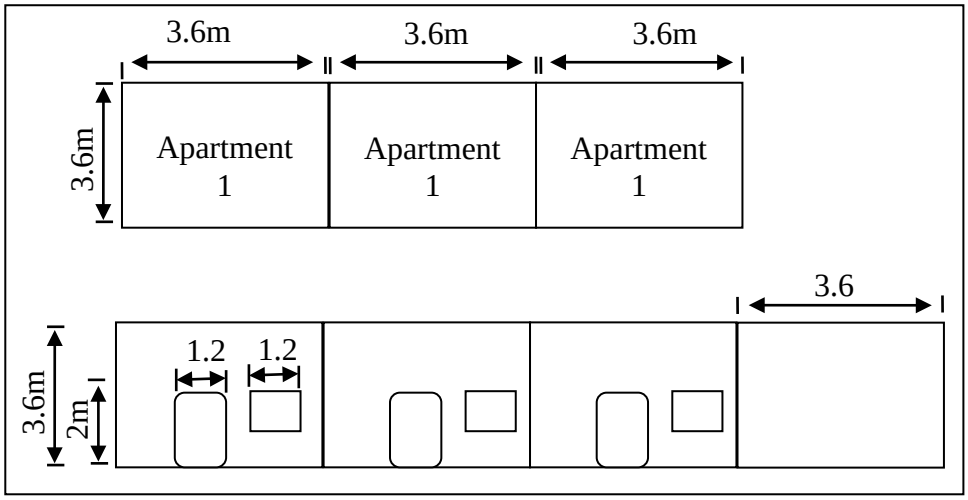
The usefulness of these products will be more prominent when they are used in the construction of a building. The division of work in a standard building is shown in table 7.

Table 7

Part	Description of Work	% of Total Work
A	Foundations + Slab + Screeding + Tarranzzo	22%
B	Walls and partitions	30%
C	Roofing Structure + Ceiling + Asbestos Roofing	21%
D	Electrical + mechanical Works	14%
E	Windows and Doors	10%
F	Painting (Inside and Outside)	3%

From table 7 it shows that parts B and C account for about 51% of the total cost of setting up a building. If we assume that for parts A, D, E and F standard materials are used for all the buildings to be considered then the buildings can be compared using only parts B and C.

Let us consider a building of three (3) apartments each apartment being 3.6m x 3.6m and 3m high, also let each apartment have one standard door and a window at the front and each apartment be separated by a wall or partition as shown in figure 3.



From the standard building let 6" block be used for the walls and the partitions and asbestos sheets be used for the roof and the ceiling.

Figure 3: Showing the views of the building under construction.

For the standard building let 6" blocks are used for the walls and the partitions and asbestos sheets be used for the roof and the ceiling.

Total area of walls and partitions.

= 3.0 x 3.6x 4 + 3.0 x 3.6 + {3 x 3.0 x 3.6-3 (1.2 x 1.2 + 1.2 x 2.2)

= (43.2+32.4+32.4 – 4.08)m^2 = $\underline{103.92m^2}$

If the cost of $1m^2$ of wall area = ₦1200.00. Therefore, 103.92m2 will cost = 103.92x 1200.00 = 124,704.00. The total area to be ceiled = 3.6 x 3.6 x $3m^2$ = $38.88m^2$. Number of ceiling boards (1.2m x 1.2m) required = 38.88/(1.2 x 1.2) = 27 sheets. Cost of one asbestos ceiling sheet = N1000.00. Therefore cost of 27 sheets = 27 x 1000.00 = 27,000.00. The area to be roofed is the same as that of the area to be ceiled. Required number of roofing sheets (1.2m x 2.4m) = (3.6 x 1.8 x 3 x 2 x 2) / (1.2 x 2.4 x 0.8) = 34 sheets. The cost of one asbestos roofing sheet = N1500.00. Therefore, the total cost of roofing sheets = 34 x 1500 = ₦51,000.00. The cost of roofing, ceiling, walling and partitioning = ₦124,704.00 + ₦27,000.00 + ₦51,000.00 = $\underline{₦202,704.00}$.

Now we shall consider the equivalent costs using our new building materials. For the walls the tiles will be used in and out. Therefore cost of walls using our produced acoustic tiles (1.2m x 1.2m) will be 103.92 x N696.32/ (1.2 x 1.2) = N72, 361.57. The total cost of ceiling tiles using acoustic tiles = 27 x 2 x ₦188.36 = ₦18, 800.64. The total cost of roofing using our new roofing material = 34 x 2 x N315.86 = ₦21, 478.48. Therefore, the total cost of roofing, ceiling and providing the walls using building materials produced by us

= ₦72,361.57 + ₦18,800.64 + ₦21,478.48 = ₦112,640.69

From this analysis it shows that the cost of using our made in Nigeria building materials from locally sourced raw materials is less than 48% of the regular materials used. Therefore, there is a decrease of 52% in the total cost of providing roofing, ceiling and walls for a building.

Hence, the use of our new materials will bring down the cost of setting up of building by at least 25%. This is a very significant decrease in the cost of construction of a building.

Comments on Conclusions

i) It is very possible to produce very good building materials from locally available raw materials in Nigeria.

ii) The economic importance of this work cannot be over emphasised as the cost analysis showed that the project is a viable and feasible one.

iii) The products produced are very cheap, durable, nail able and does not fall away easily when cracked because of the presence of fibre as a constituent.

iv) The products produced have greater advantages over the conventional asbestos because it does not fall away easily when cracked.

v) For the products to conform to defined specifications the paper should be grinded to its finest quality, also the mortar should be thoroughly mixed to ensure a uniform distribution of aggregates through out the product.

vi) The extent of work carried out has laid a solid foundation for establishing a cottage or small scale building industry in the rural areas of the country to assist the rural people.

vii) For mass production large moulds should be constructed using steel materials to eliminate the use of polythene inside the feed tray; since large volumes of mixture will be required it should be carried out with a mechanical mixer; also the glazing should be done mechanically.

viii) To achieve a faster process of drying the tiles a heat source are been provided using a locally made oven, but extreme care should be taken to avoid the burning of the tiles.

ix) Use aluminium ceiling nails to install the tiles instead of ordinary steel nails.

x) The locally produced tiles are relatively less expensive, weigh less, do not absorb heat at all and it is very good for the Nigerian environment.

xi) The walls and partitions of the building do not require painting again because of the oil paint used on the tiles this will further reduce the cost of construction of a building.

xii) The building is both sound and fire proof because of the acoustic tiles used for the ceiling, walls and partitions.

xiii) Finally, the project has actually improved on our local technology hence individuals and government should invest in the project to provide employment for some people, business break-through for others and at the same time improving the rural areas to reduce rural immigration to reduce cities congestion.

xiv) Valued added manufacture increases the national gross income of a country; therefore developing countries should pursue this venture vigorously to improve their development level.

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