LOW COST MATERIALS FOR BUILDING AND CONSTRUCTION: A CASE STUDY OF RICE HUSK

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Abstract
Nigeria has for many years been over dependent on conventional and imported building materials which are rather costly and beyond the affordability of the common man. The building industry in Nigeria is encapsulated with shortage of affordable building and construction materials. People have difficulties building houses of their own because the costs of building materials are astronomically high. A look inward reveal that Nigeria has a good number of agro-allied wastes, industrial wastes and mineral deposits such as rice husk, saw dust, coconut fiber, palm kernel fibre, marble dust, caicium cabonate to mention but a few. Rice husk is produced in many parts of Nigeria such as Abakaliki, Afikpo, Ogoja, Ikepe, Lafiaji, Badeji, Pategi, Sokoto, Birnin Kebbi, Abeoukuta, Benin and Delta regions. Rice husk dumps are mountainously available in alarming proportion in Abakaliki and other communities. The rice husk dumps contribute immensely to environmental pollution, degradation and hazards. The evacuation of rice dumps. From these communities requires urgent attention. With an optimized ratio the researcher used Rice husk, marble dust, pulp, cement and water to produce ebonite roofing tiles. The researcher invented a chemical locally made that can be used to treat rice husk and make it workable in the production of roofing tiles. It cannot work except it is treated. Also burning the rice husk before use would destroy its water repellent qualities. The equipment used are vibrator, Italian vortex hydra ferrar, pulverizing machine, oven, shovel and trowels, twenty four tests were carried out on the tiles including fire endurance (30min) U-value (0.22w/m2lx), water absorption capacity (25%). Tensile strength (45/cm^2) and modulus of rupture (0.99N/mm^2). The test results were satisfactory in accordance with Bs 1191, 6463 part 4 Bs 4550/ Bs 43359, Din 4202 and ASTMC 204. The tile is cost effective, strong, maintenance free; resistant to corrosion, water and heat, and it is not carcinogenic.

Introduction

The study of low cost materials for building and construction is an area of human endeavour which collaborates directly or indirectly to the socio cultural and socio economic setting of the people or community. The level of technological development determines the level of social, economic and environmental development. Nigeria for a long time, has depended on conventional building materials which are rather astronomically costly. The problem of over dependence on conventional building materials can be solved by diverting our attention toward the local sourcing of alternative materials for building and construction. It was for this reason that the Nigerian building and road research institute (NBRRI) was established in 1978 (Ukot 1989). NBRRI laid emphasis on the development of suitable local building materials from mineral deposits and agro industrial wastes that are abundantly available at little or no cost. The waste materials that are available in our environment include rice husk, saw dust, coconut fibre, palm kernel fibre, marble dust, stone dust to mention but a few. Rice husk for instance is abundantly produced in many parts of Nigeria such as Abakaliki, Afikpo, Ogoja, Ikepe, Lafiagi, Badeji, Pategi, Sokoto, BirninKebi, Abeokuta, Benin and Delta region. Rice husk dumps are increasing in alarming proportion at Abakaliki. Disposing and evacuating the rice dumps is urgently necessary because of the impending environmental hazards, degradation and pollution it posses to the people and the environs. In attempt to dispose rice husk, most communities, set the rice husk takes dumps on fire. Unfortunately a small heap of rice husk takes months to get burnt to ashes. Opara (1998) noted that rice husk burns to ashes at the temperature of 800°F. Even when burnt to ashes, it is still an eyesore in the communities especially during the rainy season. Rice husk dump on fire constitute

serious environmental hazards especially during the harmattan season when the dust devil and other manner of winds blow. It can set nearby buildings on fire. Some people are known to have died by unknowingly running into or stepping into rice husk dumps on fire beneath the surface.

Rice husk can be used in the production of roofing tiles. Okorie (1994) stated that the harvested rice kernel known as paddy is enclosed by the hull or husks otherwise called rice husk. To obtain the rice husk, the rice paddy is parboiled, dried and milled to separate the rice from the husk. He also revealed that the rice husk contains cuticule,a biological membrane that does not allow for easy.

Onyemachi (1994) investigated the utility of rice husk and its derivatives in the building industry. In the said study onyemachi subjected rice husk to various tests to determine its chemical composition and properties. In the process the liquid limit content of the rice husk ash was established. Compressive strength machine was used to determine the strength of the rice husk concrete. Defeasibility test was also carried out to determine the thermal conductivity of the rice husk. Rice husk has some organic substance which makes it difficult to bind effectively with cement. For this reason onyemachi converted husk into organic material by burning it to ashes.

Parry (1985) reported that fibres which have the following properties are unsuitable for the production of building materials.

1. Stiff fibre
2. Oily and greasily to touch
3. Impregnated with cement-affecting chemicals (e.g. sugar)
4. Susceptible to large dimensional changes when changing between wet and dry state.

In a study of partial displacement of cement with rice husk in concrete element, Ukpon (1991) revealed that rice husk could be used in the construction of concrete elements. In the said study, Ukpon (1991) mixed cement, sand and burnt rice husk with water. He used the mixture to make concrete cubes. The cubes were subjected to some tests which included compressive strength test, the result of the test revealed that the concrete cubes recorded adequate compressive strength.

The permeability test showed that the rate of penetration of water into the concrete was low. Ukpon added that there was reduction in the weight of the concrete when the cube was compared with similar cubes produced from the mixture of cement and sand without rice husk. The study also noted that rice husk does not burn with flame and that the rate of burning was very slow which indicates that rice husk is fire resistant. In the said study, Ukpon did not give reasons why the rice husk was burnt into ashes before use. The research was not aimed at the production of roofing sheets using rice husk. Tests, such as resilence test and ductility tests were not carried out. However, Ukpon's study recorded significant success.

In a similar study titled replacement of cement with rice husk in concrete construction, Emenari, (1987) in Onyemachi (1994) converted rice husk into rice husk ash and used it together with sand and cement to produce concrete cubes. At the end of the study, Emenari concluded that: the use of rice husk in concrete construction reduced the cost of concrete elements. In his cost analysis, Emenari stated that, if a concrete industry uses say 220, 000 bags of cement each year at the cost of N11.00 a bag, the cost is 2, 420, 000 Naira but with 15 per cent replacement of clement with rice husk ash, the cost reduces to 2, 057, 000 Naira. The study revealed that rice husk reduces hydration on concrete and improves resistance to attack by sulphate soil. The study noted that rice husk lowers the strength of concrete at the early stages and increases the strength more rapidly at the latter stages of the concrete. Though the study involved rice husk, it was not geared towards the production of roofing sheet. No test was carried out on the concrete cubes in relation to, permeability of the concrete element formed.

Fashoba (1994) also carried out a research on rice husk in concrete elements. In the said study Fashoba adopted a method of partial replacement of cement with rice husk. The concrete was cured by the use of authoclave. While the quantity of cement was kept constant, the rice husk ash was increased. Different samples with different mix ratios were obtained. Fashoba used this method to determine the mix at which the concrete had the highest strength. A comparism of

the result of compressive strength test revealed that there was no significant differences between the concrete produced from cement, sand and rice husk ash, and the concrete produced from cement, sand and rice husk ash, and the concrete produced from a cement and sand.

In a search for a low cost materials for road construction in Eastern Nigeria, Nwogu (1986) in Onyemachi (1984) reported that rice husk can be used to improve the embarkment and sub-grades of highways through marshy and waqter logged areas where unstable laterite is ecountered. The study did not indicate whether any treatment was carried out on the rice husk before use or not. Also, the study did not indicate whether any test was carried out to determine the effectiveness of rice husk as a road construction material. Rice husk, in the said study was not used in the production of corrugated roofing sheets.

While Nwogu carried out a search on low cost materials, Ojosu (1989) examined the acoustic properties of building materials for building design. Ojosu revealed that rice husk can be used with cement to produce acoustic materials. In the said study Ojosu assessed the following local material: Rice husk, palm fibre, coconut fibre and polystyrene foam. The study reiterated that the lack of proper sound treatment of various components in functional enclosure led to excessive noise and reverberation creating the difficulty of speech communication. Ojosu noted that sound treatment is particularly important in functional units such as auditoria, schools, concert halls, mosques and cinema halls. The study also revealed that rice husk can effectively be used in the production of ceiling boards and surface boards. While Ojosu concluded that rice husk was converted to ash or used in its natural state. He did not state whether the rice husk underwent any treatment. Besides, the study was not geared towards the production of corrugated roofing sheets. Also there was no indication of any tests carried out on the ceiling board.

Nevertheless, an investigation of soil amelioration with rice husk ash was carried out by Madu (1986). The study reported that rice husk ash can be used as a pozzolana in partial replacement of cement for soil stabilization. Madu, in the investigation revealed that rice husk ash has the advantage of increasing the resistance of cement stabilized soil to sulphate attacks. Also, the study revealed that rice husk reduces the rate of hardening of concrete elements. Madu added that low strength development at the early ages including high shrinkage effects were observed. Though rice husk was converted to rice husk ash, Madu did not give any reason for the conversion. No test result in relation to the permeability of the concrete element was reported.

Characteristics which Asbestos Share with Rice Husk as Roofing Tile Materials

1. Fire Resistance

Hornbostel (1991) revealed that Asbestos is fire resistant. He added that though Asbestos is fire resistant, it could deteriorate as a result of loss of water of hydration at a very high temperature of 752oF and above. At temperatures of between 110oF and 1400oF all the molecules in Asbestos will evaporate and the resultant effect is loss of strength and embritlement. However, for roofing and building construction purposes the level of fire resistance of Asbestos is very adequate.

In a study of partial displacement of cement with rice husk in concrete elements Ukpon (1991) revealed that rice husk does not burn with flame. He noted that the rate at which rice husk burns is very slow which indicates that rice husk is fire resistant.

In an attempt to burn rice husk into ashes the researcher discovered that rice husk is converted to ashes at the temperature of 800oF. In addition to the report of Ukpon, Roger (1987) in a study of chemical composition of rice husk revealed that rice husk is fire resistant. The study showed that rice husk recorded zero percent Ignation loss.

2. Heat Resistance

In a book titled construction materials, types and uses, Hornbostel (1991) reported that Asbestos is resistant to heat. He noted that asbestos roofing tiles have cooling effects on a building. Hornbostel also recorded that Asbestos is a non-conductor. Naomicahi (1989) noted that

rice husk can be used as a superior siliceous material for the manufacture of calcium silicate heat-insulating material with a good thermal durability of 1000oC. This indicates that rice husk is resistant to heat.

3. Resistance to Water Penetration, Corrosion and Chemical Attack.

Hornbostel (1991) reiterated that Asbestos is resistant to moisture penetration. Hence Asbestos roofing sheet does not allow the passage of water through it. He also noted that Asbestos is resistant to corrosion and chemical attacks. In support of the fact that rice husk is water resistant, Okorie (1988) reported that rice husk is coated with cuticle, a biological membrane which is resistant to water passage. Madu (1986) established that rice husk ash increases the resistance of cement-stabilized soil to sulphate attacks. Hence rice husk is resistant to corrosion and chemical attacks.

4. Light Weight

In further investigation Hornbostel (1991) stated that Asbestos is light in weight. Rice husk has been known to be very light in weight. The weight of a building material is a very important factor in construction industries. One of the biggest problems in the construction industry today is how to reduce to the weight of concrete elements and at the same time achieve a high strength capacity.

A comparism of the characteristics of Asbestos and rice husk show that rice husk compares favouably with asbestos as a roofing material hence, it is hoped that the production of roofing tiles using rice husk as a local raw material will compare favourably with asbestos roofing sheets.

Production of Rice Husk Roofing Tiles

The Materials used in the production of rice husk roofing tiles include

a. Ordinary Portland cement
b. Waste paper
c. Filler (marble dust)
d. Clean dry rice husk
e. Rice husk
f. Chemical for treating rice husk.

Tools and Equipments Used

a. Trowel
b. Shovel
c. Pulverizing machine
d. Vibrator-Italian vortex hydra ferrara
e. Small kitchen knife with pointed end

Ratio of Mix: an optimized ratio appropriate to the production of a strong and durable roofing tile was used.

Method of Production

a. Treat the rice husk with a local chemical invented by the researcher.
b. Add clean water to a mixture of granulated waste paper, clean rice husk, portland cement and marble dust.
c. Mix thoroughly with trowel until workability is achieved.
d. With trowel, carry and place some quantity of the mixture in the mould or batches.
e. Trowel, make well and level the mixture to the thickness of the mould gauge.
f. Vibrate the mixture for a period of 10 minutes in the vortex hydra ferrara or any other local mould.
g. Strike out the tiles from the moulds
h. Cure in oven or sun dry.

Test Result

Sample No: OMRC/81209A

Type of test	Result	Remarks
Particle crystallography	$2.05x10^{-16}$	Normal/good
Average mass of particle (g)	$0.98x10^{-3}$	Normal/good
Average area of particle (mm2)	$6.12x10^{-36}$	Normal/good
Average No. of particles with the lowest energy	$2.60x10^{7}$	Normal/good
Particle disintegration pr m2	1.65Q	Normal/good
Average bond energy, E	(lateral/angular)	Normal/good
Failure mode	Rough/ceased	Normal/good
Surface texture	12.15 N/mm^2	Normal/good
Mean compressive strength (MCS)	022.w/m^2k	Normal/good

U-value	0.22w/m^2k	Normal/good
Fire endurance	30 mins	Normal/good
Average swelling thickness rate	6%	Normal/good
Water absorption capacity	25%	Normal/good
Water vapour permeability per 24 hours	0.85g/m^2	Normal/good
Water vapour diffusion resistance	120, 000	Normal/good
Average modulus of rupture	0.99N/mm^2	Normal/good
Average thermal conductivity	1.56W/MoC	Normal/good
Tensile strength	45 KP/cm2	
Shore hardness	70	Normal/good
Thermal stability	+08°C to -20°C	Normal/good
Coefficient of thermal conduction	0.005 Kcal/mh°C	Normal/good
Linear coefficient of thermal expansion	1.5x10-5 grd^{-1}	Normal/good
Resistance to windblown fire and bright sunlight	Stable	Resistant
Resistance to acidulated water and aggressive media from industrial air pollution	Stable	Resistant

Summary of Results

The results of the test sample were satisfactory in accordance with BS 1191, 6463: Part 4, Bs 4550/BS 43359, DIN 4102 and ASTMC204

Discussion

Most researchers who worked on rice husk had always used the process of burning into rice husk arsh or boiling. From the result of the test it is observed that treated rice husk is better in other to retain its water appellant qualities which are greatly needed in roof manufacturing. Rice husk has a water proof membrane, a biological cuticle that resists easy penetration of water or misture.

The most important qualities a roofing tile is suppose to have are

1) Its ability to resist water penetration
2) Its ability to resist fire
3) Its tensile strength and mean compressive strength
4) Its u-value, modulus of rupture and thermal stability.

- A water absorbsion capacity of 25% is very good
- Fire endurance of 30 mins is encouraging
- Tensile strength of 45kp/cm2 is normal
- Mean compressive strength (MCS) of 022w/m2k is normal
- The U-value of 0.22w/m2k is good
- Average modulus of rupture of 0.99N/nm2 is good
- Thermal stability of +08oc to -20c is good and stable

Rice is in abundance in Nigeria. A good use should be made of rice husk for economic growth.

Conclusion

Judging from the result of the tests carried out, it can be concluded that rice husk in its natural state without burning into arches can be used in the production of corrugated roofing tiles. Its advantages cannot be overemphasized

1) It is environmentally friendly
2) It is cost effective
3) It is maintenance free
4) It is water repellent, fire resistant and light in weight
5) It is resistant to wind and it is not carcinogenic like asbestos roofing sheet.

Recommendation

It is recommended that

1) Rice husk be used to replace asbestors in the production of corrugated roofing tiles to solve carcinogenic problem of asbestors.
2) Small scale rice husk roofing tile industries be established in all rice producing towns and cities in Nigeria to help in solving the problem of unemployment. This will also solve the problem of environmental pollution,

degradation and hazards possed by rice husk dumps.

3) The government should encourage rice farmers through the provision incentives such as soft loans, farm machinery and appropriate fertilizer.

Implication for Sustainable Technological Development and Commercialisation.

The federal and State Governments should realize that there is urgent need for reduction of prices of contemporary building materials through the manufacture of local building materials. With the breakthrough in the sourcing of a local material that can be used in the production of roofing tiles such as rice husk, immediate action should be taken to establish large or small scale industries to utilize rice husk dumps in the production of roofing tiles.

The establishment of rice husk roofing tile industries will set in motion a giant stride in sustainable technological development in the country. . Rice husk is not carcinogenic and has no infection whatsoever. Rice is an edible food. It will project the image of Nigeria technologically to the outside world.

Rice husk roofing tile industries, if established will create an open door for job opportunities for youth wishing to choose career in the production of roofing tiles and maintenance of machines used in the production of roofing tile. It will surely reduce the unemployment and poverty rate in Nigeria.

The production of rice husk roofing tile is the most effective means of disposing of the rice husk dumps in rice producing communities thereby solving the problem of environmental degradation, environmental pollution and environmental hazards caused by rice husk dumps in the rice producing communities in Nigeria. The commercialization of this rice husk roofing tile is a direct ticket toward the achievement of the millennium goal and the seven-point agenda of the president his Excellency, Shehu Musa Yaradua[late].Investors should utilize this golden opportunity to make shelter accessible to the common Nigerian.

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