Indigenous Technology for Youth Skills Development and Entrepreneurship Empowerment: Case of Roofing Tiles Production from Rice Husk

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Abstract
A study of local waste materials relates to the socio-economic and socio-cultural setting in the construction of shelter. Rice husk and stone dust are some of the agro and allied waste products in Abakaliki. This study therefore is intended to use stone dust and rice husk to produce roofing tiles. The research used rice husk and stone dust all from Abakaliki, and cement as a binding agent with a special mix ratio to produce roofing tiles. Vibrators and corrugated glass fibber moulds were used as equipment. The products were subjected to various tests, including mean compressive strength (MCS), water absorption capacity, water vapour permeability per 24 hours, Average modulus of rupture, Average thermal conductivity, tensile strength, thermal stability, failure mode, particle disintegration per square meter, U-value and average bond energy (E) to mention, but a few. The results were encouraging.

Keywords: Technical Education, Youth Skills Development, Entrepreneurship Training

Introduction
The construction of buildings using the conventional, imported construction material has been very expensive due to the high cost of importation. Amadi (2003) stated that the rate of change of the Nigerian building construction industry with respect to costs of materials; time and culture is surprisingly high. He added that this has been mainly due to the unfavoured dynamics of the Nigerian economy, accelerated building material research, innovation, to meet most of the psychological, Socio-economic, physical and philosophical needs of the average Nigerian. However, a number of strategies or mechanisms have been put in place by government for the development of local materials and technology in Nigeria. Such strategies include:

1. Transfer of technology;
2. Network of African countries and
3. Appropriate technology.

Effective way of strengthening National Technology capacity for the production of local building materials is through the transfer of technology whereby the foremost task is for
the country in need of the technology to establish a framework for identifying and receiving the requisite technology. The transfer of technology is a partial method of ensuring that local technology capacity sustains the production of indigenous building materials. Most African countries have not reached the level of self-sufficiency in the process of developing local building materials. They are limited in their technological know-how to solve the problems involved. There are a number of proven technologies in both developing and industrialized countries. The problem usually faced is - How can the technology be transferred effectively to the country in need? Nigeria needs a local capacity for adaptation and replication of technology. This will, in turn, lead to the development and commercialization of local initiatives. The transfer of technology requires a complex, strenuous and innovative approach. In response to the challenges and demonstration of more reasonable approach towards technological transfer; the UNCHS in collaboration with the Commonwealth Science Council (ESC) initiated the NETWORK OF AFRICAN COUNTRIES (NAC) on local building materials and technology. The African countries involved in the Network program on building materials include: Nigeria, Cyprus, Ghana, Kenya, Malawi, Malta, Mauritius, Sierra Leone, Uganda, Tanzania, Zimbabwe and Kampala. The major objectives of the programme is to identify local institutions which could play a coordinating role in the promotion of local building materials both at the local and international levels and to appoint a resource person in each of the participating countries to act as a national co-ordinator and contact point for international contact in attaining the objectives of the Network.

Okot-Uma (1989) reiterated that a Network of African Countries on Local building materials and technologies is a possible medium of communication and information exchange. This will play a vital role of a link in cooperative Techno-Scientific Endeavour between a number of international and regional agencies and organizations and various national institutions and individuals in the area of local building materials and technologies in African regions, both now and for several years to come. Network of African Countries has immensely promoted the gathering and processing of information from the member countries. This led to the publication of the Journal of the network of African countries on local building materials and technologies. The major areas from which information for the journal is gathered include:
1. Research and laboratory activities
2. Account of production of selected low-cost building materials.
4. Standards and specifications of local building materials.
5. Use of local materials in construction.
6. Institutional support and policy matters.

All English speaking African Countries are being encouraged to be part of the network programs. International organizations such as Economic Commission for Africa, Shelter-Afrique, Appropriate technology international (ATI),United States Agency for International Development (USAID) Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), International Institute for Building Research (IIBR),Swiss Center for appropriate technology (SKAT), Intermediate Technology Development Group (ITDG) and Institute for new technologies (INTEC11) have expressed willingness to use the network and its journals as a medium for disseminating information on low-cost building materials.
The importance of networks in collecting and disseminating information to enhance technological capacity from one country to the other has been repeatedly emphasized in various regional and international fora. The establishment of a regional network through international cooperation should be the first step towards the establishment of a more reasonable battle against the high cost of building materials. Most developing countries do not have the necessary financial resources to establish bilateral cooperation for the acquisition of technologies. Networks catalytic role for the establishment of the requisite contacts among countries has demonstrated itself as an advantageous modality for enhancing technological capacity.

Appropriate technology (AT) is a mode of technological practice or artifacts intended to function as a relatively efficient means of production. It could be defined as artifacts, which have been tailored to fit the context prevailing in a particular location or period. Appropriate technology involves more than identification of local materials and production of building materials. It involves the entire systems of knowledge, skills, techniques, management and organization. It is a reaction to the irrational technological practice of the western societies, and to the dangers of advocating the same practice in entirely different societies and environment. Technologies can be considered appropriate if they:
1. Contribute to meeting basic needs.
2. Use and develop local natural and human resources.
4. Are compatible with the culture and knowledge of the users.

Therefore the production of corrugated roofing using rice husk as a local material is an appropriate technology toward the development of an affordable shelter in Nigeria. To overcome the problem of over-dependence on conventional building materials, efforts have been directed towards the local sourcing of alternative building materials. It was against this background that the Nigerian Building and Road Research Institute (NBRRI) was established in 1978. In its programme for the national development plan, NBRRI placed 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. Rice husk is one of the agricultural by-products that has been wasted for many years in Nigeria. Therefore, it has become necessary to look for a way of making rice husk a useful raw material for the production of building material such as roofing sheets. Two types of rice are grown in Nigeria namely upland rice and Fadama or swamp rice. The harvested rice kernel known as paddy is enclosed by the hull or husk otherwise called rice husk. To obtain rice husk, the rice is parboiled, dried and milled to separate the rice from the husk. Rice husk is available in commercial quantity in Nigeria. The available rice husk in Nigeria is enough to sustain rice husk roofing sheet industries. Climatically most parts of Nigeria soil is suitable for the propagation of either the upland rice or the swamp or fadama rice (Okorie, 1988).

While Chaudhary (1988) stated that Nigeria is blessed with abundance of natural wealth, water resources and sunshine to support massive production of rice, Utcliffe (1984) confirmed that rice produced in Nigeria is 99 per cent sufficient. Hence Nigeria is the largest producer of rice in West Africa. Rice produced by individuals and community efforts not withstanding, the government has also set up the following rice production programmes to boast massive production of rice in Nigeria. Such rice production programmes include:
1. National Accelerated Food Production Programme, NAFPP;
2. World Bank Cross River Rice Project;
3. World Bank Anambra-Imo Rice Project;
4. Federal Rice Production Programme, FRPP and
5. Agricultural Rice Development Project, ARDP.

The five main local rice production ecologies in Nigeria are the upland, the low land
swamp, irrigated, mangrove swamp and the deep flooded swamps. Rice is produced in
most States in Nigeria such as Anambra State, Enugu State, Delta State, Imo State, Abia State,
Ebonyi State, Kano State, Kogi State, Cross River State, Kaduna State, Kano State,
Kwara State, Niger State, Lagos State, Ondo State, Ekiti State, Rivers State,
Benue State, Plateau State, Gongola State, Sokoto State, Kebbi State, plus the Federal Capital-
Abuja. The Cities in Nigeria where rice is massively grown and produced are Abakaliki,
Afikpo, Ogoja, Odoro and Ikepe around the Cross River Plains; Lafiagi", Badeggi and Patagi
around the shores of river Niger; Sokoto and Brining-Kebbi around the valley of River
Sokoto and Abeokuta, Benin and Delta regions. A research visitation to these cities
unveiled numerous mountainous hips of rice husk lying waste.

Most of the components and raw materials for the production of building are imported at
exorbitant prices. For this reason, the cost of roofing sheets and other building materials are
high. Also foreign exchange constraints have limited the quantity of building related
goods imported into Nigeria. Even domestic production is generally dependent on imported
inputs. For Nigeria to move forward toward the reduction of the prices of building materials,
locally sourced materials and locally built equipment for the manufacture of building
materials must be developed and fast too.

Roofing technology has been emphasized in most regional and international discussions on
the development of local building materials. This is because, of all the elements of shelter,
the roof is the most important component in chemical composition of rice husk revealed
that rice husk is fire resistant. The study reported that rice husk recorded zero percent
ignition loss. Heat resistance Hornbostel (1991) reported that asbestos is resistant to heat. He
noted that asbestos roofing sheets have cooling effects on a building. He also recorded that
asbestos is a non-conductor. Naomichi (1989) noted that rice husk can be used as a
superior siliceous material for the manufacture of calcium silicate; a heat- insulating material
with a good thermal durability of 100°C. This indicates that rice husk is resistant to heat.

Asbestos is resistant to corrosion in support of the fact that rice husk is water resistant.
Okorie (1988) reported that rice husk is coated with cuticle, a biological water proof
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. Light weight in further investigation, Hornbostel
(1991) reported that Asbestos is light in weight. The weight of a building is a very important
factor in the building construction industry. One of the biggest problems in the construction
industry today is how to reduce the weight of concrete elements and at the same time
achieve a high strength capacity.

Resistance to Moisture Penetration
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 A Comparison of the characteristics of asbestos and rice husk shows that rice husk compares favourably with asbestos roofing material. Hence it is hoped that the production of roofing tiles with rice husk as a local raw material will compare favourably with asbestos roofing sheets.

**Methodology**

**Materials**
1) Rice husk (treated with Cabo-cleanse);
2) Stone dust;
3) Cement;
4) Clean water and
5) Copper wire.

**Equipment**
1) Electric Vibrator;
2) Fibre glass corrugated mould;
3) Trowel;
4) Roller;
5) Cellophane sheet and
6) Nib

**Procedure**
1) Prepare a paste of rice husk, stone dust, cement and water with appropriate ratios in a head pan and mix thoroughly until uniformity is achieved.
2) Prepare the table top with a cellophane sheet spread across. Ensure that the sheet is not wobbled or squeezed.
3) With the trowel, lift some quantity of the paste unto the vibrator inside the gauge, Level thoroughly and vibrate for 5 minutes.
4) Apply the roller across the paste for 5 to 6 times and allow settling for about 5 minutes.
5) Draw the cellophane together with the paste gently onto the corrugated mould.
6) Apply the roller on the paste for about 5 or 6 times for it to properly lamiae the shape of the corrugated mould.
7) Allow setting for 2 or 3 days.
8) Remove the roofing tile from the mould and put into a curing chamber for 24 hours.
9) Bring it out from the curing chamber and allow to thorough dry under the sun or dry in an oven for 10 minutes.

**Test Result 1**

**Chemical Analysis of Abakaliki Rice Husk**

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Test preference</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Appearance</td>
<td>Light brown, coarse Particles</td>
</tr>
<tr>
<td>2</td>
<td>Calcium as CaO (mg/kg)</td>
<td>0.246</td>
</tr>
</tbody>
</table>

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### Test Result 2

Sample description: grey coloured, 150/120/70 longitudinally corrugated rice husk roofing tile (340mm vide, 550mm long and 10mm thick)

<table>
<thead>
<tr>
<th>s/no</th>
<th>Type of test</th>
<th>Result</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Particle crystallography</td>
<td>-</td>
<td>Normal/good</td>
</tr>
<tr>
<td>2</td>
<td>Average mass of particle</td>
<td>(2.11 \times 10^3)</td>
<td>Normal/good</td>
</tr>
<tr>
<td>3</td>
<td>Average area of particle</td>
<td>(1.03 \times 10^5)</td>
<td>Normal/good</td>
</tr>
<tr>
<td>4</td>
<td>Average number of particles with the lowest energy</td>
<td>(6.55 \times 10^5)</td>
<td>Normal/good</td>
</tr>
<tr>
<td>5</td>
<td>Particle disintegration per m(^2)</td>
<td>(1.001 \times 10^7)</td>
<td>Normal/good</td>
</tr>
<tr>
<td>6</td>
<td>Average bond energy (E)</td>
<td>(1.52Q)</td>
<td>Normal/good</td>
</tr>
<tr>
<td>7</td>
<td>Failure mode</td>
<td>Lateral/angular</td>
<td>Normal/good</td>
</tr>
<tr>
<td>8</td>
<td>Surface texture</td>
<td>Rough/creased</td>
<td>Abnormal</td>
</tr>
<tr>
<td>9</td>
<td>Mean compressive strength (mcs)</td>
<td>(10.30N/mm^2)</td>
<td>Normal/good</td>
</tr>
<tr>
<td>10</td>
<td>U-Value</td>
<td>(0.35w/m^2k)</td>
<td>Normal/good</td>
</tr>
<tr>
<td>11</td>
<td>Fire endurance</td>
<td>32 minutes</td>
<td>Normal/good</td>
</tr>
<tr>
<td>12</td>
<td>Average swelling thickness rate</td>
<td>8%</td>
<td>Normal/good</td>
</tr>
<tr>
<td>13</td>
<td>Water absorption capacity</td>
<td>28%</td>
<td>Normal/good</td>
</tr>
<tr>
<td>14</td>
<td>Water vapour permeability per 24hrs</td>
<td>80.000</td>
<td>Normal/good</td>
</tr>
<tr>
<td>15</td>
<td>Average modulus of rupture</td>
<td>0.51N/mm(^2)</td>
<td>Normal</td>
</tr>
<tr>
<td>16</td>
<td>Average thermal conductivity</td>
<td>1.22W/m(^{0})C</td>
<td>Normal/good</td>
</tr>
<tr>
<td>17</td>
<td>Tensile strength</td>
<td>42kp/cm(^2)</td>
<td>Normal/good</td>
</tr>
<tr>
<td>18</td>
<td>Shore hardness</td>
<td>65</td>
<td>Normal/good</td>
</tr>
<tr>
<td>19'</td>
<td>Thermal stability</td>
<td>+80(^0)C to -30(^0)C</td>
<td>Normal/good</td>
</tr>
<tr>
<td>20</td>
<td>Coefficient of thermal conduction.</td>
<td>0.010klal/mh(^{0})C</td>
<td>Normal/good</td>
</tr>
</tbody>
</table>
## Summary of Results

The results of the test samples were satisfactory in accordance with BS 1191,6463: part 4, BS 4550/ BS 43359, Din4102andASTMC204. The results of the tests were quite impressive in the sense that all, except test number 8 were normal and good. Normal means that they are okay and measure up to the standards required of roofing tiles. Number 8 test sample's surface texture was rough, creased and abnormal. The abnormality was caused by creased cellophane sheets, placed under the gauge before the pouring and placement of the stone dust, rice husk, and cement paste. It is not a serious problem but a question of using a better and stronger cellophane sheet that will squeeze, shake or fold in the process of production. Amobi (2006) stated that the stability of roof is generally sufficiently satisfactory and therefore needs minimal maintenance but the materials providing the water proof covering are vulnerable to changes in climatic conditions since the roof is more
exposed than any other part of the building.

Conclusion
Appropriate indigenous technology involves more than identification of local materials and production of new building materials. It involves the entire systems of knowledge, skills, techniques, management and organization. It is a reaction to the irrational technological practice of the western societies, and to the dangers of advocating the same practice in entirely different societies and environment. In Nigeria, and in fact the under developed countries of the world, there has been sky -rocketed costs of roofing materials, for instance. Amobi (2005) also noted that the requirement of a roof include providing suitable water-resisting covering, made from durable material and to provide suitable insulation. Omange, et al (2003) reported that fibre Concrete roofing sheets/tiles provide cheaper, alternative roofing materials to conventional sheets of asbestos.

This is because there is no alternative local roofing material;
- To overcome the problem of over dependence on conventional building materials, effort should be made towards local sourcing of alternative roofing materials.
- Emphases should be laid on new driven research on the development of suitable and sustainable local waste materials for roofing purposes.
- Rice husk, treated with Cabo-cleanse can be used to produce very good and durable roofing tiles. Burning of rice husk (into ashes) before use in the production of tiles destroys the water proof biological membrane in rice husk.

References