Characterization of inorganic-bonded and wood shavings earth bricks in core housing delivery in Nigeria

AJAYI, B.¹ and TAIWO, A.A. ²

¹Department of Forestry and Wood Technology, The Federal University of Technology, Akure,
²Department of Architecture, The Federal University of Technology, Akure, Nigeria.

ABSTRACT: This study looks into alternative and affordable building materials for construction of low-cost houses particularly for the low-income public servants. Cement-bounded stabilized earth bricks were made from 5% wood shavings and 5% cement stabilizer by weight. These were thoroughly mixed together in order to avoid the formation of wood shavings/cement stabilizer lumps. The mixture was manually poured inside wooden formworks measuring 240mm x150mm x 100mm. After 28 days of casting, the compressive strength, abrasion and the water absorption of the earth bricks were examined with the aim of determining their effects on the strength properties and dimensional stability. The study revealed average compressive strength of 2.9N/mm², abrasion action of 2.6mm depth and water absorption of 16.1% respectively. The study proposed that the cement-bonded wood shavings stabilized-earth bricks can be used in construction of core houses for the low-income public servants in Nigeria.

Keywords: Core housing; cement-bounded; wood shavings; earth; bricks; public servants.

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INTRODUCTION

Earth has been used in numerous places throughout the world since pre-historic times, it seems that today this material is in need of some re-evaluation in order to produce attractive sustainable and value-added products. Earth is a local material and very much in abundance in Nigeria. As a result of global economic recession, developing countries, particularly Nigeria, is reconsidering earth (laterite) as a suitable material for building construction works because earth is freely available, endowed with remarkable qualities of plasticity and thermal inertia (Arayela, 2002). In countries characterized by relatively humid and raining weather, like Nigeria, earth is not itself a particularly durable building material. Because of its exposure to rain water which causes erosion, instability and movement. Stabilized Compressed Earth Bricks (S.C.E.B) is a modified form of earth which is one of the oldest materials commonly used for building construction works. The S.C.E.B can stand as the best alternative to ordinary and unstabilized earth bricks. The use will solve environmental problems posed by wood wastes, increase wood resources utilization, increase raw materials supply for construction, create job opportunities, (Ajayi, 2006; Aladenola and Ayodele, 2008).The basic raw materials needed to produce stabilized, compressed earth brick is soil with a good grain size distribution and a small percentage of clay as binder to provide good cohesive performances as suggested by Ogunsusi and Kolawole (1994). An example of S.C.E.B is a cement-bonded composite that is a value-added wood product made from the

¹Correspondence to: Ajayi, B.; babatundeajayi2000@yahoo.com
combination of two or more raw materials such as wood particles, agricultural wastes, cement and a catalyst. The product can be moulded into any form and shape to meet specific end uses. Wood waste bonded with cement has been used over the years as raw material for board production (Ajayi, 2006). Cement is an essential ingredient in almost all forms of construction. It is a vital binding agent in mortar, concrete and in rendering. It is also used in the production of walling blocks, cement-bonded boards, etc.

Core housing is a major variant of the self-help housing technique which often times used by the low-income earners in developing countries as a means of gradually providing shelter for themselves. Core housing was introduced into the under developed areas of the world by the United Nations. Abrams (1966) affirmed that the core-house scheme rests on the premise that a family with little additional work, can move into the core house immediately and thereafter expand the house as time and fund allow. The study re-emphasizes the use of stabilized earth bricks with cement and wood shavings as a means of meeting the acute housing problem in Nigeria, particularly for the low-income public servants. The aim is to provide an organized, cheap and practical scheme for the urban and urbanizing areas of poorer countries.

MATERIALS AND METHOD

The Experiment
The research was carried out using excavated laterite from a suburb of Akure in Nigeria. The soil was then transported to the laboratory and then sieved, using wire mesh of 10mm x10mm. Powdery material was kept for a few days thereafter, it was mixed with the stabilizers. The stabilizers used in this experiment are cement and wood shavings. The homogeneous wood shavings were collected from a saw mill in Akure, kept in the open air to reduce the moisture content and degradation of chemicals in the wood materials. Cement as a stabilizer in this experiment binds the earth particles together and reduces the sensitivity to water (risk of shrinkage and swelling).

60,000cm³ of treated sieved soil was mixed with 6,000cm³ of cement in volume separately. Similarly, 60,000cm³ of treated sieved soil was mixed with wood shavings measuring 6,000cm³ both mixtures were thoroughly done to avoid formation of balls and lumps. All two stabilizers were kept clean from all forms of impurities. Dry mixing of the sieved earth with the two stabilizers was carried out on a hard clean surface with shovels. In the first instance, 2 loads of wheelbarrow of earth and one and half gallons of wood shavings were thoroughly mixed until a homogeneous mix with uniform distribution of the wood shavings was obtained.

Water was then added to the mixture gradually. The mixing process continued until the required semi-paste was achieved and thereafter cast inside wooden moulds of 250mm x 150mm x 100mm. Each sample was pre-compressed at the corners of the moulds to compensate for the low compression at the corners, after which they were compacted with a tampering rod several times. Six samples were prepared for each test from which averages were determined. The same process was carried out using cement as a stabilizer and six samples were also prepared and tested.

Curing of Earth Bricks
The bricks were carefully removed from the moulds after 24 hours. The six samples of the wood-shaving earth bricks were air-cured under a covered shade. While the cement stabilized bricks went through the wet curing process under the cover of a polythene sheet for the first 7days. The curing process took place under shade in order to control the rate of evaporation of moister from the earth bricks. The curing periods of 7, 14, 21 and 28 days were recorded respectively and compressive strength of each of the sampled bricks was equally recorded on each of the days mentioned above.
Testing Process
Compression test was conducted using a prier crushing machine in accordance with British Standards Institutions (BSI, 1967). Compression stress was slowly and gradually applied on each sampled earth brick until failure loadings for each of the curing days were recorded and averages were found. Abrasion test was conducted on the sample of earth bricks. This test gave a good idea of the surface resistance of the bricks. An iron brush was manually used in the conduct of this abrasion test with equally applied forces on the sampled earth bricks. The iron brush was used moving it up and down the surface of the sampled bricks 20 times each with a maximum force. The depths of abrasion from the surfaces of the sampled bricks were then measured. In the water absorption test or capillary test, the 28-day cured bricks were weighed and laid vertically on a soft towel in contact with water in a container below the towel. Water was then added from time to time to the container below the bricks until the water level remained constant. The level of capillary on the wood shavings earth bricks and the cement stabilized earth bricks were recorded after 24 hours. The bricks were re-weighed and the difference in the initial and final weights was taken and the water absorption expressed in percentage.

RESULTS AND DISCUSSION
The results of compressive strength of earth bricks produced using wood shavings and cement stabilizers is presented in Table 1. The average values range between 1.8 and 2.7N/mm² for wood shavings stabilizer and 2.4 and 3.2N/mm² for cement stabilizer after a curing periods of 7, 14, 21, 28 days respectively. Corresponding earth bricks produced from cement stabilizer at various curing periods have higher compressive strength than that of wood shavings stabilizers. Cement stabilizer provides higher bonding potential and formation of strong and increased bond networks with earth whereas wood shaving stabilizer only provide inter-flakes contact areas with the formation of normal bond networks with the earth without strengthening these bonds like in cement binder but rather prevent the cracking of the earth bricks. The wider and slender the flakes, the greater and increased inter-flakes contact areas and bond networks, the better the resistance to forces of compressive stress and abrasion (Ajayi, 2000, and Ajayi 2005). The average compressive strength after 28 days of curing for 5% wood shavings and 5% cement stabilized earth bricks were 2.7N/mm² and 3.2N/mm² respectively. Bricks produced at 5% wood shavings and 5% cement at 28 days curing period were the strongest, with highest compatibility and less spring back tendency, that provided the highest resistance to force applied. From the result obtained, the wood shavings have the least average compressive strength value while the cement stabilizers have the highest value. The wood shavings earth bricks have rough surfaces due to emergence of the shaving on the surface, and curly nature of the wood shavings may have improved its bonding effect. The result of the 28-day compressive strength for all the samples exceeded the suggested minimum strength for earth bricks; of 1.5N/mm², as suggested by Ndububa (1995). Nnok and Ogunsusi (1995) in his own work, asserted that cement stabilized bricks of compressive strength between 1.1N/mm² and 2.5N/mm² can be used for small single storey buildings with light roof structures. It then shows that the result obtained for the wood shavings earth bricks can also be used for small single storey buildings in meeting low cost housing needs as its average compressive strength of 2.3N/mm² approximately falls between this standardized given range. The result shows that those wood shavings earth bricks can be used to construct core houses for the low-income public servants who do not require more than a bungalow or at most a storey building. From Table 1, the average compressive strength of the wood shavings and cement stabilized earth bricks fall within the suggested range of compressive strength for earth bricks used for small single storey buildings.
Table 1: Result of Compressive Test

<table>
<thead>
<tr>
<th>Type stabilizer (soil composite)</th>
<th>Curing periods (days)</th>
<th>Compressive strenght (N/mm²)</th>
<th>Average (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5% Wood shavings</td>
<td>7, 14, 21, 28</td>
<td>1.8, 2.0, 1.6, 1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>5% Cement</td>
<td>7, 14, 21, 28</td>
<td>2.3, 2.4, 2.6, 2.7</td>
<td>2.2</td>
</tr>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>

Source: Fieldwork (2008)

From Table 2, shows the results of the abrasive action on both the cement and wood shavings earth bricks. The values for abrasive action on wood shavings earth bricks and cement earth bricks were 4.2mm and 1.12mm respectively. This shows that the abrasive action on wood shaving earth brick is higher than the cement earth brick. The cement content in the brick caused the additional formation of bonds that increased strength and high compactibility between earth and cement particles capable of resisting the abrasive action on it and reduction in the depth of the grove. Nnok and Ogunsusi be used for either external or internal walls. Meanwhile, the average abrasive action of the cement stabilized earth bricks gives 1.12mm, which shows that these bricks are very resistant and can be used without rendering.

Table 3 shows that the result of water absorption by the wood shaving earth bricks (18.1%) and cement stabilized earth brick (15.6%). The wood shavings bricks had higher water absorption capacity than the cement stabilised earth bricks and also increase in weight. This shows that wood shavings earth bricks absorb more water than the cement stabilized earth brick.

Table 2: Results of The Abrasion Test After 28 Days of Curing

<table>
<thead>
<tr>
<th>Brick Type</th>
<th>Abrasive Action with iron brush (mm)</th>
<th>Average Abrasive Action (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5% wood shavings earth bricks</td>
<td>5mm, 4mm, 3mm, 5mm, 4mm</td>
<td>4.2mm</td>
</tr>
<tr>
<td>5% cement stabilised earth bricks</td>
<td>0.8mm, 1.2mm, 1.0mm, 1.5mm, 1.10mm</td>
<td>1.12mm</td>
</tr>
</tbody>
</table>

Source: Fieldwork (2008)

(1995) asserted that bricks which have more than 10mm deep-cut or groove due to abrasive action should not be used for foundation or wall bases. And where such bricks are highly exposed to direct rainfall, they should be rendered. The wood shavings earth bricks have an average of 4.2mm of abrasive action which shows that the wood shavings earth bricks can brick. The addition of cement may have caused reduction in the availability of void spaces capable of accommodating water and increase in weight, a parameter used in the determination of water absorption property (Ajayi, 2005). Also, the wood shaving stabilizer has the tendency to move and absorb water due to its hygroscopic nature, which resulted into
spring back and create more void spaces to accommodate water when in contact with it. All the factors could cause and aggravate the dimensional movement of the wood shaving earth bricks, increase in weight due to water absorbed when compared with cement stabilized earth bricks.

Table 3: Results of Water Absorption Test

<table>
<thead>
<tr>
<th>Stabilised Brick Type</th>
<th>Weight of Brick (Dry) kg</th>
<th>Weight of Brick (Wet) kg</th>
<th>Average Moisture Absorption (%)</th>
<th>Water Absorption (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood shavings Bricks</td>
<td>7.20, 7.10, 7.00, 7.20, 7.20</td>
<td>8.50, 8.40, 8.30, 8.50, 8.50</td>
<td>1.30</td>
<td>18.1</td>
</tr>
<tr>
<td>Cement Stabilised Bricks</td>
<td>7.60, 7.50, 7.60, 7.50, 7.60</td>
<td>8.78, 8.66, 8.78, 8.77, 8.79</td>
<td>1.18</td>
<td>15.6</td>
</tr>
</tbody>
</table>

Source: Fieldwork (2008)

CONCLUSION AND RECOMMENDATIONS

The results showed that the average compressive strengths for both the wood shaving earth bricks and the cement stabilised earth bricks are adequate in strength and can be compared with masonry blocks. To achieve better results certain factors must be carefully taken into consideration such as the fibre volume ratio, clay type, clay content, percentage of stabiliser, mixing process and curing method. Wood shavings earth bricks gave less compressive and abrasive strength capacity when compared with that of cement stabilised earth bricks. The wood shavings earth bricks also gave higher moisture absorption characteristic than the cement stabilised earth bricks at every curing period. Cement stabilized earth bricks were stronger and more stable than wood shavings earth bricks, but both bricks produced at the highest curing period of 28 days performed best as shown in their values. It is recommended that where the wood shavings earth bricks will be used, they should be protected by plastering the exposed surfaces. The wood shavings earth bricks should be used as internal non-load bearing walls for core housing buildings while the cement stabilised earth bricks can be used as external load bearing walls. The foundations of such buildings should be constructed with stones or sandcrete blocks. The Governments at Federal, State and Local levels are encouraged to embrace the use of stabilised earth bricks because the raw materials can be abundantly sourced for locally and the fact that it is cheaper than the sandcrete blocks.

REFERENCES


