Investigating Potential Green Materials to improve cost Effectiveness for Low-Cost Building Construction in Nigeria

Shogo Mushau Adeniyi, Sarajul Fikri Mohamed

Abstract: Developing countries are facing greater and pressing challenges to provide adequate shelters. Nigeria is presently facing a shortage of about 17 to 20 million housing deficit. The aspiration of owning a house by the low income and middle-income families is becoming a difficult reality and need an innovative solution. Thus, it has become necessary to adopt cost-effective, innovative and environment-friendly housing technologies for the construction of houses and buildings for enabling the common people to construct houses at affordable cost. Therefore the study reviews and analyze potentials green materials such as earth bricks, bamboo, timber, stone walls, and thatches suitable for low-cost building constructions. This result reveals that about 16.67% to 67.99% of the construction materials can be saved by using innovative green materials such as adobe bricks and bamboo respectively. It can be concluded that green materials are cost-effective and sustainable for low-cost building construction.

Index Terms: Keyword: Low-Cost Building Construction, Green Materials, Cost, Effectiveness, Nigeria.

I. INTRODUCTION

Nigeria construction industry which formally commenced operations in the 1940s relied on the importation of building materials. However, in the last decade, the high cost of these conventional materials has resulted to increase in the overall cost of building projects which made it difficult for low-income earners in Nigeria to build a house of their own. The housing can only be affordable if the rental cost or mortgage repayment cost does not exceed 30% of household income for households in the lowest 40% of the income distribution range (U.S. Department of Housing 2006). With this scenario, Nwoke (2011), Kayode (2013), Ben (2015) and Bredenoord (2017), suggested the use of natural materials or green materials such as earth bricks, bamboo, thatch as a remedy and way out to produce affordable and low-cost building construction. A low-cost house is designed and built as any other house with regard to substructure, superstructure, and strength. The reduction in cost is achieved through effective utilization of locally available building materials and techniques that are durable, economical, accepted by users and not requiring costly maintenance (Miles, 2000). Therefore the indigenous technology using locally available green materials will be an alternative solution to achieve low-cost building construction in Nigeria.

II. THE POTENTIAL GREEN MATERIALS FOR LOW-COST BUILDING CONSTRUCTION

Green materials that suitable for building construction are readily available in large quantity across Nigeria. The availability varies, dependent on the geographical location of the area as well as the chemical and physical components of such materials. Green materials are those building materials that is found around us with less stress or no further processing before been used for construction works.

Bredenoord (2017), suggested some green materials which include but not limited to the following as good and promising for low-cost building construction.

Table I. Scholars studies on some of the potentials green materials

<table>
<thead>
<tr>
<th>No.</th>
<th>Material</th>
<th>Objectives</th>
<th>Cost-effective</th>
<th>Author(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Earth bricks</td>
<td>Using earth as a building material for sustainable low-cost housing in Zimbabwe</td>
<td>To replace steel as reinforcement in concrete for the low structural elements in low-cost house</td>
<td>Zami, (2008)</td>
</tr>
<tr>
<td>2</td>
<td>Bamboo</td>
<td></td>
<td>Does not required Sophisticated fluid guzzling procedures for processing</td>
<td>Sabnani, Latkar, &amp; Sharma, (2013)</td>
</tr>
</tbody>
</table>

Revised Manuscript Received on 04 May 2019

Shogo Mushau Adeniyi, Department of Quantity Surveying, Faculty of Built Environment, University Teknologi Malaysia, Johor Bahru, Malaysia, sogo4qs@gmail.com
Sarajul Fikri Mohamed, Department of Quantity Surveying, Faculty of Built Environment, University Teknologi Malaysia, Johor Bahru, Malaysia, sarajul@utm.my.
Investigating Potential Green Materials to improve cost Effectiveness for Low-Cost Building Construction in Nigeria

| Stone / Rock | Vernacular Architecture of Northern Nigeria in the light of sustainability | 3 | Using Local Timber - contributing to sustainable construction. Guidance for North Scotland | 4 | The availability of Thatches and grasses in the middle belt and Northern region of Nigerian. | 5 | Thatches / Grass |

Stones are the most utilized materials; some of them prevent moisture and humidity which are used in building foundations etc. Reducing the amount of carbon dioxide (CO2) in the atmosphere which is fundamental to combating climate change. Thatch is one of the oldest building materials known, is a good insulator cheap, and easily harvested.

Onyegiri & Ugochukwu (2016)

Fradinho & Nedelcu, (2017)

Fig. 1. Mud sun dry bricks and bricks walling.

Fradinho & Nedelcu (2017), assert that the basic house walls in most of the traditional architecture in Nigeria were built of ‘earth’ in simple low-cost and self-help construction arrangement. Earth greatly differs in quality from the excellent brown clay to the blackish type, the development of the adobe brick, a performed modular masonry unit of sun-dried mud, came into existence with higher civilization levels. Mud and clay walls floors and roofs constructions were rendered with materials like indigo leave, cattle waste, colored mud to prevent water penetration into the surface wall.

One of the oldest material but due to its limitation like erosion, water penetration, termite attack and high maintenance it is less used. However, Srivastava & Kumar (2018), stressed that this limitation can be overcome by:

1. Compressed earth block – developed from adobe block or also known as earth block, consist of cement using the manual press.
2. Non-erodible mud plaster – Its constituents are bitumen which is mixed with a specific mud paste. Has the ability to resist water.

A. Earth Bricks

Oshike (2015), reveals that since man begins the act of shelter construction, the earth has been the main material for wall constructions. Prior to the foreign incursion into the west coast of Africa, the earth was the predominant building material in the sub-region. It was used effectively in the various climatic zones, the application method depends on the type of soil, technical know-how and tools as well as local traditions and customs of the community. Zami (2008), further stressed that earth has been used as a construction material in every continent and in every age, largely due to its versatility and widespread availability. It is one of the oldest building materials. The use of earth on site as a building material saves manufacturing cost, time, energy, environmental pollution, and transportation cost. Due to their low cost and easy production, without high energy embodied materials, earth structures have been continuously used in construction from prehistory. Zami (2008), concludes that 33% of worldwide houses are still built with earth till date.

B. Bamboo

Bamboo has a lot of potential as a building material for low-cost building and it is readily available in all parts of Nigeria. According to Nwoke & Ugwuishiwu (2011), bamboo is one of the oldest traditional building materials used by mankind. Uses of bamboo can also include building construction, both in exterior and interior design elements. Unlike wood, bamboo regenerates very quickly. Bamboo has been the construction material used in about 70% of the houses found in the rural areas of the eastern part of Nigeria [6].

Puri, et.al (2017), and Oladiran (2015), described bamboo as a giant grass with more than 1200 species, some of them were said to grow at a phenomenal growth rate of 91 cm per day. Bamboo is pliable, lightweight has the excellent
tensile strength and has a very good weight to strength ratio which makes it highly useful against high-velocity winds and earthquakes.

Srivastava & Kumar (2018), compared bamboo to materials like steel, plastics, aluminum and discovered that it requires very less energy for production. Steel requires 50 times more energy than bamboo to produce 1 m³ material per unit of stress. However being susceptible to termite attack it needs to be treated first either by chemical or non-chemical treatment which increases its life span. They stressed forward that bamboo has a high tensile strength with a good weight to strength ratio thereby making it highly useful in sustaining high-velocity winds and earthquakes.

According to Nwoke & Ugwuishiwu (2011), bamboo is widely used as a basic timber for rural housing. It is used as poles, purlins, trusses, rafters, mats for wall/ceilings/roof, the frame of doors & windows and fence posts, especially in tropical countries. Bamboo is mostly used in construction structural members of wall, roofs, floors, and ceiling so also in fence construction in Nigeria [11]. Kayode & Olusegun (2013), reveals that the ultimate tensile strength of some species of bamboo has been found to be about the same as that of steel at its yield point is on average of 1,400 kg/cm² to 2,800 kg/cm². Also Sharma, et al (2014), found out that the ultimate tensile strength of some species of bamboo is comparable to that of mild steel and it varies from 140N/mm² - 280N/mm². Bamboo is able to resist more tension than compression. In the outer zone are highly elastic vascular bundles that have a high tensile strength. The tensile strength of these fibers is higher than that of steel, but it is not possible to construct connections that can transfer this tensile strength.

C. Stone / Rocks

Stone is a highly durable, low maintenance building material with high thermal mass. It is versatile, available in many shapes, sizes, colours and textures, and can be used for floors, walls, arches and roofs. Manufacture et al. (2017), described stone as a natural product of the earth which is constantly being recreated by natural tectonic processes. They stressed further that most of the early building in the world were constructed with stone or rocks. Stone has been used as a building material for thousands of years. It has long been recognized as a material of great durability and superior artistic quality, the foremost choice for buildings associated with status, power, and religion. The pyramids in Giza, burial chambers in the UK and temples in Malta were all built from stone over 4000 years ago and are still standing.

Kayode & Olusegun (2013), found out that Stone joined with laterite mortar or lime stabilized mortar produces a desirable building wall with high compressive strength. Stones are the most utilized materials, it prevents moisture and humidity. Fradinho & Nedelcu (2017), pointed out that in some parts of Northern Nigeria, stones are used in building foundations because of its moisture-proofing property and in some areas with heavy rainfall, layers of stones or un-coursed rubble are used in other to reduce the amount of the moisture movement from the foundation upwards.

D. Timber

Ramage et al., (2017), described timber as one of the many forest products used around the world for construction activities. It is used in both small and large buildings projects and it is a natural material that is readily available and also has a wider usage across the construction industry in Nigeria. Timber is one of the few natural building materials, which has a lot of advantages. Generally, timber is non-toxic, does not leak chemical vapor into the building and is safe to handle and touch. It also means that as timber ages, it does so naturally. The best timber used in northern part of Nigeria is obtained from the trunks of a male palm tree. According to Fradinho & Nedelcu (2017), timbers are commonly called “Azara” beams. They are rigid and heavy, resistant to termite attack, and very durable because they took several decades if not a century without signs of decay. Dean (2010), described timber as a primary construction material, and in
The market survey was carried out on the prices of sand creates blocks, adobe bricks, steel reinforcement and bamboo in Kwara state Nigeria.

Two major green materials, earth bricks and bamboo were compared and contrast with sandcrete blocks and steel reinforcement in table II & III respectively.

**Table II. Market Prices comparison of Sandcrete Blocks with Adobe Bricks**

<table>
<thead>
<tr>
<th>No</th>
<th>Item</th>
<th>Unit</th>
<th>Market Price per unit (N)</th>
<th>Sandcrete Blocks (Qty)</th>
<th>Adobe Bricks (Qty)</th>
<th>Amo unt (N)</th>
<th>Amo unt (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>225x225x4 50mm</td>
<td>Sq.m</td>
<td>180</td>
<td>10</td>
<td>1800.00</td>
<td>25</td>
<td>1500.00</td>
</tr>
<tr>
<td>2</td>
<td>100x140x2 90mm</td>
<td>Sq.m</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Savings</td>
<td></td>
<td>16.67%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table III. Market Prices Comparison of Steel Reinforcement and Bamboo in lintel and short beam**

<table>
<thead>
<tr>
<th>No</th>
<th>Item</th>
<th>Unit</th>
<th>Market Price (N)</th>
<th>Steel bar (len in meter)</th>
<th>Amo unt per len (N)</th>
<th>Amo unt (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12mm diameter bar</td>
<td>m</td>
<td>2500.00</td>
<td>12</td>
<td>208.3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Bamboo with treatment</td>
<td>m</td>
<td>800.00</td>
<td>0</td>
<td>66.67</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Savings</td>
<td></td>
<td>67.99%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The analysis as shown in the table above indicate that there could be tremendous saving while using the green materials to replace the conventional materials. Comparing the prices of sandcrete blocks and adobe bricks, it was discovered that, there is a saving of 16.67% if adobe bricks are selected. Also, there is a saving of 67.99% if bamboo is considered in lintel and short beam reinforcement as a replacement for steel in a bungalow building.

**IV. CONCLUSION**

The aspiration of low-income and middle-income to build houses of their own remains a mirage and becoming a difficult reality. Thus the need to erupt a cost-effective, innovative and environment-friendly materials for the construction. The study analyzed the cost-effectiveness of using relevant green building materials as an alternative solution to the conventional materials which made affordable housing difficult to the low-income earners in Nigeria. Market surveys of two relevant green materials and conventional materials were carried out respectively. It was found out that about 16.67%
and 67.99% of the materials cost, can be saved by using the adobe bricks and Bamboo in placed of sand creates blocks and steel reinforcement respectively. This results is closely related to the outcome of the study carried out by Nwoke & Ugwuishi (2011), where it was established that between 30% and 80% could be achieved by substituting steel reinforcement in concrete element with locally available bamboo. This shows that the cost benefits of using potentials green materials towards low-cost housing technologies is achievable in Nigeria.

ACKNOWLEDGMENT

This paper has been carried out in Quantity Surveying Department, Universiti Teknologi Malaysia. The author presents its heartiest gratitude towards Assoc. Prof. Dr. Sarajul Fikri Mohamed for constant encouragement, guidance, and support.

REFERENCES