

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

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**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 etc 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

No	Material	Objectives	Cost-effective	Author(s)
1	Earth bricks	Using earth as a building material for sustainable low-cost housing in Zimbabwe	The use of earth on site as a building material saves manufacturing cost, time, energy, environmental pollution and transportation cost	Zami, (2008)
2	Bamboo	To replace steel as reinforcement in concrete for the low structural elements in low-cost house	Does not required Sophisticated/fuel guzzling procedures for processing	Sabnani, Latkar, & Sharma, (2013)

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3	Stone / Rock	Vernacular Architecture of Northern Nigeria in the light of sustainability	Stones are the most utilized materials; some of them prevent moisture and humidity which are used in building foundations etc.	Fradinho & Nedelcu, (2017)
4	Timber	Using Local Timber - contributing to sustainable construction. Guidance for North Scotland The availability of Thatches and grasses in the middle belt and Northern region of Nigerian.	Reducing the amount of carbon dioxide (CO2) in the atmosphere which is fundamental to combating climate change. Thatch is one of the oldest of building materials known, is a good insulator cheap, and easily harvested.	[5]
5	Thatches / Grass			Onyegiri & Ugochukwu, (2016)

**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.



**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.

**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.



**Fig. 2.** Bamboo arrangement in a concrete beam.  
Source: engineering- society.com

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 1m<sup>3</sup>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 1,400kg/cm<sup>2</sup> to 2,800kg/cm<sup>2</sup>). 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/mm<sup>2</sup>- 280N/mm<sup>2</sup>. 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



**Fig. 3.** Stone materials used for walling in Offa Grammar School Hall, Kwara State Nigeria. Built-in 1943.

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 rubbles 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



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terms of sustainability, it is one of the best. It is renewable, it requires little in the way of energy to make the transformation from living tree to usable timber, and in North Scotland, it is grown and processed locally. The Hardwood is a natural product of the earth that is constantly being renewed. It is completely biodegradable and can be easily recycled at the end of its life and used as fuel, or in other projects (Manufacture et.al 2017). As a natural material, timber exhibits an inherent variation of its properties across samples of the same species. According to Ramage et al. (2017), this is due to the interaction of characteristics at the molecular and macro scales.

## E. Grasses / Thatches

Fradinho & Nedelcu (2017), described grass as a building material with a wider usage, grass and earth form a composite material, while the grass is the reinforcement, the earth serves as a matrix or binder as it surrounds the straw or thatch. They described grass as a good insulator and easily harvested. Onyegiri & Ugochukwu (2016), revealed that grasses were found in the Middle Belt and Northern region abundantly for the purpose of construction in Nigerian Traditional Architecture. They further stated that type of grasses available in a locality depends on the climatic region, vegetation, and closeness to a water source. For instance toward the South of the Middle Belt region, elephant grasses were common and also in the Northern part of South Western, Mid –Western and Eastern region. While in the Middle Belt and Northern region, spare grasses were very common. Many African tribes have lived in homes made completely of grasses and sand year-round.

Thatches are used throughout the world for walls and roof construction. Nma & Murtala, (2016), argues that in the older traditional architecture, roofing was done of leaf and reed thatches on a skeleton of pales and stakes tied together with ropes and the thatch/straw possess a tensile strength while used on the roof. They stated further that thatch construction uses matted or baled straw from wheat, oats, barley, rye, rice and others as a wall or covered by earthen or lime stucco. Thatching methods have traditionally been passed down from generation to generation, and numerous descriptions of the materials and methods used over the past three centuries. Thatch is still employed by builders in developing countries, usually with low-cost, local vegetation. However, with the emergence of zinc, aluminum roofing sheets, and cement the use of thatch as a building material was greatly affected and diminishes its use in housing construction

## III. COST-EFFECTIVENESS OF USING GREEN MATERIALS

The major objectives of cost-effective housing are to reduce the cost of construction and at the same time not to sacrifice any element of safety or serviceability of the house over the life cycle. Sharma, et-al (2014), in their study reveals that the cost of construction is increasing by 50 per cent over the normal inflation due to hike in the cost of conventional building materials and labor. Consequently, even basic housing is now beyond the reach of a common person in rural areas. There is an imperative need to utilize technology options leading to cost-effective results.

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

No	Item	Unit	Market Price per nr. (N)	Sandcrete Blocks (Qty)	Amount (N)	Adobe Bricks (Qty)	Amount (N)
1	225x225x4 50mm	Sq .m	180	10	1800.00		
2	100x140x2 90mm	Sq .m	60			25	1500.00
3	<b>Savings</b>		<b>16.67%</b>				

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

No	Item	Unit	Market Price (N)	Steel bar (len in meter)	Amount per len (N)	Bamboo (len in meter)	Amount (N)
1	12mm diameter bar	m	2500.00	12	208.33		
2	Bamboo with treatment	m	800.00			12	66.67
3	<b>Savings</b>		<b>67.99%</b>				

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 & Ugwuishiwu (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.

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