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Exploration of the Potentialities of Contemporary Earth Construction for Provision of Sustainable and Affordable Housing in Nigeria

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Abstract

Developing countries facing challenges in provision of housing especially with the increasing population in Malaysia, large demand on the construction materials resulting the construction cost to increase tremendously. Using low-cost housing material will be beneficial to provide affordable housing in order to meet society needs. This study investigates Potentialities of Contemporary Earth Construction for Provision of Sustainable and Affordable Housing in Nigeria. Building with earth is an ancient technology which is still being practiced today. Earth as a construction material has been the most essential of the building materials, since the dawn of man, and it is available everywhere, existing in many different compositions that can be processed in a myriad of ways. This paper is a review of the potentialities of contemporary earth construction to address urban housing crisis. A critical literature review method was adopted in this article to investigate the economic benefits of contemporary earth construction in low-cost urban housing compared to conventional brick and concrete construction, historical evidence of the success of earth construction, the environmental benefits of using earth in construction, both locally and nationally. The article briefly reviews the technical aspects of building with earth blocks in the development of housing. The paper conclusively submits that contemporary earthen architecture shows significant evidence solving housing crisis in the developing countries.

Keywords: Keywords: Earth, Potentialities, Contemporary Earth Construction, Urban Housing, Nigeria

Introduction

Affordable housing is needed in many countries of the world especially the developing ones. In Nigeria,the need for affordable housing is especially critical considering the huge n umber of the populace who cannot afford decent accommodation. Among the many alternat ives available for lowcost housing production are the compressed laterite soil blocks or bricks Onaolapo,A.N. (2010). Earth has been, and continues to be, the most widely used building material throughout most developing countries: it is cheap, available in abundance and simple to form into building elements. Earth is an alternative building material that is significantly cheaper than using conventional brick and concrete, and is also environmentally sustainable. Earth has been used as a construction material on every continent and in every age. Compressed stabilised earth blocks (CSEBs) were successfully used for low-income housing in Sudan (Adam and Agib, 2001 cited in Hadjri et al, 2007). Earth construction offers a way for people to feel and actually become more meaningfully connected to nature because it is a form of natural architecture built with environmentally friendly materials (Taylor, 2009). Earth, on the strength of its affordability, abundance and availability, earthen materials will continue to be of fundamental importance in the production of low income housing

Scholars have agreed that high cost of building materials is one of the major problems militating against adequate housing supply (See Onibokun, 1986; Onibokun and Agbola, 1990; Agbola. 1993 and Agbola, 1998). Generally, the problems here include that of scarcity and high cost of imported building materials or those with foreign components as well as low patronage of local building materials. Similarly, there is low, insufficient production of local building materials in Nigeria. Although there have been efforts to boost local production, the Nigerian Building and Road Research Institute (NBRRI) established in 1978 for that purpose has not achieved much. In developing countries such as Nigeria, the need for locally manufactured building materials can hardly be overemphasized because there is an imbalance between the demands for housing with the use of expensive conventional building materials compared with traditional building materials. To address this situation, attention has been focused on low cost alternative building materials. Stabilized earth is an alternative building material that is significantly cheaper than using conventional brick and concrete, and is also environmentally sustainable.

Thus, contemporary earth construction is economically beneficial in the construction of low-cost urban housing. This article aims to identify the potentials of contemporary earth construction. It reviews the literature. It also assesses and recognizes the local conditions

instrumental to making contemporary earth construction economically viable for low-cost urban housing across the globe. The urge to find alternative materials to existing conventional ones and the need to bring down the cost of construction has compelled the researchers to intensify work on earth with a view to investigating its usefulness wholly as a construction material or partly as a substitute for fine aggregate component of sandcrete. Doing this, it is necessary to examine possibilities of introducing the use of our local material such as laterite which will assist in construction of low-cost housing, yet more durable buildings to that of sandcrete blocks. This paper investigates the information available on earth material and their potential use as a low cost sustainable building material in Nigeria in the light of problem of affordable structure. This article reviews the benefits of using earth as a building material, and describes the associated innovative construction techniques (Compressed Earth Block) for urban housing provision in developing countries. There is therefore an urgent need to assess alternative building materials and techniques that are both affordable and sustainable.

The whole world is in dilemma because of depletion of natural building material. Nigeria is therefore not an exception to the universal problem. This paper investigates the information available on bamboo, palm fibre and earth material and their potential use as a low-cost sustainable building material in Nigeria in the light of problem of affordable structure.

Significance of the Study:

Need to develop affordable housing is necessary because of the numerous homeless people living in the developing countries; the present work is an attempt to alleviate the housing problem facing populations of these countries. This paper is meant to make available information to different groups of individuals or institutions concerned with building and construction in developing countries. For example, housing authorities, building research organizations, government officers, financial institutions, builders, architects, and voluntary organizations.

The Study Methodological Approach

Based on the qualitative nature of the study, the research method adopted a **Desk Review Research Approach** by reviewing relevant archival materials (literatures) relating to the subject matter – ***Exploration of the Potentialities of Contemporary Earth Construction for Provision of Sustainable and Affordable Housing in Nigeria ,*** where data was gathered

through existing research, books and articles written on the study. Systematic Review of Literature was employed to pursue the goal of the paper, thereby establishing a theoretical background between Earth Construction and Sustainable/Affordable Housing in Nigeria.

The Concept of Earth and Earthen Construction

Building with earth is definitely an appropriate and cost-effective technology. Obviously, one has to know the material and master its disadvantages, which normally are variations in the soil quality and hence the block quality, shrinkage cracks, lower strength than high quality fired bricks or concrete, production of the blocks on site, etc. Since half a century, research and development has proved the potential of earth techniques. Earth can be used as a quality and modern building material almost everywhere in the world. One of the main key points for a general revival and dissemination of earth techniques is respect for Nature and the management of resources. Earth as building materials is available everywhere, existing in many different compositions that can be processed in a myriads of ways. Earth is the oldest building material. It use is as widespread as humanity as well. Nearly half the world's population lives in structures made with some kind of earthen construction technique. According to Jennifer (2010), earth construction is the practice of building with unfired, untreated, raw earth. It has been successfully used around the world for over 11,000 years, and it is estimated that around half the world's population today live and work in earth buildings.

Mohammad (2009) opined that Stabilized earth is an alternative building material that is significantly cheaper than using conventional brick and concrete, and is also environmentally sustainable. Earth has been used as a construction material on every continent and in every age. Earthen construction remains the most economically viable and popular method of construction. Earth construction technologies are generally used to construct homes. Other structures such as offices, stores, warehouses etc can also be made using earth. The most obvious advantage of earth construction is the abundance of the raw material – earth. Contemporary earthen architecture shows significant evidence solving housing crisis in the developing countries. Rao (1990) noted that earth has been the most essential of the building materials, since the dawn of Man. Ever since mankind first congregated in villages almost 10,000 years ago. Unbaked earth has been one of the principal building materials, used in every continent. Earthen construction is an eco-friendly and low-cost technology from the past and very relevant to the future. Several expensive homes have been built using these technologies.

The emphasis must be on low-cost housing and earthen construction is an ideal technology to address this global problem. Recently, earthen construction has gained some

recognition in the first world, where various scientific mechanisms are being applied in an effort to improve its durability, aesthetics and cost effectiveness. Earthen construction has been, is and will continue to be a reality. Recent statistics show that the percentage of earthen housing in the next 15 years will be higher than 50% it has been used for sustainable buildings and homes for a long time and now its getting a lot of attention.

The Need for Sustainable and Low-cost Urban Housing

Sustainable Housing could be described as the housing that put into consideration the long-term environmental, social, cultural and economic balance of the housing stock and its occupants. Jimoh et al, (2014) opined that Sustainable housing has to do with economic development of all income groups and to inclusive institutions. Sustainable housing should be affordable and the planning and building process should be harnessed to empower communities and build people's skills and capacities (UN-Habitat, 2012).

The urgent need to develop suitable and affordable housing is born as a consequence of the fact that over one billion people in the world, most of who live in the developing nations, are either homeless or live in very poor housing (BASIN news, 2001). Earth has been used for thousands years by civilizations all over the world. Earth as a building material is available everywhere. In developing countries, earth construction is economically the most efficient means to house the greatest number of people with the least demand of resources. Gilkinson & Sexton (2007) defined sustainable housing as a form of affordable housing that incorporates environmentally friendly and community-based practices. Sustainable housing provision requires proper definition of housing needs, and the participation of the end users to ensure their satisfaction. The general goal of sustainable development is to meet the essential needs of the world's poor while ensuring that future generations have an adequate resources base to meet theirs. It is thus geared towards meeting the needs of the present generation without compromising the ability of future ones to meet their own needs (Adedeji, 2007).

There is an urban housing crisis in most of the developing countries and this is largely attributed by the rapid urbanization (Dwyer et al, 1981,). Sustaining housing development especially to the low-income group of the society has become a huge challenge in developing countries. Thus, acquisition of indigenous building materials has been suggested as a way out.

Zakari et al (2013) opined that the construction industry has succeeded in improving its performance and in the alleviation of at least a part of the housing problems in urban areas by developing and applying innovative building technologies based on locally available resources that can be sustained economically and ecologically. Laterite has been used in construction of shelter from time immemorial and approximately 30% of world's present population still lives in laterite structures. Laterite is cheap, environmentally friendly and abundantly available building material in the tropical region (Fales, 1991). Nigeria has a population of over 140million (FRN, 2007). The average population density according to (UNDP, 1999) is approximately 124 persons per square kilometre, making Nigeria one of the most densely populated countries in the world. Access to decent and affordable housing to this large population is a daunting challenge which has made housing an issue of national concern.

As asserted by Adam and Agib (2001) housing in developing countries is one of the most important basic needs of low-income groups. Olotuah (2009) has shown that the lack of adequate housing in Nigeria is a manifestation of poverty which is the main reason why a significant proportion of the urban dwellers lives in high density housing and environmental conditions. This has constituted serious health hazards and threats to their general productivity. It has been shown that the poverty level of most Nigerians makes it difficult for individuals to own their houses (Daramola, Alagbe, Aduwo, and Ogbiye, 2005) since construction costs are beyond the means of the poor. The costs of conventional building materials need to be addressed by focusing on low-cost alternative local and indigenous building materials. An understanding of the present attitudes towards earth construction is necessary in order to support traditional earth construction as an acceptable way forward in contemporary architecture.

Historical Overview of Earth Building Technology - The Current and Historical Trends

Raw earth is commonly acknowledged as the world's most widely used building material. Throughout recorded history artisans and village builders have used it to create durable housing. Today, earth building is in resurgence, but modern applications demand higher standards and greater care in construction than in the past. Stanford-educated inventor, author, teacher, and builder David Easton is the preeminent advocate for building with earth. Historically earth was used as a construction material all over the world and universal use of earth construction technology proves that, it is advantageous.

According to Easton (1996), rammed earth (RE) construction is a cheap way of providing shelter since earth is an abundant resource. It is essential to look at historical evidence

of the success of earth construction. It is currently estimated that over one third (Dethier, 1981) to over one half (Smith and Austin, 1989) of the world's population lives in some type of earthen dwelling. The history of earth building lacks documentation, because it has not been highly regarded compared to stone and wood. (Houben and Guillaud, 1989, p8). There are cities built of raw earth, such as: Catal Hunyuk in Turkey; Harappa and Mohenjo-Daro in Pakistan; Akhlet-Aton in Egypt; Babylon in Iraq. In Africa, the Egyptian civilisation provides abundant evidence of the use of earth in building as found in the early human settlements at the Merimd and Fayum sites in the Nile delta, which dates from the fifth millennia before Christ. The dominance of the Egyptian dynasty promoted buildings of prestigious structures made of brick from the Nile clay, desert sand and straw from the grain fields. These bricks were made by hand and dried in the sun before the development of the mould. In Africa, suitable soil is found in most of the countries. Adobe Block, Compressed Stabilised Earth Block (CSEB) and Rammed Earth (RE) are the most common earth construction methods experimented in most of the countries in Africa (Zami, 2010). Considering the local situation and the drawbacks of earth construction, the stabilised form (RE/ CSEB) of earth construction is most suitable to address the low cost housing crisis in most of the countries in Africa because the drawbacks that are derived and discussed in the different literature are from the experience of un-stabilised earth construction.

Houben et al (1989) opined projected that "30% of the world's population, or nearly 1,500,000,000 people, live in a home built in unbaked earth. Roughly 50% of the population of developing countries, the majority of rural populations, and at least 20% of urban and suburban populations live in earth homes" There are cities built of raw earth, such as: - Akhetaten in Egypt (see Figure 1); Babylon in Iraq (Easton, 1998, p3). Fortified city in the Draa valley in Morocco was constructed out of unbaked earth, which is around 250 years old (see Figure 2).



Figure 1: Ancient city of Akhetaten, Egypt.

Source: Ashton and Down (2006).



Figure 2: Fortified city in the Draa valley in Morocco.

Source: Google images, 2011.

Benefits (Advantages) of Contemporary Earth Construction in Urban Housing

Earth as a construction material has inherently good environmental characteristics and could make a significant contribution to the improved sustainability of construction. Thus, Earth materials have significant environmental advantages when compared to many other building materials. The most obvious advantage of earth construction is the abundance of the raw material earth. Other advantages of earthen construction are multiple and complementary and are as follows summarized below:

- *High thermal insulating properties*
- *High sound insulation*
- *Not susceptible to insects or rodents*
- *No waste generated during construction*
- *Inert- contains no toxic substances*
- *Construction is inexpensive and simple*
- *High workability and flexibility*
- *High fire resistant.*
- *Earth construction is economically beneficial.*
- *It requires simple tools and less skilled labour.*
- *It encourages self-help construction.*
- *Suitable for very strong and secured structure.*
- *It saves energy (low embodied energy).*
- *It balances and improves indoor air humidity and temperature.*
- *Earth is very good in fire resistance.*
- *Earth construction is regarded as a job creation opportunity.*
- *Earth construction is environmentally sustainable.*
- *Easy to design with and high aesthetical value.*
- *Earth buildings provide better noise control.*
- *Earth construction promotes local culture, heritage, and material.*
- *Earth is available in large quantities in most regions.*

The Innovative Techniques of Earth Construction

Earth in its fullest sense is currently widely used in construction, (innovative and appropriate uses of earth) and has the potentials to be used to produce high quality building products, which satisfy the requirements of existing construction industries in developing countries especially in Nigeria and the most common techniques of earth construction are:

a. **Mudwall:** This is a simple historical technique of monolithic walling, using an earth straw mix.
b. **Rammed Earth:** In this technique earth is compressed between temporary shuttering to create dense monolithic walls. Compaction Moist subsoil is layered into a temporary formwork (shuttering) and then rammed (tamped) for by manual or mechanical means. The layers can be rammed continually until the wall is complete, with no need to wait for each layer to dry out. The walls are then allowed to dry naturally once the frame is removed. Rammed earth is stronger than cob, but more expensive because of the shuttering required
c. **Earth Brick:** This is an ancient material comprising un-fired bricks of varied composition. This method of construction covers a range of techniques from hand-made mud bricks, known as adobe, to the factory production of unfired clay bricks and the size of individual units varies according to context.
d. **Compressed Earth Block**: Compressed earth block used for walling in residential building (see figure 4). This is a modern material similar to earth brick, but having better load bearing capacity. This type of earth block is produced in a manually operated press, which exerts a large amount of pressure on the earth in the mould. Blocks are thus produced in standard sizes. The soil requirements are similar to those for rammed earth
e. **Earth Infill in Timber Frame Construction**: This involves light earth/fibre mixes either formed on site or in block form. It can give good thermal insulation and is particularly appropriate to Scottish construction practices.
f. **Earth Products:** A range of prefabricated products is available, including blocks, boards and panels. These are currently imported from Germany.
g. **Earth Plasters**: These are effective as either traditional wet plaster or as Plasterboard.

Compressed Stabilized Earth Block Technology

Compressed Earth Blocks

Compressed earth blocks (CEBs) are a relatively recent technology and combine the nest characteristics of traditional earthen technology and modern brick making processes. The concept is akin to a miniature rammed earth wall. Earth is poured into moulds and compressed either manually or mechanically (see figure 3). The constituents of the earth mix are the similar to those of adobe: clay, sand and additives or stabilizers such as cement or fly ash. CEBs structures have been found to be a lot stronger and more weather resistant than traditional adobe structures. Several experiments have been carried out to determine the best practices of making the earth mix and the blocks themselves. There are several manually operated and mechanical block making machines available. The Balram, Cinvaram, TEKram are all examples of manual compressors. Mechanical CEB machines that run of diesel or gasoline engines can churn out up to 1000 units of superior quality per hour (AECT CEB Machines, 2003). CEBs are better than other earthen construction products as they are more uniform and are therefore easier to work with. Additionally, they help increase the speed of construction, which is otherwise a limiting factor. Also, the use of CEBs ensures a stronger structure that is possesses all the positive characteristics of earthen construction and fewer shortcomings. Codes for CEB technology are similar to those for low strength masonry. New Mexico and California have the most detailed codes thus far and it is possible to construct CEB buildings with the help of these codes in other states as well.

In Africa, suitable soil is found in most of the countries. Adobe Block, Compressed Stabilized Earth Block (CSEB) and Rammed Earth (RE) are the most common earth construction methods experimented in most of the countries in Africa (Zami, 2010). Considering the local situation and the drawbacks of earth construction, the stabilized form (RE/ CSEB) of earth construction is most suitable to address the low cost housing crisis in most of the countries in Africa because the drawbacks that are derived and discussed in the different literature are from the experience of un-stabilized earth construction.

Advantage of Compressed Earth Blocks (CEB)

a. Soil is available in large quantities in most regions.
b. Cheap and affordable - in most parts of the world soil is easily accessible to low-income groups. In some locations it is the only material available.
c. Easy to use - usually no specialized equipment is required.
d. Suitable as a construction material for most parts of the building.
e. Fire resistant - non-combustible with excellent fire resistance properties.
f. Beneficial climatic performance in most regions due to its high thermal capacity, low thermal conductivity and porosity, thus, it can moderate extreme outdoor temperatures and maintain a satisfactory internal temperature balance.
g. Environment appropriateness- the use of this, almost unlimited its natural state involves no pollution and negligible energy consumption, thus, there is further benefit of the environment by saving biomass fuel.

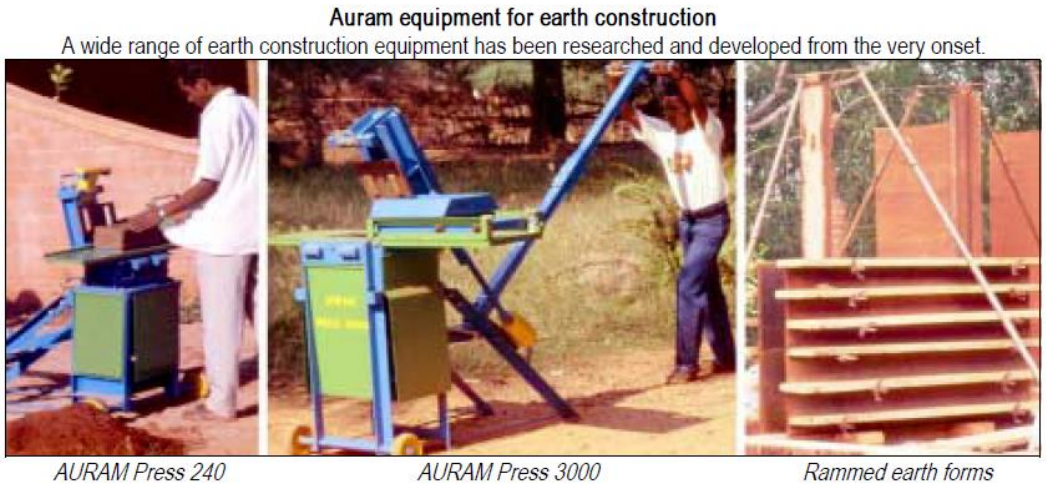


Figure 3: Equipment for Compressed Earth Blocks
Source: **(UNESCO Auroville Building Centre/Earth Unit) Web site: http://www.earth-auroville.com**



Figure 4: Compressed earth block used for walling in residential building Source: authors' fieldwork (2014)

Policy Suggestions and Conclusion

The conclusion is that the dream of housing can only be achieved if the abundant local structural engineering materials in Nigeria, on which a lot of research works have been done, can be used to get affordable houses and structures. The failure of the government in the provision of adequate houses for the population has made laterite blocks inevitable for the masses. The Problem of housing is closely tied to the question of how to build an affordable house by the urban low-income earner. This calls for practical solutions to low-cost housing design and construction through the use of locally-sourced building materials and culturally sensitive designs. This includes the development of building methods and technologies that are both appropriate to the resources and skills available, and which offer flexibility while reducing cost. It is evident from the above literature review that Earth is affordable and available and would be appropriate in the case of low cost house construction in Nigeria and as well as in many African countries.

Moreover, the insufficient use of low-cost traditional building materials and construction techniques in residential construction has resulted in expensive housing stock for the majority of the urban poor. This paper has argued that earth as an affordable alternative material to housing in such a way, that if compared to established conventional materials, it should prove to be an ideal alternative that is worthwhile. The rationale for earth building is established, and the unique elements of earth block construction are identified. Economic and

technical aspects of building with earth blocks were also examined, It is notable from this overview that contemporary stabilized earth construction is environmentally sustainable compare to the conventional (sandcrete block, concrete, etc.) building materials and would be appropriate in the case of urban house construction.

Hence, Promotion and adoption of stabilized earth as an alternative urban house construction material is worthwhile and significantly helpful in achieving environmental sustainability. Thus from the findings of this research there is a valid case for promoting indigenous earthen dwellings through improved and appropriate earthen construction techniques.

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