

PAPER 117 – AFFORDABLE HOUSING USING INDIGENOUS BUILDING MATERIALS

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ABSTRACT

Provision of Housing in Nigeria has been overwhelmed by many challenges over a long time. These setbacks have been categorized as both qualitative and quantitative. The challenges have continued to become a nightmare, which has affected the socio-economic aspect of Nigerian, even though some efforts have been made to curb these lapses such as the Presidential Executive Order No. 5 to improve local content in public procurement with science, engineering and technology components. One of the major challenges is the high cost of building materials. These high cost of building materials has become a bottle-neck to developers trying to make profit off their investments thereby increasing the cost of the houses being constructed for the masses. It has become paramount for the Nigerian government to curtail the crisis resulting to the high cost of housing in Nigeria which calls for innovative solutions, and more funding for research institutes to drive the Research and Development sector to develop and improve an indigenous building technology to ease housing development in Nigeria. This paper, therefore, tends to explore indigenous building materials and technologies that are cheap and readily available to ease housing construction in Nigeria.

KEYWORDS: Affordable, Indigenous Materials, Housing Deficit, Sustainability.

1. INTRODUCTION

Housing plays a predominant role in the well-being, economy, education, environmental, political and social life of any nation (Alaghbari, et al. 2011). Despite this role, many people in the low-income categories in developing countries such as Nigeria found it difficult to have buildings of their own due to high cost of conventional materials used in constructing the building. Like many urbanised societies, Nigeria is not an exception in experiencing acute difficulties in the provision of adequate housing for her citizens. The lack of access to adequate housing, which is priced out of the economic reach of the poor, is sometimes so serious that some are forced to construct shacks on pirated land with all manners of refuse materials (Olotuah, A, 2000; UNCHS (Habitat), 1992). Research shows that increasing demand for wood for housing construction is considered to contribute severely to the adverse environmental effects attributed to the building sector in most nations. Although according to (Alam and Starr, 2009; Duguma and Hager, 2010), the effects vary from one country to the other, as policy strategies and regulatory reforms have been proposed to encounter such problems in most developing countries. For example, in Sub-Saharan Africa, building developers are encouraged to switch from the use of conventional clay burnt bricks to alternative building materials to minimise the inefficient wood consumption mostly for brick making (GoM, 2004).

Provision of adequate and quality housing units, is among the role of any government, since, housing is one of the human fundamental needs. This indicator signifies, among other factors, the standard of living of a country's populace. It can also be used to measure the economic viability of a nation. Housing deficit, when left to persistent, could lead to increase in crime, outbreak of diseases, unaffordable house prices, poor standards of living as well as high mortgage payments, just to mention but few (Henilane, I., 2016).

Research by Anderson, L.M. et'al. (2003), further explained that when low-income households do not have affordable housing, family resources needed for food, medical or dental care, and other necessities are diverted to housing costs. The consequence of the above turns out to be a cost worry or overburden, especially where 50% or more of household income is expended on housing rent.

However, the use of alternative building materials has been advocated by the United Nations Commission for Human Settlement since the early 1990s (UNCHS, 1993). The use of alternative building materials is also considered as a means of enhancing the housing stock for low-income populations by using local and affordable materials and methods available. Although, the perception of using alternative building materials has highly been criticised by previous authors such as Myers, G. A., 1999 for a number of reasons. In addition, the structures built using alternative building materials are considered as structurally poor in terms of durability due to the lack of technological knowhow during material manufacturing or house construction process (Wells et al., 1998b).

Despite all the criticism the use of alternative building materials is gaining more favour as most of the problems highlighted are being addressed through research and development. (Kuchena and Usiri, 2009; Venkatarama 2007a and b; and Acosta, 2000)

1.1 Affordable Building

In most developed economies, the housing sector is seen as an important sector for stimulating economic growth. In Nigeria, however, access to affordable housing has largely, remained an unfulfilled dream to many numbers of people, especially, the middle and the lower earners.

Affordable building has been defined in various forms by scholars in building industry. However, others are of the believe that housing is considered affordable if it consumes 30% or less of a household's income (Community Tool Box. 2018). In other word, affordable building may be referring to as house that can be acquired by median group whose income is below middle-class income in the society. The choice of an affordable house goes beyond having a roof over one's head; it involves choosing your neighbourhood, amenities, and services that come (or don't come) with it (Wilson, K. 2018). The ability to access wealth by the majority of the citizen often puts upward pressure and competition from high-income masses on housing prices, thereby posting a higher risk for low-income masses (Community Tool Box. 2018).

Globally, affordable housing is defined in many ways, and one of such definition is that affordability which takes into consideration the degree of spending on housing to income of the house hold. However, one of the major challenges of the low-income group is the affordability of building home of their own due to high cost of building materials for house construction (Saad, T.,1992). Hence the need to know what is building materials.

1.2 Building Materials

The cost of building materials and components are known to constitute about 60-70% of the cost of the buildings. Currently, the gap between the rising demand and declining production levels is widening at an alarming rate. This will lead to the increase of prices of building materials in Nigeria, which will seriously affect the affordability of housing for the vast majority of the population. Building materials are the essential components of buildings construction and these materials must be sustainable for both the present and future generations (Usman, A. U.2018; CIB, 2011). As a result, there has been a surge of interest in developing Alternative Building Materials which are capable of meeting our structural needs with lower energy and material consumption (Usman, A. U., 2018). The global trend towards increased environmental awareness and climate change has also resulted in a surge of interest in ecologically friendly building materials known as alternative building materials.

1.3 Alternative Building Materials.

Alternative building materials can play a vital role in the Nigerian building construction industry, however; there is the need to understand what constitutes the term "Alternative Building Materials". Alternative building materials are building materials that are developed through modifying conventional industrial materials or unconventional/indigenous/traditional materials or modifying unconventional /traditional/indigenous materials which are particularly attractive for housing (Anigbogu, N. A., 1999).

The major advantages of these materials over conventional materials typically include a low embodied energy (often leading to reduced embodied greenhouse gas emissions), ease of construction, widespread availability and low cost, they are ozone-friendly, they are reusable, as well as biodegradable. These properties make alternative housing technologies attractive not only for housing in developed countries but also for use in humanitarian engineering projects in developing countries (Sharman, J., 2016). Despite its advantage, it was established that building constructed with natural material is associated with problems of acceptability, low strength, high level of maintenance and deforestation among other issues. It is on this basis that the Nigerian Building and Road Research Institute (NBRI) is making effort in contributing it quota to the development of affordable housing in the country.

2. NIGERIAN BUILDING AND ROAD RESEARCH INSTITUTE (NBRI) AS A CONTRIBUTOR TO THE PROVISION OF AFFORDABLE HOUSING

The Nigerian Building and Road Research Institute (NBRI) is one of the parastatals under the Federal Ministry of Science, Technology and Innovation (FMSTI), whose mandate is to conduct integrated Research and Development activities into the varied aspects of the Building and Road construction industries, build capacity and set the pace in indigenous construction technology development to improve the quality of life of Nigerians in the areas of affordable housing and increased economic empowerment.

2.1 Nbrri Technology and Innovation

The need to adopt measures for economic growth as well as provide adequate housing for the Nigerian is paramount, as such there is a growing awareness for the utilization of locally sourced materials especially in the deployment of mass housing construction schemes. For the materials to be appropriate to the needs of developing countries, they must be indigenous, locally available in abundance with low energy input in terms of production, maintenance and transportation costs, and labour intensive.

2.2 Some Research Carried Out By The Institute

This section intends to highlight some of the achievements recorded in the past few years by the Institute. The highlight cut across Building Research Department, Road Research Department and Engineering Materials Research Department as it mandates. They are as follows:

2.2.2 NBRRI Pozzolana

In line with the current thrust of the Institute to boost local content and produce a cheap, qualitative and yet highly competitive alternative to the conventional Portland cement, a product known as NBRRI Blended (Pozzolana) Cement as shown in Figure 1 was been produced and will soon be available in the market. It is locally sourced due to its availability all over the country and can be used with Portland cement at a ratio depending on raw material but varying from 20:80 to 50:50. This will reduce the cost of housing provision as well as provide employment for skilled, semi-skilled and unskilled. Pozzolanas are very good innovations in material production and utilisation in the building industry, they are siliceous and aluminous materials which in themselves possesses little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties. The utilisation of pozzolans brings about economic, environmental and technical advantages. The technical advantages involve the improvement of the quality of concrete i.e improved workability, improved resistance to sulphate attack, reduced alkali-aggregate reaction, reduced heat of hydration and thermal shrinkages and increase in water tightness.



Fig 1: NBRRI Blended Pozzolana

2.2.3 NBRRI Compressed Stabilised Earth Blocks

Walling takes up about 40% of construction costs, therefore it becomes imperative to explore cheaper means of wall construction materials such as drywalls and earth walls. Extensive research has been undertaken to produce quality and acceptable compressed stabilized earth blocks (CSEB) for low-cost housing. Paul O. A. and Isaac I. A. 2014; Patowary et.al, 2015, in their work evaluated the compressive strength of lateritic bricks stabilized with cement, lime and termite-hill.

The breakthrough in the design and production of interlocking Compressed Stabilized Earth Blocks (CSEBs) at 5% cement stabilization by the Nigerian Building and Road Research Institute as shown in Figure 2a, has made a giant achievement towards achieving the Sustainable Development Goals. These NBRRI CSEBs have under gone several tests such compressive strength and moisture absorption and have met the standard required for construction purposes. With cement stabilisation, the blocks must be cured for 28 days weeks after manufacturing. After this, they can dry freely and be used like common bricks with a soil cement stabilised mortar. Figure 2b shows the installation of CSEBs while 2c shows complete single bedroom using CSEBs.



Fig 2: Compressed Stabilized Earth Block (a) the CSEB (b) Installation of the CSEB (c) Single Bedroom

2.2.4 NBRRI Interlocking Block Making Machines and Laterite Grinding Machine

The Interlocking block making machines shown in Figure 3a were designed and fabricated specifically for the production of laterite blocks shown in Figure 2(a) while the laterite grinding machine in Figure 3b, grinds laterite to required mesh size for block production. The laterite grinding machine eliminates material wastes and guarantees high productivity. The Interlocking block making machines are simple and robust and produce a minimum of 500 blocks per day depending on the power source. They are ideal for mass housing delivery and can also serve as a means of economic empowerment.

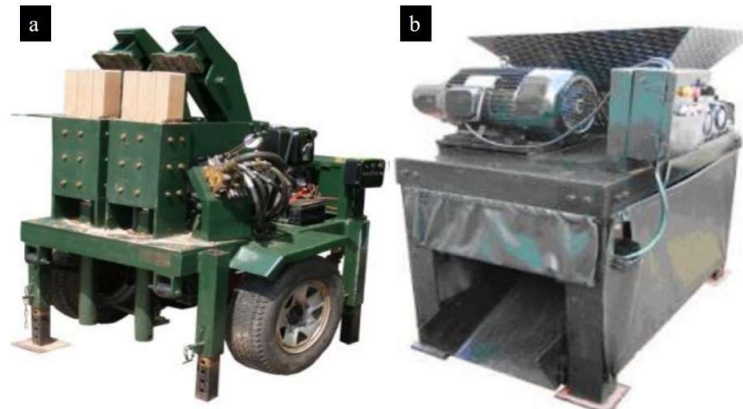


Fig 3: (a) Interlocking Blockmaking Machine -(Diesel) (b) Laterite Grinding Machine

2.2.5 NBRRI Laminated Bamboo Panels

The Bamboo plant is rated as the fastest growing plant on Earth. It has played an important role in the livelihood of millions around the world which has become a replacement for timber (Liese & Köhl, 2015).

One of the major problems is that it attracts living organisms when not treated. In Nigeria, Bamboo is an under-utilized raw-material (Ogunsanwo et al. 2015). It is most commonly used as follows; scaffolding, supports (studs), fencing, fuel, ladders, Yam Stakes and frames for mud houses in rural areas in the south east and south-south states of the country. Hence NBRRI has developed bamboo laminated panels used for ceiling and floor finishes during construction. The major raw materials required for the production of the laminated bamboo floor finishes are recycled bamboo used as scaffold which qualifies it to be sustainable. Figure 4a shows the Laminated Bamboo Panel produced. Figure 4b and 4c show how they are applied on floor and ceiling finishes.



Fig 4: (a) Laminated Bamboo Panel (LBP) (b) Installation of LBPs as Floor Finish (c) Installation LBPs fitted as Ceiling Finish

2.2.6 NBRRI Mador Tiles as Roofing Materials

Roof coverings also play a major role in the high cost in construction which are mostly imported into Nigeria. With the desire to lower construction cost, building professionals have been on the search for cost effective and light roofing which are durable and are less labour intensive. Coir is a green building material and has potential as a raw material for the production of roofing materials like corrugated sheets and tiles (Darsana P et' al, 2016). This is why NBRRI research team were able to innovate a fibre concrete roofing tiles (called MADOR tiles) with locally sourced raw materials and manufactured with specially fabricated machine in order to cut down production cost. The raw materials required for the production of the NBRRI MADOR tiles are all locally sourced and are readily available, the materials used includes fiber from plants such as coconut and a small amount of port-land cement. The machine required for the production of the tiles were also locally fabricated which makes all the production processes indigenous. Figure 5 show the production stage of mador tiles.



Fig 5: (a) Placing the mix on the Vibrating Machine (b) Mador Tiles as Produced (c) Application of the Mador Tiles

2.2.7 NBRRI Rubberized Asphalt Mat (RAM)

Based on studies from other parts of the world, the use of rubberized asphalt can improve pavement performance and serve as a better method of road maintenance for the safety of transport services and better service life of the pavement. The material used for the NBRRI RAM are aggregates, bitumen and Crumb rubber. Crumb rubber is a term usually applied to recycled tyres from automotive and truck scrap tires which are derived by reducing the rubber into uniform granules with reinforcing materials such as steel and fiber being removed along with any other type of inert contaminants such as dust and glass. There are two processes of incorporating crumb rubber into bitumen and these processes are the wet process and the dry process. However, the wet process was adopted in this study which involved incorporating the crumb rubber into the bitumen as part of the binder and the modified binder was mixed with aggregate and shaped in form of a mat to produce a rubberized asphalt mat (RAM).

A rubberized Asphalt mat is a mixture of crumb rubber derived from waste tyres as fine particles, aggregates of different sizes with bitumen as the binding agent. The use of crumb rubber for the modification of bitumen will not only reduce the environmental problems associated with its disposal but can also enhance the elastic responses of bitumen at higher ambient temperatures. Figure 6 shows the production stages of RAM.



(a) BITUMEN MODIFICATION

(b) AGGREGATE AND BINDER MIXING

(c) RAM COMPACTION

(d) RUBBERIZED ASPHALT MAT

Fig 6: Stages of production of NBRRI Rubberised Asphalt Mat

2.2.8 NBRRI Dismantlable House (NDH)

In a bid to demonstrate the application of NBRRI innovations and its potential for modular construction, the NBRRI dismantlable house was designed. The modular prefabricated housing technology is still nascent in the Nigerian Construction Industry despite having been in existence for at least 25 years. The NBRRI dismantlable house presents a hybrid of innovative building construction technologies such as dry construction, indigenous materials, green and recycled materials, and emerging technologies and composites. It is a quick assembly of affordable housing model that addresses the Nigerian housing needs as well as having the potentials to respond to emergency needs for temporary housing provision using the prefabrication technology while incorporating strategic NBRRI R&D outputs in materials and technological processes.

The NDH is a housing model that has evolved over the years from a simple One-Bedroom to a more robust Three-Bedroom structure. The NDH is 100% indigenous from design (spatial considerations, aesthetics and function), and materials selection (locally sourced), to construction (dry stacked/mortar-less) which has been tailored to suit the socio-economic peculiarities of the Nigerian climate. Its application is not restricted to only residential buildings; it can also be satisfactorily applied to the construction of schools, hospitals, shops, warehouses, etc. Furthermore, the building's aesthetics, especially on the facade, was achieved through appropriate proportioning of elements, highlighting and detailing of fenestrations, while the finesse was achieved through competent craftsmanship and appropriate colour complementation.



Fig7: (a) NBRRI Dismantlable One-Bedroom (b) NBRRI Dismantleable Three-Bedrooms

2.2.9 NBRRI Technology Village

In line with the housing challenges as well as NBRRI's R&D outputs in the housing sector, NBRRI technology village was set up to fill this gap by taking practical measures that will ensure a paradigm shift from the era of theoretical analysis to justifiable actions. This concept was also borne out of a desire to project the totality of NBRRI innovations for full visibility to the entire country and beyond in projects that display the entirety of NBRRI innovations in one location. Considering the materials and methodology adopted the approach is in line with the Sustainable Development Goals (SDGs) for sustainable affordable housing in Nigeria. This project is aimed at building confidence in the general populace to adopt NBRRI innovations in line with Presidential order and Federal Government's drive toward promoting local content.

3. CONCLUSION AND RECOMMENDATIONS

3.1 Conclusion

Due to the large housing deficit of about 17 million in Nigeria housing problems has continue to become a nightmare which has affected the socio-economic aspect of Nigerian, even though some efforts have been made to curb these lapses such as the Presidential Executive Order 5 to improve local content in public procurement with science, engineering and technology components. It has become paramount for the Nigerian government to curtail the crisis resulting to the high cost of housing in Nigeria which calls for innovative solutions, and more funding for research institutes such as Nigerian Building and Road Research institute to drive the Research and Development sector to develop and improve on alternative building technologies to ease housing development in Nigeria. Home grown technologies that are sustainable will help curtail the menace of building collapses which is as a result of poor workmanship and compromise by contractors trying to make maximum profit due to the high cost of building materials in Nigeria. Alternative building techniques are excellent strategy to solving the high cost of housing provision and should be considered as they are much simpler and cheaper to implement which will help boost the Nigerian Housing industry.

3.2 Recommendations

Some of the measures to be put in place to provide decent accommodation for Nigerian citizens include:

- (i) Government should deliberately explore alternative and innovative ways of cost-effective, quality, healthy, large-scale housing stock delivery programmes that are achievable within short delivery duration; and hinged on NBRRI Dismantlable House concept, across the country. This could be within its housing programmes or in response to emergencies or crises.
- (ii) Government should as a matter of deliberate policy promote and adopt the use as well as encourage direct patronage of NBRRI innovations
- (iii) Reduce the dependency on imported machines by fabricating and using locally-made ones
- (iv) Making raw materials for building cheap and affordable e.g. cement, sand, laterite, roofing materials, ceiling materials, glass window materials, plumbing materials
- (v) Capacity building in terms of artisan training, e.g. masonry, carpentry, Tiling, iron binding, plumbing and electrical training.
- (vi) Restructure and adequately fund the Nigerian Building and Road Research Institute (NBRRI) to perform its statutory role.

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