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MEDIUM PRODUCT IN THE RIMA BASIN, NORTH-WEST OF NIGERIA: AN ENVIRONMENT FRIENDLY HABITATION

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ABSTRACT: *The provision of environment friendly housing has remained a challenge to the Nigerian Government and to people who inhabit the Sudano-sahelian portion of Northern Nigeria. Despite the sinking of billions of Naira into the National Housing programme with the aim of creating a liveable environment for the Nigerian Low income earner the final product were in most cases not environment friendly and could not provide the necessary thermal comfort for the inhabitants most particularly in places of high temperatures like the Rima Basin area. In an era of climate change the emission of pollutants resulting from the manufacture of modern building materials and efforts to modify internal temperatures sometimes to induce cooling of houses makes the buildings no less uncomfortable because in the first instance, they have not been designed to be environment friendly. It is in the light of this that, this paper aims to identify and highlight the potentiality of medium product, in promoting the creation of an environment friendly habitation in the Rima Basin area. It also holds the prospect for the creation of affordable housing for the low income earner. This stems from the fact that, the building materials are cheaper and environmentally sustainable. The focal period of concern is the last three and a half decades, beginning from 1980.*

KEY WORDS: Environment friendly building, Medium product, Rima Basin,

INTRODUCTION

The history of early man's building effort throughout the world was directed towards the use of available local resources and ecological construction techniques. The current wave of modernization and westernization driven by Machine Technology has led to the creation of environmentally inappropriate building forms that do not provide the thermal balance between the human body and the natural environment. The need to deal with such problems as noise, energy conservation and pollution to increase the health of our planet and our own lives, underscore the need for the creation of an environment friendly habitat.

This paper therefore seeks to examine the possibility of retaining the use of our indigenous building materials and designs while incorporating the result of contemporary researches aimed at improving the material strength and performance of the indigenous materials. Through this, it is believed that a conscious ordering of the environment which will be culturally valid and environment friendly will be achieved.

The Study Area

The Rima Basin lies in the North –west Nigeria and the areas of Southern Niger republic. R.K Udo locates the basin between latitude 11degrees and16 degrees north and longitude 4 degrees and 8 degrees east.[1] However, M.A.Gill and R.A.Augi have opined that historically, the area

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extends as far north as the main edge of the Plateau of the Azben and Southwards to the valley of the River Niger of which the system is a tributary, in the east it extends to the dissected Plateau of western Rima from which most of the major tributaries of the Rima notably, Bunsuru, Gagare, Gulbin Maradi, Sokoto, Zamfara and Ka rivers originates. The Rima Basin extends roughly from Latitude 11^0N and 16^0N and from longitude 4°E and 8^0E.[2]

The Rima Basin area is located in the tropics receiving intense tropical heat and strong sunlight. Temperature conditions are generally too high throughout the year except during the nights. This underlay the requirements for buildings in this area to be suited to the local conditions to provide the required internal environment for comfortable living.

The climate of the Rima Basin is of tropical continental type. Two air masses dominated the region; they are the tropical continental air mass and the maritime air mass. The Tropical air mass is warm dry dusty and north-easterly air mass formed over the Sahara desert and when on move it becomes known as the Harmattan. The Harmattan period persist from November to March. This is a period of great body discomfort, requiring adequate shelter to mitigate the situation[3]. On the other hand the maritime air mass is associated with the South-westerly winds and this is the main rain bearing winds of the region. The rainy season extends from mid-May to mid- September. In relation to building, the most significant factor is not so much the annual amount of rainfall but how it falls. In this region the rains with accompanying thunderstorm are intense especially during the Months of August and September.

The vegetation of the Rima Basin is the Savanna type comprising of the northern guinea Savanna (found around Dendi region and Southern Zamfara), the Sudan savanna (covering the greater part of the region around the central plains) and the Sahel Savanna extending to the extreme Northern parts of the basin in such areas as Arewa ,the land of Zaberma, Konni, Adar and Gobir.[4] . Within each of these vegetation zones there exist local variations between the vegetation in the valleys and that of the upland areas.The Savannah vegetation consists of grasses and sparsely distributed trees. The most common grasses trees and shrubs that are of special importance to indigenous building practice includes,*Gamba(Adropogon gayanus), Sabara(Guira senegalensis) Giginya* (Deleb palm) tree, *Tsiriri* (Combretun leestingii)) *Gwadda* (Custard apple) *Rama* (Heeria insignis) among others.

An Environmental Friendly Building

The new International Webster's Comprehensive Dictionary of the English language defines environment as 'the aggregate of all external and internal conditions affecting the existence, growth and welfare of organism'. It includes variations in climate such as heat, cold, rains, wind velocities, movement of the Sun among others.[5] On the other hand, the word friendly has been defined by the New Oxford Thesaurus of English as cordial, easy to get along with, favourable.[6] To accommodate the seasonal variations in providing natural thermal comfort satisfaction for the inhabitants of a building requires the employment of appropriate construction materials and methods of construction.

Therefore, the problem of designing a building that seeks to establish a thermal balance between the human body and the natural environment extends beyond mere organising of space and the erection of a superb structure, to include the integrating of the total form to its natural and architectural environment. For example, in relation to the climate and building it has been pointed out that:

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Climate must be taken into account when deciding on the overall concept of a project, on the layout and orientation of buildings, on the shape and the character of the structure, on the spaces to be enclosed and last by no means the least, the spaces between buildings. In other words, climate must be considered at the early design stage[7]

The term environment friendly building in this work refers to building construction involving the use of abundantly available and reusable materials that are environmentally friendly and ecological construction techniques with less dependence on fossil fuels. The created structures should provide thermal comfort and security with maximum economy to the inhabitants throughout its life cycle from construction to maintenance, renovation and even demolition. The following section intend to dwell on these characteristics to see how a miscegenation of the materials and building techniques could lead to the creation of an environment friendly building in the Rima Basin.

The Building Materials

The choice of appropriate construction material is central in the establishment of an environment friendly building. The primary indigenous building material – earth has been used as a construction material in every continent and in every age. It is one of the oldest building materials.[8] One of its greatest advantages is that it is readily available – in different types. In the Rima Basin area, the reddish earth at times with a clayey mixture is usually obtainable from the low hilly outcrops in the area. The Black and whitish earth materials are available at water ponds, around lakes or Fadama areas, or even from Termitariums, which are a natural feature of the landscape in the area.[9]

Moreover the prevailing savannah environment in the area support the growth of a number of vegetal stalks, straw and some common trees and shrubs used in indigenous building. Such vegetal stalks, as has already been mentioned in this study – included, cornstalks, *Gamba, shalla(* a kind of thatching grass) *shibci* (thatching grass) trees and shrubs such as *[oruwa (*locust beans tree) *Giginya, Gwadda (* custard Apple), *Geza* (*combretum micranthum)* among others, are in abundant supply. Those cut during the dry season regenerates or even new additional ones sprout up during the rainy season of the year. It is for this natural replenishing that the materials sustained the indigenous building industry for centuries.[10]

Another major advantage of the indigenous building materials is that, they are recyclable and reusable.[11] This is in sharp contrast to a number of modern building materials. The earth collapsed or demolished wall could be recycled without degrading of quality and re-used in erecting a new wall. This has been the case with the collapsed or abandoned remains of city walls all over Hausaland. The earth has been pillaged for house building and other structures.[12]

Similarly, vegetal materials even when they are bad in relation to the building could be recycled back into building construction processes or put to other uses. For example, bad thatch from thatch roofs (of *[aki, Kudandam, Rumbu, Rufewa*, etc) – could be used in the treatment of mud for building as *Ramno* (binding agent). In addition, the corn stalks and wooden materials removed mud or thatch roofs, *Zana* or *Darni* fence walls, could be use to generate energy for cooking.[13]

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Biodegradability is another characteristic property of indigenous building materials, which make them environment friendly.[14] Earthen, wooden and thatch materials decompose easily and come back to mother earth. This is in sharp contrast to the modern building materials like concrete, glass and ceramics that takes several years to decompose, thereby becoming health hazard in the environment.

Building Technique

Indigenous building construction involves bringing together of the various building materials, using manual labour to erect the desired building structure. The building bricks, the walls and the roofs are manually produced, and relying on renewable solar inputs to dry mud bricks and grows the thatching materials and poles, require no input of fossil fuels.[15] From this it follows that, the construction technique is cheap and environment friendly as it obviate the problem of carbon dioxide emission to the environment, something which the modern construction industry is notoriously known for.[16]

Another significant ecological building construction technique is the orientation of the buildings at an acute angle to the prevailing winds. The area has two prevailing winds that play decisive role in the design of buildings. These are the dust laden North-east winds from the Sahara desert and the moisture laden South-west monsoon winds from the Atlantic Ocean. The usual orientation of buildings in the area as informed by indigenous knowledge is on east-west axis with the Doorway and the small highly placed openings facing the western direction. As stated earlier in this study, other directions are resorted to only when this is not possible. Building oriented at right angles to a strong prevailing wind suffer greater damage and challenges than those oriented at acute angles to the axis of the prevailing winds.[17] Most particularly the openings like doors and windows, dust and rain water will periodically disturb the comfort of the dwellers.

An important factor that is usually considered in the erection of an environment friendly building is the direction of sun light and heat. This is more important in the tropics like the Rima Basin area, where the direct heat of the sun descends on the environment. Therefore to counter the influence of the sun rays and heat, windows are punched at a very high position on the load bearing wall and the openings were constructed small to minimise sun glare and also the entry of the hot outside air into the interior of the room. The positioning of window openings to the western side is meant to ensure that, by the time sun glare get into the room, the sun is already setting, and its heat is waning.

To further create comfortable interiors shielded from the scorching heat of the sun, massive mud walls and roof structures were constructed. Mud is a dense (heavy weight) material and has a low rate of thermal conductivity. It absorbs heat slowly in the afternoon, thus providing cool interiors on hot days, while it dissipates the heat slowly in the nights resulting in warm interiors in cold nights.[18] It has been reported that, warmth takes almost 12 hours to work its way through a 300mm thick and wall. The sun's warmth will reach the interiors of the house during the cold hours of the night.[19] Zami and Lee have beautifully summarised the relationship between earth walls and the changing climatic condition of the tropics, 'Earth construction provides excellent heat insulation, so the ulterior space is cooler in summer and hotter in winter than a building made of conventional building materials such as concrete and brick''.[20]

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Similar observations were made by Umar when he argued that:
Mud bricks has 65% thermal comfort satisfaction despite the seasonal variation of summer and winter periods, whereas cement have less than 50% thermal comfort satisfaction in both two seasons hence the occupants has to supplement or complement with artificial system of cooling or heating system.[21]

Artificial cooling or heating is however expensive considering the inadequate supply of public electricity in the area. To obtain constant and regular supply of electricity involves the use of power generators with high cost of fuelling and maintenance. The generators also release dangerous gases to the environment. Moreover, earthen roofs resist wind pressure something that is often very high during the rainy season and the Harmattan periods. It is a common scene that strong winds cause destructions, tearing zinc and aluminum roofs off buildings and in some cases pulling down Cement block walls.

Similarly, vegetal walls and roofs exhibit the qualities of checking the transmission of heat through radiation into the structure. It allows for inflow and outflow of air, thereby providing comfortable interiors. This is quite in contrast to the use of metal roofing sheets, which are apart from the expense, very good conductors of heat, and create hot interiors in the afternoon, while morning and evening are very cold and draughty during the cold season.[22] However, a major shortcoming of building in vegetal materials is high combustibility and termite-penetration. As mentioned earlier in this study, the use of some methods from other parts of the world and of course some modern techniques have been shown to mitigate these problems.

Mud walls are good noise absorbent, which is quite a desirable quality in house design.[23] It also provides adequate security from fired bullets and arrows.[24] To achieve similar results using modern cement blocks, a three horizontal row of blocks with cardboard sheets inserted in-between the rows of building blocks were built into the wall, and the building is extended to at least the average human height.[25] The cost involved in this solution could explain why it was not popular and today virtually non-existent.

Because of the hot climatic condition in the Rima basin, in indigenous building design, a compound usually consists of separate buildings allowing for the unobstructed free flow of air in the house. The cooking area is separated from the living and sleeping areas because of the heat generated. This is in contrast to the modern designs of placing all rooms under one roof, thereby creating a hot environment requiring artificial cooling.[26]

Moreover, indigenous building designs provided that, in buildings for human habitation, the toilet is placed far away from the living rooms. This is an environment friendly design as it minimises contact with the unpleasant odours and health hazards associated with sewage. It is also the simplest and cheapest method of sanitation,[27] most particularly in our area, where adequate supply of water to the inhabitants is still a mirage.

Another significant feature of an environment friendly building design in domestic buildings is that, houses are built around a courtyard. In a hot dry climate as obtained in the Rima basin, a central courtyard could provide a cool refuge when the heat of the day penetrated the fabric of the rooms in the house. During evening times when the sun moves to the west, the walls provided shaded environment for human activities. A tree is usually planted or a corn stalk shed erected inside the house to provide necessary shading. During the hot season, when even

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the nights are hot, the courtyard provided a secured place for outdoor sleeping for comfort and as a way of avoiding heat related diseases.[28]

The colour and texture of mud walls make it compatible with the yellowish-brown dust brought in by the North-easterly winds to the environment. Bright coloured painted walls are easily stained and defaced by the dust, requiring constant dusting to maintain the brightness.Despite the advantages of naturally available building materials in the construction of environment friendly buildings as stated in the above lines, one of their greatest limitations is their low resistance to wear and tear and less durable, calling for frequent repairs and maintenance. Earthen materials are easily washed away by the torrential and incessant rains of the Malka period (around August when the rainy season is at its peak) while the wooden and thatch materials are destroyed by the ants that are part of the eco-system of the area. It is to address this limitation that the paper advocated for an intermediary approach through the employment of some recent researches and discoveries by government agencies in Nigeria and some International research centres concerned with improving the material strength of indigenous building materials. The adoption of this strategy will result in the production of a medium product which retains the indigenous building materials as their core while accommodating some other materials to improve the general material strength of the building materials for a more durable, affordable and environment friendly buildings.[29]

Stabilization of indigenous building materials

Indigenous Hausa masons in the area have since very early times noted the limitations of their working materials leading to the invention or adoption of a number of precautions to prevent excessive deterioration. Some of the very popular methods of improving the strength properties of mud employed by indigenous masons are the addition of grasses, cow dung, soil from termite moulds, Earth worm cast, corn husk, *Makuba(*empty pods of locust beans Tree) solution among others.[30] To protect the load bearing walls from the direct action of rainfall, wide eaves were created (over hanging edges of the roof), and in some cases, the wall surface is smeared with water repellent materials such as *Makuba* (empty pods of *parkia biglobosa*) *Bagaruwa* (*acacia arabica)* and *Loda* (*Rogeria adeno plylla)* solutions among others.[31]

The concern over the high cost of modern building materials spurred some local and international agencies and scholars into serious researches with the aim of improving the material strength of the readily available building materials.[32] Such institutions included the National Construction Building and Road Research Institute (NCBRRI), Nigerian Building and Road Research Institute (NBRRI), the raw material research and development council(RMDC) established by the Nigerian government, the centre for earth construction technology (CETECH) Jos established by NNCMM in conjunction with the French embassy opened in Jos in 1992, to promote earth building technology and help realize the government vision of housing for-all by the year 2000. Some international agencies established to conduct researches and provide training on improved earth building materials included CRA Terre-EAG the international centre for Earth construction established in 1979 the Auroville Building centre/Earth unit established in 1989 but later in 2004 became transformed into Auroville Earth Institute.[33] These institutions and agencies have succeeded in coming up with methods often referred to as stabilization.

The purpose of soil stabilization is to make it less pervious less compressible or stronger.[34]Spence and Cook have identified three broad methods of stabilization which include

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stabilization by mechanical compaction, stabilization by the addition of binders and stabilization by adding water proofs[35]. The cheapest and most widely method used by indigenous masons is the mixing of *Parkia biglobosa* pods solution (*Makuba*) with laterite in a required proportion to serve as a binding agent. This is done to the mud for plastering as well as in the process of moulding blocks. The *parkia biglobosa* solution contains some substances with gummy characteristics that improve the natural durability and strength characteristics of soils. Research experiments carried out by Abubakar has shown that Makuba-laterite bricks at 8%,10% and 12% stabilization produces a compressive strength that falls within the recommended dry compressive strengths requirements of the federal ministry of works and housing and those of the British standards (i.e. Minimum compressive strength of 2.10N/MM^2 and 3.50N/MM^2 respectively)[36] Similarly, soil stabilization with rice husk ash has been shown to produce a very impressive individual and average compressive strength. The high silica content of the ash reduces the danger of swell and linear shrinkage of soil which results to cracking.[37]

Furthermore, another important stabilizing agent that is also naturally available is lime. Lime has high water retention capacity and strong bonding. It strengthens earth greatly when it reacts with the clay content. Stabilisation with lime is better with earth of high clay content.[3839]
A very popular and efficient stabilizing agent is cement. Abdullahi has shown that, cement mixed with laterite at the ratio 1:6 produces a very good result of an average compressive strength of 4.76N/MM^2.[40] However, research findings by the Nigerian building and road research institute (NBRRI) have shown that 4 percent cement addition is sufficient to achieve excellent stabilization.[41] Cement stabilization for earth meant for moulding of building blocks manually or with machine or wall plastering is widely used in the area.

Another common use of cement to strengthen mud walls is the practice of plastering the walls with cement screed. However, the problem of building between cement and mud wall due to differential curing, and subsequent expansion and contraction, made this solution a temporary one. Abdul Razak argued that, even in the best of cases, this solution rarely exceeds ten years.[42] It was to address this weakness that some master masons have devised a technique of mixing cement and some quantity of earth to create a rough surface plaster. This is believed to last longer than ordinary sand-cement plaster.[43] More modern methods involve the use of wire netting nailed on the wall before the cement-sand plaster is applied. This is considered an effective solution to the peeling of mud wall cement sand plaster.[44]

Bitumen is also used for earth stabilization. It increases the tensile strength, pressure resistance and water proofing properties of earthen walls. It also improves its thermal qualities of low heat conductivity. In block preparation, it confers extreme internal dryness in the blocks thereby enhancing its durability.[45] It is for these properties that mud roofs and Granary walls are often smeared with this material.

Moreover, to enhance the strength properties of grass and straw used in indigenous building, an application of mud plaster consisting of clayey soil and bitumen on both sides of a thatch roof or a corn stalk fence has been found to reduce the risk of fire hazards and improves durability.[46]. This solution has been in use for centuries in such places as Cutch, Sind and Baluchistan all in India.[47] Moreover, Thatch board or mat is made by binding together pre-cut length of thatch with galvanised wire at the desired thickness and then used, and can be impregnated with fire resistant and preservative chemicals.[48] For example, a research

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conducted by the Niger State housing corporation, has shown that, an application of Duldrex 20 emulsion diluted with water at the rate of one litre of the emulsion to sixty litres of water, using a spray gun, and could protect the thatch component of building from the activities of termites.[49]

Furthermore, the use of some fabricated machines in the moulding of the building blocks is known to have produced wonderful results in the compaction and the material strength of the blocks. The first manual press (the Cinvaram) for earth building materials was developed in the 1950's after the inauguration of a research programme for affordable Housing in Colombia.[50] In Nigeria the Nigerian building and Road Research Institute (NBRRI) produced simple machines for block making manually or hydraulically operated presses for stabilized blocks. The manual presses operate with a compaction of not less than $3N/mm^2$. A number of machines have been developed around the world for improving the compressive strength of earth building materials; these included the Auram press developed in India and the Hydraform machine manufactured in South Africa.

The usual method for the production of the block is that the earth stabilized or raw is slightly moistured poured into a steel press (with or without a stabilizer) and then compressed with a manual or motorized press. They are then dried and used like common blocks. However, those stabilized with cement needs to be cured for some time before use[51].

Some government agencies in the Nigerian area of the Rima Basin have experimented the use of stabilized earth block building machines, with a very fascinating result. For example, the Sokoto state Government at the beginning of the 21stcentury procured the Hydraform block building machines which were used by the Sokoto state Housing Corporation in the moulding of earth blocks stabilized with cement used in the building of a housing estate in Arkilla area of Sokoto City. But the fact that the results of these experiments were not popularized could explain why its use stopped only with the initial government projects and made no impact on the development of the building industry.

CONCLUSION

The paper argued that, it is only through the design and development of an appropriate building taking into cognizance of the readily available building materials and the various environmental elements (Temperature , Wind and Rains) acting on the building structure could a conducive and comfortable building that is environmentally friendly be erected. This will lead to a substantial reduction in the cost of providing the desired environmental comfort through the use of mechanically controlled measures like air conditioners, heaters, extractive fans, among others, as well as protect the environment, the lives of the inhabitants and also ensure that future generations have adequate resource base to meet their needs.

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