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SUSTAINABLE DESIGN STRATEGIES AND BUILDING MATERIALS: THE NEXUS.

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ABSTRACT

Man has always tried to shelter himself from elements of weather, using building materials within his immediate environment. Consequently, houses were built using earth to produce adobe or compressed earth block and bricks for walls. Other materials used for walls as well as roofing materials include woods, bamboo, thatch and straws, anyhow he connects these materials to make comfortable shelter for himself is primarily his design. Research has shown that these local materials are biodegradable and has shown high level of sustainability. The recent trend in building design and the use of building materials shows that there is clear deviation from sustainable design and the use of sustainable materials. The aim of this paper is to establish a relationship between sustainable architectural designs and building a material. The objective is to highlight local building materials in Nigeria which have been found to be sustainable for improved awareness, understanding and practice. Results show that most local building materials are sustainable and should be encourage for use in construction processes. Data sources for this research include, review of related of literature, secondary data sources etc. this paper provides a proposition for professional in the building industry in terms of choice of materials in the face of lingering environmental issues.

Keywords: *Sustainable, Design Strategies, Building Materials*

INTRODUCTION

The selection of building materials which are sustainable is a sustainable design strategy and is performed both at an early stage of the design process (when general and strategic choices concerning the building are made) and at the working plan (when materials available on the market are selected). Design decisions regarding the selection of less environmental impact building components need careful consideration during the building design process. Careful building design and materials selection can substantially reduce environmental impacts(Kim & Rigdon, 1998).Achieving sustainable

architecture is not to limit the total amount of buildings, but to pay more attention to how sustainable building design and material selection can improve occupants' living condition(Yiming & Zhang, 2018).Many studies have confirmed that construction industry consumes the most energy and releases greenhouse gases. With the development of building technology and manufacturing process, the energy intensity of building materials has decreased, resulting in a significant reduction in energy consumption per unit area of production and manufacturing of building materials(Zhang, He, & Tang, 2015).The construction industry consumes about 24% of the world's raw materials and a large amount of energy(Bribian, Capilla, & Uson, 2011) conventional building materials, including steel, concrete, aluminum and glass, are all high energy materials. The building uses a variety of materials at different stages and the choice of materials used in a building will affect its life cycle performance in turn. Therefore, the designer's choice of raw materials during the design phase can play an important role in the life cycle impact of the building. Building materials have an impact on both the building and the natural environment throughout their life cycle. It is essential to select sustainable materials in the early stages of design, establish strategies for sustainable building materials and conduct market research. It is also suggested that the selection of materials will affect the overall performance of buildings, and sustainable building materials should be considered at an early stage from a life-cycle perspective(Esin, 2007.). The life cycle of building materials is from cradle to grave, which is closely related to the life stages prior to the use of the building, including the extraction of raw materials, the manufacturing and transportation process, and the maintenance and renovation requirements during building operation

LITERATURE REVIEW

Many research are attempting to solve the problem of material selection, there is no uniform definition of "sustainable building materials" Esin, (2007.)points out that sustainable building materials are materials related to resource and energy efficiency in the manufacturing process, and these materials should have little pollution and no negative impact on human health. Abeysundara, Babel, & Gheewala, (2009)develops an evaluation matrix to help decision makers balance environmental, economic and social factors in sustainable materials assessment; Anastaselos, Giama, & Papadopoulos, (2009.) takes environmental, economic and social aspects into consideration during the thermal insulation evaluation. Asif, Muneer, & Kelley, (2005) took Scottish dwellings as a prototype to analyze eight

types of building materials (wood, concrete, glass, aluminum, slate, ceramic tile, gypsum board, moisture barrier and mortar), and the results show that concrete contributes to the highest energy consumption (up to 61%) , and wood and ceramic tiles account for 14% and 15% of the total energy, respectively; meanwhile, the carbon dioxide emissions of concrete reach 99% of the total residential emissions.

It is also indicated that building materials with low initial construction energy consumption may not reduce the building's whole life cycle energy consumption(Utama & Gheewala, 2009.)For example, although using wood has a positive effect on reducing environmental impacts such as carbon dioxide, some studies show wood will eventually be incinerated or landfilled, and thus will lead to carbon dioxide emissions into the environment(Peuportier, 2001)In an LCA study in New Zealand by Mithraratne & Vale, (2004), three residential buildings of the same design were analyzed, but the materials used for the structures were different. The results revealed that the initial energy consumption of concrete structure and super thermal insulation building is higher than that of light structure (wood structure) by 8% and 14% respectively, but the whole life cycle energy consumption of concrete and super thermal insulation structure is lower than that of light structure by 5% and 31% respectively.

Even if the same raw materials are used, the material usage and the internal energy consumption are different through different processing methods(López-Mesa, Pitarch, Tomás, & Gallego, 2009) . At the same time, building materials with lower initial building energy consumption may not produce lower full life cycle energy consumption. For example, one study conducted LCA analysis on two seven-story residential buildings that also used concrete, but one case used cast-in-place concrete and the other case used precast concrete. Precast concrete slabs have an environmental impact of 12.2% less than cast-in-place concrete, as precast concrete slabs can achieve greater spans between beams, reducing the number of mains and foundations, and reducing the amount of concrete used in the building. In addition, methodologies such as the reuse of materials such as materials and ecological materials have recently attracted academic attention. Erlandsson & Levin, (2005)studied a new method of recycling materials and argued that if the basic functions are the same, then the strategy of reusing this material is better for the environment than building a new building. Some studies have reviewed the literature on the selection of existing building materials and proposed a simplified method for assessing

the environmental load associated with the selection of product materials, i.e., the materials are divided into glass, ceramics, non-ferrous metals, non-ferrous metals, paper, and polymers. And wood, bamboo, clay and durable, renewable materials as an alternative can also promote reuse techniques and methods and have proven to be sustainable.

Criteria for the selection of sustainable building materials

The design standards for sustainable building materials are mainly divided into the following aspects;

Firstly, sustainable building materials are often natural materials with low energy consumption and low maintenance costs, and should be easily dismantled and recyclable during demolition. The embodied energy consumption of building materials includes initial energy consumption and recurred energy consumption. The former is associated with the energy consumed in the construction phase, and the latter refers to the energy consumption required during the operation phase, including the processes of material replacement, repair and maintenance during the effective life cycle. However, the energy consumption of building materials is not only related to the embodied energy consumption of raw materials recycling and building materials processing, but also related to construction energy and transportation energy during on-site construction. The intensity of energy contained in building materials depends on energy, technology use and manufacturing processes, and will vary from region to region and from manufacturer to manufacturer. Low maintenance requirements could be achieved by the durability of design or repairing existing building materials to extend buildings' life cycle.

Secondly, sustainable materials should be environmentally friendly and reduce environmental hazards without releasing pollutants or other emissions that affect human health and comfort throughout the life cycle. Nowadays, indoor conditions have an important impact on the health, wellbeing and performance of users, as people often spend more than 90% of the time indoors(Frontczak & Wargocki, 2005) It is obvious from the research that building materials are an important factor in determining indoor air quality, among which formaldehyde and other volatile organic compounds (VOCs) released from building materials have serious adverse effects on human health, comfort and productivity (Li & Niu, 2005) Materials containing pollutants may have adverse effects throughout their life cycle, affecting workers during the production process, affecting the occupants of the building during the use phase, and causing pollution

during recycling and terminal treatment. Therefore, sustainable building materials are materials with low or no emissions of carcinogens, regenerating noxious substances or irritants, and have no negative impact on the building and the natural environment. In addition, sustainable building materials are mainly derived from renewable energy sources, not non-renewable energy sources. They should also be sustainable throughout their life cycle and use less energy in the manufacturing process.

Local Building Materials as Sustainable Building Materials

African traditional architecture is essentially sustainable and had evolved culturally to suit the people. Usually, earth, timber, straw, stone/rock and thatch were constructed together with the simplest of tools and methods to build simple, livable dwellings.(Onyegiri & Iwuagwu, 2016). Although globalization has consigned them as being 'primitive', this 'primitive' classification comes partially from the building materials and their relatively low technological uses when compared to present day western (Architectural) construction techniques which result in skyscrapers. Present interpretations of sustainability have given them a new status as likely technologies for the contemporary world. Along with the others that have been re-devised, earth has of late gained acknowledgement as a suitable technology for contemporary buildings. Earth/mud/adobe has been one of its most important and chief building material combined with timber (mostly from palm trunks), palm/coconut/grass thatch and straw bales as roofing; all materials abundantly available in the settlements. In entirety, Africa's traditional architecture made certain that its use of the resources neither diminished their availability, nor adversely affected the ecological balance upon which it relied on as an agrarian society.

MATERIALS AND METHODS.

Information for this came mostly from secondary sources, which were largely obtained from the extensive review of the existing literature on sustainable building materials and other related areas within the scope of study. These include; books, articles, journals, and web information. Other information also came from primary sources mostly interviews from professional in the built industry.

Presentation.

Bamboo as a Building Material for Sustainable design.

Bamboo is a building material that is readily available in Nigeria but has not been properly utilized as established by various researches (American

Bamboo Society., 2002 ,Cleaver, 1993).Raw Materials Research and Development Council , (2004.) (RMRDC), described bamboo as a widely available and distributed material for building construction in the Southern and Middle belt regions of Nigeria. According to the report, the distribution of bamboo in Nigeria is associated with the ecological conditions of the rainforest areas having the most abundant rainfall. The distribution pattern indicates that bamboo is particularly adapted to the rainforest belt of Nigeria where it is found in abundance due to the high mean annual rainfall and length of the rainy season. According to Aribisala, (1993), the Southern parts of Nigeria has the highest mean annual rainfall, which is more than 1000mm as compared to the North-Central zone which has a mean annual rainfall of between 600-1000mm. The North-Western and the North-Eastern zone of the country have a mean annual rainfall of between 400-600mm.Taraba State in the North-Western region of Nigeria has a sub-temperate climate which makes available in the state because of this climate (RMRDC, 2004).

Bamboo is commonly available in almost all the states of Southern region of Nigeria except for Bayelsa State and Lagos State where the distribution is considered to be relatively low. The states with the abundance of bamboo occurrence are identified to be Abia, Anambra, Akwa Ibom, Cross River, Delta, Edo, Ebonyi, Enugu, Imo, Ogun, Oyo, Osun, Ondo, and Rivers States. Also, the report of RMRDC (2004) indicates that at least ten (10) per cent of the natural vegetation in these states is dominated by bamboo, with the existing bamboo clumps showing substantial gregarious growth that is continuous over large areas. In states like Bayelsa, Benue, Ekiti, Kogi, Kwara, Lagos and Nassarawa States, the distribution of bamboo was observed to be frequent; indicating that between six (6) to nine (9) per cent of the natural vegetation is occupied by bamboo. Several bamboo clumps were also reported in Niger, Plateau and Taraba States as well as within the Federal Capital Territory (FCT). However, there are 12 North-Western and North-Eastern states where the bamboo occurrence is rare. These states include Adamawa, Bauchi, Borno, Gombe, Kano, Kaduna, Katsina, Kebbi, Sokoto, Jigawa, Yobe, and Zamfara State.

Bamboo is regarded as a sustainable and renewable building construction material which is harvested and replenished sustainably with virtually little or no impact on the environment. Bamboo has an embodied energy which is very low when compared to other construction materials like concrete, steel, and plastic. Bamboo also helps in controlling erosion and flooding as

well as controlling the local climates through photosynthesis. Bamboo as a crop is usually cultivated yearly such that only ripped and matured culms are harvested while younger ones are left to grow continuously. After harvesting the matured bamboo, the root system remains unharmed and healthy, which is still ready to yield more shoots, as is in the case of grass. Bamboos are also be regarded as a biodegradable material because its products can be incinerated or digested in sewage. Bamboo, as a building material, possesses high flexibility, strength, and versatility. This favorable characteristics of bamboos make it a suitable building material for practically every part of a building (i.e., foundation, flooring, walls, and roofs) when treated and appropriately used. It also has different use within the building construction industry due to its favorable advantages of easy availability, low cost, and high strength. It can be used to replace conventional and relatively scarce materials such as mild steel and galvanized steel mesh, or various fibres like asbestos in reinforcing cementitious materials. Bamboo is also light in weight but yet a sturdy building material which is usually used for building construction after treatment against fungi and insect infestation. It has the property of a hardwood, which is both light and exceptionally tough. Bamboo structures are usually lightweight, flexible, durable, and have some form of resistance against natural disasters like earthquakes.

Bamboos also have the economic advantage of being among the cheapest building materials in addition to other technical advantages of use as a sustainable construction material. Other significant advantage of bamboo as a sustainable building construction material includes prefabrication, easy assembly, and easy replacement of structural parts. Its elements can be easily dismantled and reused, making it a sustainable building material. Bamboos are also used for fences, bridges, and scaffolding. They can be used to reinforce cement concrete flexural and compression members, as well as soil-cement elements. As the case of other vegetable fibres, bamboo fibre could also be used as a substitute for steel reinforcing rods in concrete construction to reinforce cement concretes and mortars. The process is such that meshes made of bamboo splints are used to reinforce cement mortar and obtain thin, fibre-cement-like material.

Uses of Bamboo as a building Material

Sakaray, Togati, & Reddy, (2012) and Salzer, Wallbaum, Lopez, & Kouyoumji, (2016) has ascribed the use of bamboo for building construction to be diverse, but presently, only a part of temporary

structures or buildings in rural and urban areas utilize the use of bamboo for construction in Nigeria. This use does not exploit the full potential of bamboo as a sustainable building material. Hence, other significant uses of bamboo that can be explored in the building construction industry include;

i. Foundations: The use of bamboo has been limited for the foundation purpose mainly because bamboos deteriorates and decay quickly when in contact with the damp ground. However, despite this disadvantage of deterioration, the use of bamboos for foundation or supporting posts in buildings is possible when treated with some effective preservatives and built on raised platforms. The different construction processes of bamboo foundations include:

a)Bamboo in direct contact with the ground: Bamboos are placed on either the ground surface or buried to the ground. Bamboo with nodes that are closely spaced having large diameters and thick sections are used to achieve the best strength and stability. In the absence of this, smaller sections of bamboos can be tied together and preservatives applied to reduce the process of deterioration that usually occurs between 6 to 24 months.

b)Bamboo on concrete footings or rocks: The stiffest and largest sections of bamboos are used for bearings and are placed on footings of either rock or preformed concrete without direct contact with the ground.

c)Bamboo integrated into concrete footings: The poles of bamboo are directly placed into concrete footing which can take the form of a single post or strip footings.

d)Composite bamboo/concrete columns: A bamboo with a post that is integral and durable is achievable through the use of a concrete extension to the bamboo by using a plastic tube with the same diameter of the bamboo.

e) Bamboo piles: Bamboo piles are used to reduce settlements of building and stabilize soft soils. This is done through the use of bamboo poles that are split into sections and treated by filling them with coconut coir strands wrapped with jute and tied with wire. Sandy materials are used to cover the area after installation of the piles.

ii. Floors Bamboo can be used as a building material for flooring due to its wear and tear resistance as well as the resilience properties it possesses. The floor covering is done using bamboo boards, mats, etc. employing wire to the frame. The various construction processes of bamboo flooring include:

a)Small bamboo culms: Bamboo culms are directly tied and nailed together.

b)Split bamboo: Bamboo culms are spitted into strips of several centimeters wide along their length

c) Flattened bamboo: They are produced by splitting bamboo culms and removing the diaphragms, then rolling and flattening the bamboo culms so that the resulting board is laid and fixed by nailing or tying them across the joists. After that, they are screeded with cement mortar to make it easy to clean.

d) Bamboo mats: Thin strips of bamboo which vary in size between 5-6mm or 10-15mm and thickness between 0.6-1.2mm are woven into mats of different sizes according to construction demand and specification.

e)Bamboo plastic composites: It is an innovative bamboo flooring technology which combines bamboo fibre and plastic as a core material for flooring. It has the advantage of higher water resistivity and dimensional stability than other types of bamboo floorings.

iii. Walls and Partitions: The most common use of bamboo for building construction is for the walls and partitions. Bamboo as a building element is used for columns and beams, which generally constitute the structural framework. They are used to carry the self-weight of building and the imposed loads exerted by the building occupants. An infill between framing members is necessary to protect the wall against rain, wind, and also to offer privacy. The infill in-wall aims to provide in-plane bracing and ensure the overall stability of the overall structure when subjected to horizontal forces.

iv. Doors and windows: Bamboo is also used for doors and windows in buildings. The use of bamboo frames usually replaces the conventional timber frames often used for doors. Bamboo mat shutters are then fixed to the bamboo frame to serve as the door when hinged to the wall. Also, Small bamboo frame can be used to serve as windows when hinged to the top of a wall.

v. Scaffolding: The use of bamboo has for scaffolding has been in existence for centuries in Asian countries like China and Hong Kong and, despite competition with many metal-scaffolding systems; it remains one of the most preferred systems(Fu, 1993) Also, due to the low construction cost of bamboo and its high adaptability, it can be constructed any layout to follow various irregular architectural features of a building within a relatively short period (Chung & Siu, 2002).They are used in construction sites in Nigeria to provide temporary access, working platforms for site workers and supervisory staff, and to prevent

construction debris from falling onto passers-by. They are either used as Single Layered Bamboo Scaffolds (SLBS) for light work or a Double Layered Bamboo Scaffolds (DLBS) for heavy work. Therefore for Bamboo scaffolding like any other, scaffolding must be laterally stable and must possess integrity.

vi. Trusses One prominent use of bamboo for building construction is the fabrication of roof trusses. Bamboo has a high strength/weight ratio, which makes it an excellent material for roof framing. Achieving any span of truss is possible with bamboo because of its lightweight property alongside its strength and stiffness. The use of bamboo for trusses also results in considerable savings due to the non-use of heavy lifting equipment.

vii. Roofing: The roof of buildings serves as protection against weather of varying conditions including sun, rain, and wind, and also functions as a shelter for the usable space underneath the roof canopy. The roof should be able to withstand the tremendous forces generated by wind and roof coverings. This makes bamboo a suitable roofing material because of its lightweight and durability. The structure of the bamboo roof can be made of bamboo trusses, rafters, and purlins.

Other uses of bamboo for building construction include:

i. Disaster Mitigation: The lightness and availability of bamboo abundantly as well as the possibility of using bamboo to construct shelters from modular units lead to its use for post-disaster shelter construction. An example is a project by the UNHCR in which temporary shelters are fabricated from A-shaped bamboo frames and supported with horizontal members at the apex and mid-height of the A-shaped frame. A waterproof sheet is then used as draping over this frame for covering.

ii. Bridges Bamboo materials are also used for the construction of bridges. The bamboo used for such construction purposes requires specific constructional techniques, which limit vibration, bending, and twisting due to its property of being much more elastic than solid timber. Such bridges, when constructed with bamboo, are usually covered to reduce their exposure to severe weather conditions. According toJayanetti & Follet, (1998.) the various bamboo bridges construction consist of:

a. Footbridges: They are simple bamboo cross-braced frames with the walkway formed at the crutch. Bamboo lashings bind the culms of diameter between 50 to75mm. These bridges are suitable for rivers with sandy or muddy base where the height above bed does not exceed five (5) meters. A typical crossing of the bridge might be as long as 20m.

b. Handcart Bridge: The construction of this bridge is more elaborate, having abutments and pilings. These abutments are formed from pairs of

culms of bamboo that are staked to the ground while the bridge assembling is stabilized by horizontal culms which form the pile cap and diagonal braces. Three longitudinal bamboo beams of 100mm diameter which are lashed to the caps and tied together at the Centre of each bay with a cross-member are used to form the roadway.

Plate 1: showing bamboo as a building material for construction. (source:www. Archdaily.com)

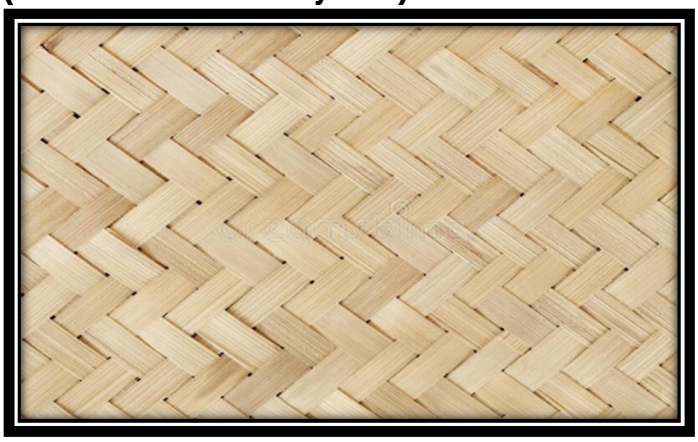

Plate 2: showing bamboo used for floor mats. (source:www. Archdaily.com)

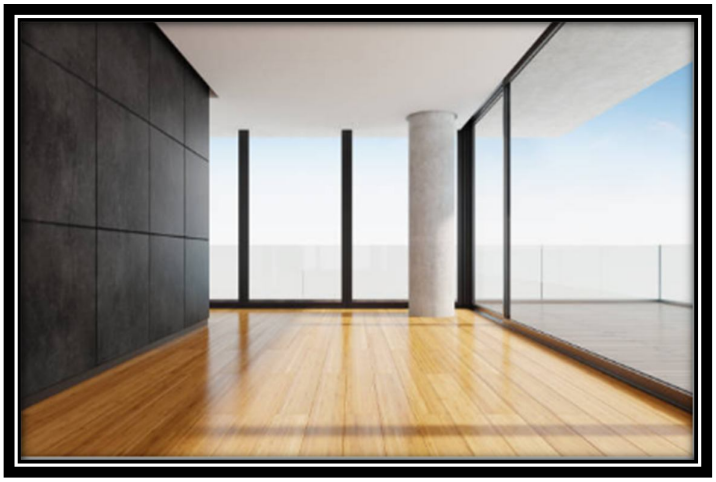

Plate 3: showing bamboo as a prcessed building material used as floor finish.
(source:www. Archdaily.com)

Clay as a Building Material for Sustainable design.

Clay earth is an economical structure material that has been utilized by people on the planet for quite a long time. It is not difficult to unearth from the beginning little preparing is required, which implies that energy and tedious cycles is decreased. Clay can be made Mud blocks, clay bricks, rooftop, floor tiles and clean apparatuses are made of the normal mixes of clay and water in close by creation plants and utilized locally. That maintains a strategic distance from long vehicle courses. They are flexible, energy proficient, tough, and stylish(Lake, 2012). Furthermore, it is utilized for protection to get a good deal on numerous conventional structure strategies. Saving expense on energy bill is additionally conceivable; given that structures will save more energy with clay as warmth separator(Lake, 2012).Satiated that clay structures don't utilize more power than required, this will permit homes to keep up their warmth throughout the cold weather months and keep up the agreeable temperatures throughout the mid-year months. Clay earth is perceived as an economical assurance building material since it gives amazing protection properties and warmth stockpiling limit, assists with lessening energy utilization in structures.

Clay earth building materials are healthy, stable and warmth protections. In this way, structures made of earth building items can last over 100 years' life expectancy. The earth block is inherently feasible and assists with limiting the inward temperature vacillation occasionally. They additionally have low encapsulated carbon, it thusly less harming than some other structural materials and gives low upkeep cost in the existence circle of structures.

Likewise, clay stores heat in the colder time of year and coolness in the late spring and contributes significantly to energy reserve funds. Low energy is needed for the readiness and handling, working with clay is harmless to the ecosystem in the assembled climate.

Clay building materials are sustainable and comply with numerous government rating and green buildings standards. Also, clay has excellent insulating properties because of its high thermal mass. It absorbs stores and releases heat very effectively, making the building interior cooler in summer and warmer in winter. This makes the internal environment more comfortable and also reduces energy demand and associated carbon emissions (Kefas, Patrick, & Chiroma, 2007).The three essentials properties of clay that make it different from other building materials are plasticity, porosity and verification.

Uses of Clay as a building Material

Utilization of clay as feasible structure material is turning into a need for building designers in the constructed environments, for tending to worldwide convenience in workplaces, private and different foundations, likewise clay is an essential fixing utilized in many structure procedures. Clay is utilized to make adobe, cob, string wood, smashed earth designs and building components, for example, clay mortar, clay, clay floor tiles and clay paints and clay earthenware production building materials. As structure material clay, have been utilized in development, since the earthman time. Dated back clay earth is utilized to make blocks, burnt bricks, tiles, clean and roofing materials. China clay, dominatingly kaolinite is utilized as filler and in drug fabricate. Extended clays are utilized as a lightweight total in the production of extended squares utilized for protection of environment. Clay has been utilized in the assembling of the accompanying building structures segments.(Umaru, Aliyu, Aris, & Munir, 2012)

1. Clay material and floor tiles: offer significant answers for energy reserve funds and diminish ozone harming substance discharges in the environmental area. Clay floor tiles are frequently called earthenware or porcelain tiles, produced using combinations that incorporate mud clay as a typical fixing, terminated in an oven and solidified. Mud floor tiles are coated, giving them an assortment of tones and a water-safe surface.

2. Heat Sinks and Stacks: Warmth sinks are intended to draw heat away from explicit regions to abstain from overheating. Since earth is heat safe

and can likewise move heat, mud floors are once in a while worked to go about as warmth sinks, drawing heat away from furnaces, stoves or different gadgets to forestall harm. Most smokestacks are worked of dirt blocks up to the rooftop level and afterward the stack polished off with red blocks; it was more normal for the whole chimney stack to have been worked of clay blocks on account of their solidarity, virtue of clay and capacity to withstand extraordinary warmth. Ball clay is altogether utilized as crude materials for sterile products, emergency clinic and latrine tiles due to its versatility, functionality and strength in case of fire state.

3. Plasters and Rendering: Clay mortars have been utilized broadly for structures in the Assembled Realm and without a doubt everywhere on the world for millennia. In spite of the fact that it isn't generally known, there are most likely over 1,000,000 structures with earth materials in their construction in the Assembled Realm, and a large number of these have mud mortars. All the time clay mortars are not perceived in light of the fact that they are painted or have a slight lime clay skim coat over them, both inside and remotely. Numerous dirt mortars are as yet performing great after numerous hundreds of years, both in vernacular structures and in higher status properties remembering their utilization for mouldings, elaborate safeguards, etc. Clay mortars have unmistakable and, from various perspectives, extraordinary characteristics which are very appropriate to noteworthy structure conditions for various reasons: breathability, adaptability, reversibility and tasteful characteristics(Su, Gu, & Yang, 2010.)

4. Clay as a Binder: Clay are widely used in construction as binders, also for castles, public and religious buildings, and monuments such as the 35-metre-high minaret of Tarim in Yemen and the long great of wall of China. Clay is used as wall binders. Although they have the limitation that they soften when wetted, they are also undoubtedly the cheapest binders, at sites(Berger, Singer, Bliss, & Moring, 2011).
Clay can also be used to form traditional earth blocks as evident in Francis Kere Gando design of the primary school in Burkinfaso were Local raw materials and basic tools were used.

Plate 4: showing the use of traditional earth block in Francis Kere's Design of a primary School in Burkinafaso- assembly area (source: www.archidigest.com)

Plate 5 : showing the use of traditional earth block in Francis Kere's Design of a primary School in Burkinafaso- Elevation.(source: www.archidigest.com)

Plate 6: showing the use of traditional earth block in Francis Kere's Design of a primary School in Burkinafaso- perspective view (source: www.archidigest.com)

Plate 7: showing the use of traditional earth block in Francis Kere's Design of a primary School in Burkinafaso- Approch.(source: www.archidigest.com)

Wood as a Building Material for Sustainable design.

Wood is a fibrous rigid material of plant origin. The word, timber, which is wood that is prepared for use in building construction, is sometimes used interchangeably with wood in our construction parlance. It is broadly classified as hardwood and softwood. Hardwood is derived from angiosperm or broad-leaved trees such as Iroko, Mahogany and Danta. Softwood is obtained from coniferous trees, which have needle-like leaves. Examples of softwood trees include Scots Pine, Norway spruce and Douglas fir. Timber has been used as a primary source of building material for ages in construction of building. The Raw Materials Research and Development Council of Nigeria, RMRDC, (1998) opined that the roof structure and ceiling noggins of most buildings are constructed with timber because of its workability and durability. Most wood with yellowish, appearance and very hard are used for door and window frames because of its natural resistance to insect attack. Timber is natural and renewable. It has a high strength to weight ratio and is easy to work with, making it especially useful even where only basic technology and procedures are available (Apu, 2003). According to Douglas, (1995.) timber remained the most predominant building material until the last half of 19th century. Today, proponents of timber as a building material perceive it as an

attractive building material while its opponents opine that it is unreliable for construction. However, Andreas, (2005) asserted that architects are only limited not by the material but their knowledge of how the material works.

One of the most important questions in environmental sciences is how we can continue improving human welfare within the limits of the earth's natural resources. A possible solution to this dilemma is sustainable development, a term popularized by '' Our Common Future'', the 1987 report of the World Commission on Environment, chaired by Norwegian Prime Minister Gro Harlem Brundtland (and consequently called the Brundtland Commission). In the words of this report, sustainable development means ''meeting the needs of the present without compromising the ability of the future generations to meet their own needs''(Cunninghan, 1997). This implies that, sustainable building material is the one that do not have much negative impact on the environment. It also means the utilization of resources available to the present generation without depriving the future generation of resources for their effective living.

Inherent in this definition is the aim of the concept which is to satisfy, social, environmental and economic goals of utilizing building material put into cognizance safety, health, efficient and productive life that is in harmony with nature. The concept of sustainability in its entire facet ecological, economic and social is vital. This involves amelioration of weather pattern and climate, provision of clean air, protection of biological diversity, protection of soil and food crops, carbon sequestration, provision of employment opportunity (poverty alleviation) and provision of recreational facilities.
According to Okereke, (2006.)a sustainable material should possess the following characteristics:
v) Easily available and affordable, preferably locally;
vi) Meet with the requirements as specified in National Standards; in terms of durability and maintainability;
vii) Should be environmental friendly and should not constitute any health hazard;
viii) Should be versatile in usage, that is, it could be used for different purposes (as walling materials, flooring, etc.). It is obvious that timber has these qualities.

Timber apart from its warmth creates a welcoming environment and also blends naturally with nature while at the same time creating an authentic appeal that most other materials do not have. Wood is also a natural product that degrades after its life cycle without much impact on the environment. The strength and durability of wood is evident in many heritage buildings that can be found worldwide.

CONCLUSION

The purpose of this study was to highlight how sustainable locally sourced building materials can be and the importance of their selection and incorporation in building design by architects and professionals in the construction industry with growing environmental concerns. It's also important to note that with their obvious weaknesses the local materials can be improved to facilitate their consistent use in the construction industry.

RECOMMENDATION

Based on the extensive studies carried out, the following recommendations can serve a headway towards sustainable design and building materials.

1. Re-Engineering of local Building Materials:

Local building materials should be re-engineered to suit the present need of building materials, like the compressed earth block (CEB). this is an emerging alternative to adobe blocks and wattle and daub construction. Compressed earth blocks are a creative, re-engineering of the adobe brick. Unlike the native adobe block, which is a mixture of soil, water and distinct cultural additives moulded to desired shape with the hand, the compressed earth block is supplemented in very small amounts (in most cases less than 10%) with either cement or lime component in its blending process. The blend is not worked to achieve a plastic state, but simply blended until the cement/lime and soil are thoroughly mixed. Afterwards, the mixture either machine pressed or placed in a mould and compacted with a high level of pressure applied through a hand- operated machine. After aeration, the CEBs gain a high compressive strength appropriate generally for three floors constructions but higher potentials can also be attained for up to five floors constructions(Maini, 1999) CEB construction is more durable than wattle and daub, and is also accepted as a more refined construction method than wattle and daub.

2. Combination with Modern Building Materials:

There should be combination of conventional building materials with traditional African building materials to add to their strength and durability.

One of the disadvantages is strength, but that notwithstanding, in high rise buildings CEB could be used for the walling system not minding the height of the building while the conventional materials would be used for the foundation, reinforcement etcetera.

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