International Journal of Civil Engineering, Construction and Estate Management

Vol.1,No.2,pp. 39-46,September 2014

Published by European Centre for Research Training and Development UK (www.eajournals.org)

AN ASSESSMENT OF TIMBER AS A SUSTAINABLE BUILDING MATERIAL IN NIGERIA

[1]Abimaje, J. and [2]BABA, Adams Ndalai

[D]epartment of Architecture,

[D]epartment of Urban and Regional Planning, Federal Polytechnic, Idah, Nigeria.

ABSTRACT*: Timber, as a building material, was assessed for its sustainability using data from secondary sources. It established that a sustainable building material must be environmental friendly, affordable, flexible in usage and durable. Timber possesses these characteristics. The paper thus compared fuel energy required to produce timber as well as carbon dioxide released and stored during production with other common building materials such as steel, concrete and aluminium. It observed that 750 MJ/m^3, 26600MJ/m^3, 4800MJ/m^3 and 1100000 MJ/m^3 of fossil fuel energy is required to produce Rough Sawn Timber, Steel, Concrete and Aluminium respectively. The work revealed that timber stores as much as 250 Kg/m^3 of carbon dioxide (CO_2) and releases only 15Kg/m^3 into the atmosphere. In contrast, Steel, Concrete and Aluminium store no carbon dioxide while they release 5320 Kg/m^3, 120Kg/m^3 and 22000 Kg/m^3 respectively into the atmosphere. Additionally plants, the primary source of timber, absorb carbon dioxide and release oxygen into the atmosphere during photosynthesis with a comparatively low thermal conductivity advantage. The paper consequently concluded that since timber is readily available in the country, it is a highly sustainable building material in the nation. It posited that the problems associated with the usage of wood, such as attack by insects, fungi, fire, depletion of natural resources etc can be ameliorated with the aid of preservative treatments, fire retardant and afforestation.*

KEYWORDS*:* Assessment, Timber, Sustainable, Embodied Energy, Building Material, Nigeria.

INTRODUCTION

Timber 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. Opepe (*Nauclea diderrichii*), a yellowish, very hard timber is 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.

Statement of the Problem

A building requires assembling different materials through the process of construction. Some of these materials include concrete, timber (wood), steel and glass and so on. Energy is involved in the extraction of these raw materials, their processing and transportation from the factory to the construction site and their eventual placement. In most of the developing countries, Nigeria inclusive, there is a general dependence on fossil fuel for energy generation for these processes. This results in the emission of greenhouse gases such as carbon dioxide, sulphur dioxide, methane etc in the atmosphere resulting in the depletion of ozone layer thus causing global warming and by extension, climate change.

Some building materials such as steel, glass, concrete are manufactured from raw materials that their replacement require geological years while tree is continually being fell for construction work without due consideration for afforestation, consequently the nature is over exploited resulting in environmental degradation, desertification, desert encroachment and imbalance in the ecosystem. Fewer trees mean more carbon dioxide in the atmosphere since plants absorb carbon dioxide and release oxygen into the atmosphere during photosynthesis. This has engendered the need to investigate the potentials of building materials that are comparatively sustainable, hence the topic ‘’an assessment of Timber as a Sustainable Building Material in Nigeria’’.

Aim and Objectives

This paper aims at assessing the potentials of timber as a building material in Nigeria with a view to determining its comparative sustainability against other commonly used building materials.

To achieve the above aim, the study objectives are to:

i) Investigate the qualities of timber as a building material
ii) Examine the challenges of timber as a building material.
iii) Investigate the sustainability of timber as a building material.
iv) To advance recommendations that will enhance the sustainability of timber as a building material in Nigeria.

QUALITIES OF TIMBER AS A BUILDING MATERIAL

The qualities of timber as a building material include availability, physical and aesthetic qualities, workability and versatility, environmental sustainability, flexibility of space arrangement, dry construction, industrial production and comparative cost effectiveness (Gregory, 1984; Nolan, 1994 and Whitelaw, 1990).

i, Availability and Acceptability

Timber is locally available in Nigeria. It can be purchased from local suppliers and transported to site using even small vehicles. Timber is accepted as an attractive building material in most cultures.

ii, Physical and Aesthetic Qualities

Timber has a high strength to weight ratio making it an attractive framing material. Some species are highly resistant to rot. Timber withstands humidity with less structural change than other building materials. It is very durable and there are numerous finishes available to protect and enhance the natural beauty of the material. These sealants and protective finishes promote

its durability. If well protected and well installed, timber can last for centuries with minimum maintenance (Sturges, 1991). Timber is more fire resistant than bare steel, as charring forms an insulating layer that protects the inner core of the material. Heavy timber construction is less prone to damage by short-term high temperatures allowing for a longer period for evacuation in case of fire.

iii, Workability and Versatility

Timber can easily be shaped by simple hand tools. It can be cut, planed and chiselled. There are many ways to connect timber to timber or to other materials since timber can easily be secured or fastened with nail, screws, bolts and other connectors. There are many design options possible with wood that are not practical with inorganic materials such as concrete or steel. The design performance required by a particular building application can be more flexibly matched by selecting timber of the appropriate density, compressive and tensile strength, colour, texture and fire resistance (Anderson, 1970).

iv, Environmental Sustainability

Environmental sustainability recognises that human activity over time and the health of the environment are interdependent and that environmental health has necessary social, political and economic determinants. Probably the most significant environmental benefit of timber is its renewability and biodegradability (Resource Assessment Commission, RAC, 1991). It has low manufacturing process energy and benign air emissions (Townsend and Wagner, 2000). Timber is an excellent insulator against hot or cold weather. The old ‘’log-house’’ remains a model for minimum energy consumption in buildings (Ogunsote, 1993).

V, Flexibility of Space Arrangement

Partitions made from timber can easily be moved around to change layout in response to new functional requirements.

Vii, Dry Construction

Unlike concrete floors, timber floors do not require a curing period before achieving maximum strength. Construction is therefore faster. Finishing is also faster, since timber walls can be painted immediately, unlike plastered walls which require several days to dry.

Viii, Industrial Production

Timber is especially well suited for mass production. Standard components such as doors, windows, boards for walling construction, floor, ceiling and roof tiles as well as skirting can be purchased in standard sizes.

ix, Comparative Cost Effectiveness

The local availability of high quality wood and the abundance of local millers make timber production less dependent on imports. Prices are relatively stable, since they are less influenced by the volatile foreign currency exchange market. This gives timber a cost-comparative advantage over other materials that have high import content.

CHALLENGES OF TIMBER AS A BUILDING MATERIAL

No building material exists without its challenges; however, the limitations posed by these materials exist only in relation to subsisting level of knowledge, creativity and technology. Materials must be studied and scientifically explored. With the advancement in technology, new applications and potentials of materials are emerging. This is corroborated by Andreas (2005) that ‘’There is no law, no principle, based on past practice, which may not be overthrown in a moment, by the arising of a new condition, or the invention of a new materials.

i. Fire

The greatest challenge of wood as a structural material has been fire. Studies have shown that wood as a building material is the only material that insulates itself after the initial charring.

Studies have shown that when timber burns, it gets momentarily protected by its own charring, which creates an insulating charcoal layer that reduces the speed of spread of fire. This means that a timber structure, if well designed, will remain capable of carrying the load it has been designed for, even when exposed to fire for a reasonable time for evacuation.

However, the best control in timber building as with other buildings is prevention in the first place and the use of fire rated timber in places that are susceptible to fire outbreak.

ii. Weathering and Decay

Another factor that affects timber is weathering and decay. Timber decay arises from fungal attack in combination with excessive moisture, while weathering occurs as a result of chemical and light reactions (William, 1983).These effects of weathering can be prevented through the application of coatings on the surface of the timber. The choice of coating is dependent upon what is expected to be achieved. Coatings are classified into two; there are those that form a thin layer or coating on the surface of the timber while the second type provides protection through penetration without leaving any coating. However, the protective benefits of all coatings also depend on proper maintenance of the coating. No coating will last indefinitely and all need to be periodically reapplied.

iii,Termite Infestation

Termite control is of very high importance; however, the likelihood of termite encroaching into a dwelling is not dependent upon the type of frame used in construction. All that needs to be done is a simple adherence to some basic principles of maintenance. Some of the processes involved in controlling termite infestation are Suppression, Site Management, Soil Barriers and choice of foundation.

a, Suppression

This involves the systematic location and destruction of colonies, the inspection of timber products to treat an infested area, the burning of infested lumber and heat treatment of reclaimed lumber.

b, Site Management

Site management is another avenue where termite infestation can be controlled. This can be achieved through the proper disposal of construction debris, pegs and concrete form works rather than burying them.

c, Chemical and Soil Barriers

Termite infestation can be controlled by the application of environmental friendly chemicals. Sharp sand laid along the foundation footing has been found to be a very strong barrier because they are too heavy for the termites to move and the spacing between them is too small for the termites to squeeze through.

d, Slab and Foundation Details

Foundation walls and slabs can be designed to inhibit their entering into the building. The detailing of the foundation with concrete cap will force termites to the surface where they can easily be detected. Foundations without the concrete cap allow easy and hidden boring of termites.

TIMBER AS A SUSTAINABLE BUILDING MATERIAL

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 Brundland 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,1992). 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 utilising building material put into cognizance safety, health, efficient and productive life that is in harmony with nature. The concept of sustainability in all its 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 posses the following characteristics:

v) Easily available and affordable, preferably locally;
vi) Meets 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. Wooden buildings like Norway's beautiful Stave Churches are still structurally sound and are still in use today, centuries after being built. Timber construction can therefore be seen as agents of green architecture. A green design reduces resource consumption both by ensuring that a structure lasts and that it can be easily adapted if necessary: The 19th century barn at Falling water in Pennsylvania is a great example (plate 1);even though the use has changed the structure was successfully adapted for the new use with little adjustment.

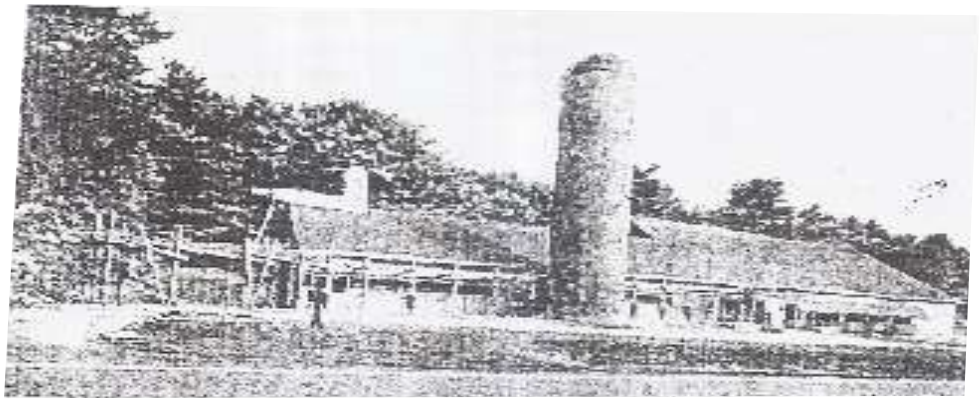

Plate 1. The barn at Pennsylvania built in 1870.
Source: Http://www:fallingwater.org/49/about-the-barn-at-fallingwater.

Wood structures require less energy to build and to operate, which reduces our reliance on fossil fuels. Wood can be recycled and renewed, again and again and only few other materials can match the unique combination of benefits; strength, affordability and environmental sustainability of wood.

The embodied energy of materials in buildings forms a significant component of the total life cycle energy consumption. This measures the total energy required to transform raw materials into ready- to- use building products. It is expressed in gigajoules per tonne (GJ/t) or megajoules per kilogram (MJ/kg). Embodied energy includes:

a) the energy required to obtain raw materials and to process them;
b) the energy used in transporting the material(at all stages); and
c) the energy used in construction.

The consumption of energy during each of the above stages can have similar environmental impacts to the consumption of energy in the operation of the building. Manufacturing of wood-based semi-finished and finished products also requires little energy.

The sustainability of timber can also be determined by comparing its impact on the environment with three other common building materials as presented by Ferguson *et al*.,(1996) and John(2003). From Table 1, rough sawn timber uses 750 MJ/m^3, steel uses 266000 MJ/m^3, concrete uses 4800 MJ/ m^3 and aluminium uses 1,100,000 MJ/m^3 of fossil fuel. When fossil fuel is burnt, greenhouse gases such as carbon dioxide, sulphur dioxide, carbon monoxide and methane are emitted into the atmosphere. They have negative impact on the environment. It is obvious from Table 1 that timber requires less fossil fuel to manufacture than steel, concrete and aluminium. Therefore, it is more environmental friendly or sustainable. Table 2 reveals that rough sawn timber releases 30 Kg/t of Carbon dioxide, while steel, concrete and Aluminium release 700Kg/t,50 Kg/t and 8700 Kg/t respectively. It also shows that rough sawn timber stores 250 Kg/m3 of Carbon dioxide while steel, concrete and aluminium do not store any. It obvious that timber releases the least and stores the highest amount of carbon dioxide during its manufacture, hence it releases less greenhouse gases into the atmosphere.
Table 3 shows thermal conductivity of some building materials. Fired clay has 1.0 $J/m^{-I}K^{-I}$, cement board 0.6 $J/m^{-I}k^{-I}$, limestone gravel 0.6 $J/m^{-I}k^{-I}$, concrete 1.4-2.9 $J/m^{-I}K^{-I}$, stone 1.5-3.0 $J/m^{-I}K^{-I}$, wood 0.05-0.0.15 $J/m^{-I}k^{-I}$ and steel 19.0-21.0J/m^{-I} k^{-I}. From this, it is apparent that timber buildings require much less insulation to retain their warmth. The greatest challenge of tropical regions is the excessive heat gains in buildings especially those built of concrete and steel. Thus, it will be of great advantage to explore this potential in timber in order to have energy savings in cooling houses. Table 3 shows that timber is better than stone in terms of resistance to heat flow and the same with concrete. When compared with steel, it is also resistant to heat flow. The resistance of heat flow found in timber can therefore be of great advantage as less energy will be required to cool the interior spaces of the dwellings.

CONCLUSION

Sustainable building materials are those that are environmental friendly, readily available, durable, maintainable and versatile in usage. Timber as a building material possesses all these qualities and performs better when compared with most other common building materials in Nigeria. Thus it is a sustainable building material.

RECOMMENDATIONS

This paper recommends that a good technical knowledge of timber is necessary for its application. The guiding factors in the choice of timber for a specific constructional work include detailed knowledge of the functions of the structural unit and the specific properties of timber in relation to functions of the structural unit.Adequate information on the magnitude of load, rate of loading and the duration of the load should be ascertained to enhance informed decision on the appropriate timber to be used.

Timber is also recommended due to its quality of environmental sustainability, physical and aesthetic qualities, workability, and flexibility of space arrangement, dry construction, industrial production and comparative cost effectiveness. In order to avoid biodegradation of timber members, possible failure and collapse of timber structure; it is necessary to subject timber to some prophylactic treatments. These may be inform of seasoning and application of chemical preservatives. Thorough seasoning of timber should be carried out to reduce instances of dimensional instability and distortion of timber structural member in service.

References

Anderson, L.O. (1970*). Wood-frame House Construction*. Us Department of Agriculture.

Andreas, F. (2005). Architectural forms of massive timber, 'structural forms and system,. Doctoral thesis presented at the Lulca University of Technology Sweden. (page v) (27). Sp External Scientific Publication.

Apu, S.S. (2003). Wood Structure and Construction Method for Low-cost Housing. *International Seminar/ Workshop on Building Materials for Low-Cost Housing, September 7-28*, Indonesia

Cunninghan, W.P. (1997). Environmental Science: A Global Concern (Fourth Edition) Barbara Woodworth Siaga, WCB McGaw Hill, Boston, Massachusetts, USA.

Douglas, W.M. (1995). America's Forest: A history of resiliency and recovery*: Forest Products Journal 45(10) 18-28*

Falling water about the barn, retrieved from http://www.fallingwater.org/49/about-the -barn-at falling water) on 24 February,2010. 5:12 pm.

Ferguson, I., La Fontarie, B., Vinden, P., Bren, L., Hateley, R. and Hermesec, B. (1996). Environmental Properties of Timber. Research paper commissioned by the FWPRDC.

Gregory, N. (1984). *The Culture of Using Timber as a Building in Australia*. The Pacific Timber Engineering Conference, August.

John H. I.(2003). A heat transfer textbook, pg 698-703 pub Phlogiston Press Cambridge Massachuetts.

.Nolan, G. (1994). The Culture of Using Timber as a Building Material in Australia. *Proceedings of the pacific Timber Engineering Conference*. Australia.

Ogunsote, O.O. (1993). An Introduction to Building Climatology- A Basic Course for For Architecture Students. Ahmadu Bello University, Zaria.

Okereke, P.A.(2006). The Use of Sustainable Materials and Equipment for Construction Process. In Proceedings, Thirty six Annual General Meeting of The Nigerian Institute Of Builders; Sustainable Development and the Built Environment; 9th-12th August,2006. Tin City: Pg 13-18.

Resource Assessment Commission, RAC (1991). *Forest and Timber Inquiry Draft Report*, Volume 1.

Raw Materials Research and Development Council, RMRDC (1998). Local Building and Construction Materials. *Report of the Multi-Disciplinary Task Force on the Survey and*

Update of the Report on Local Sourcing of Raw Materials for Building and Construction Industry in Nigeria, 27-39.

Sturges, W.G. (1991). Towards a Definition of Sustainable Construction Technologies of Framework of performance Criteria Evaluating Three Wooden Light Frame Floor and Roof Structural Systems in Cascadian Region. Unpublished report, University of Oregon.

Townsend, P. And Wagner, C. (2000). *Timber as a Building Material : An Environmental Comparison against Synthetic Building Materials*. National Association of Forest Industries.

William, C.E. (1983). Weathering and Protection of wood, Feist, William C. Weathering and protection of wood. In proceedings, seventy-ninth annual Meeting of the American Wood-Preservers' Association;1983 April 17-20; Kansas City; Mo. Stevensville, MD:Pg:195-205.

Whitelaw,S. (1990). Architects Love Timber. Australian Forest Industries Journal. March.

Table 1: Fossil fuel required to produce four common building materials.

Material	Fossil fuel energy (MJ/m^3)
Rough sawn timber	750
Steel	266000
Concrete	4800
Aluminium	1100000

Source: Ferguson et al.,(1996).

Table 2: CO_2 release and storage of four major buildings materials

Material	CO_2 released (kg/t)	CO_2 Released (kg/m^3)	CO_2 stored (kg/m^3)
Rough sawn timber	30	15	250
Steel	700	5320	0
Concrete	50	120	0
Aluminium	8700	22000	0

Source: Ferguson et al.,(1996).

Table 3: Thermal Conductivity of some Building Materials.

S/N	Material	Thermal conductivity($J/m^{-I}\,k^{-I}$)
1	Fired clay	1.0
2	Cement board	0.6
3	Limestone gravel	0.6
4	Sand and gravel (concrete)	1.4-2.9
5	Stone	1.5-3.0
6	Wood	0.05-0.15
7	Steel	19.0-21.0

Source: John(2003). Heat transfer text book.