INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Sustainable Architecture Practices – The Extension of the Useful Life of Office Buildings, South Western Cities of Nigeria

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Abstract:
Architects are required to design with sustainable practice measures in mind due to the rising global carbon emissions as a result of increased energy consumption. The service sector is rapidly expanding world over and South-West Nigerian cities are not left out. It is desirous that office buildings have service lives that ensure optimum performance thereby reducing the alternative of constructing new offices to replace old ones. This paper focuses on how service life of office buildings in South-West Nigeria could be maximized through critical studies of identified factors in literature affecting their 'well-being' over time. Thus contributing to sustainability by conserving resources and preventing the consumption of more energy that would have been experienced in the process of designing and constructing a new building. Secondary data are employed to theoretically deduce means by which service life can be maximized. Findings point to the fact that properly designed purpose-built office buildings with appropriate specifications and 'change of use' office buildings which have been converted with comfortable provisions for all facilities required are likely to have maximized service life, therefore, contributing to the conservation of the earth's resources.

Keywords: *Building components, office buildings, service life, sustainable practice, energy consumption*

1. Introduction

Over the years, global consumption of energy has increased significantly and as world population increases, more pressure will be put on primary energy production and consumption. In its 'International Energy Outlook' (a 2006 publication), Energy Information and Administration predicted that world marketed energy consumption would rise to 212 quadrillion giga watt hours by year 2030 (see Figure 1).

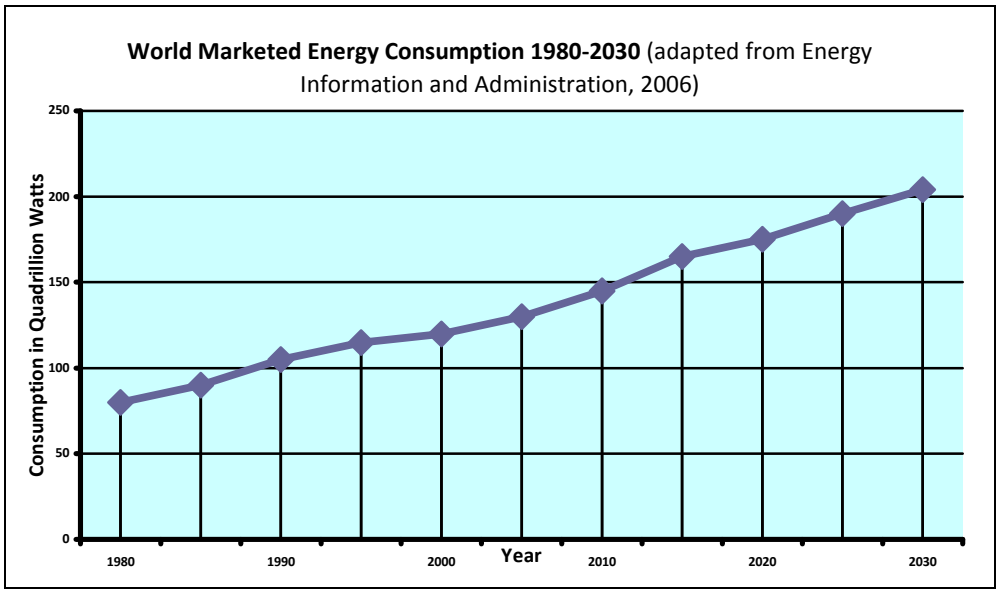

Figure 1: World Marketed Energy Consumption 1980-2030 (adapted from Energy Information and Administration, 2006)

Ways to tackle the effect of this prediction are to change the rate of consumption of primary fuels (petroleum, coal etc.) by switching to the use of alternative energy (solar, wind etc.) and secondly reduce energy use within rapidly growing sectors. If energy consumption rates are not controlled and are allowed to go as predicted, expected global carbon emissions could rise as high as 10 billion metric tons by the year 2025 as indicated in Figure 2 below.

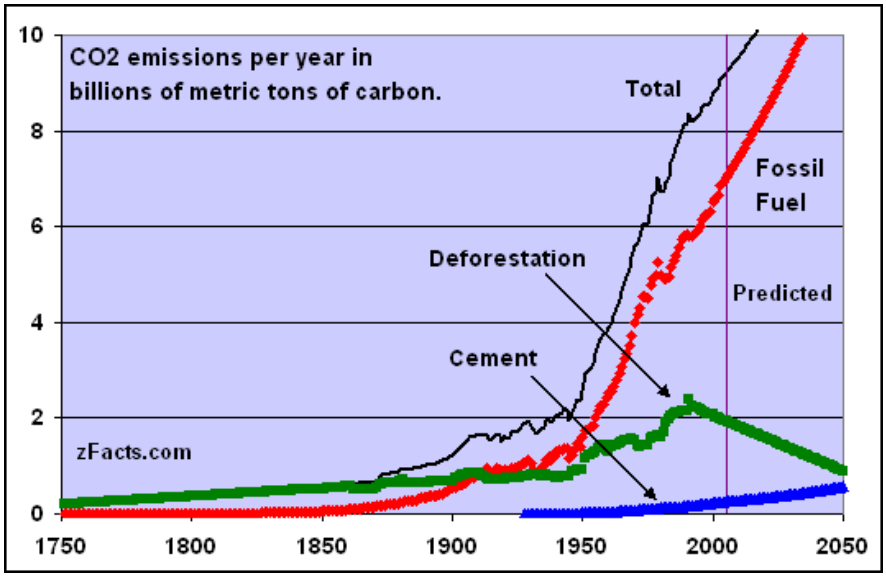

Figure 2: CO_2 Emissions per year in billions of metric tons of carbon (Source: www.zFacts.com)

The increasing rate of carbon emissions has set off series of global reactions in which global warming is at the top of the list. This change has resulted in anomalies in global surface temperatures (see Figures 3) as well as anomalies in global climatic events.

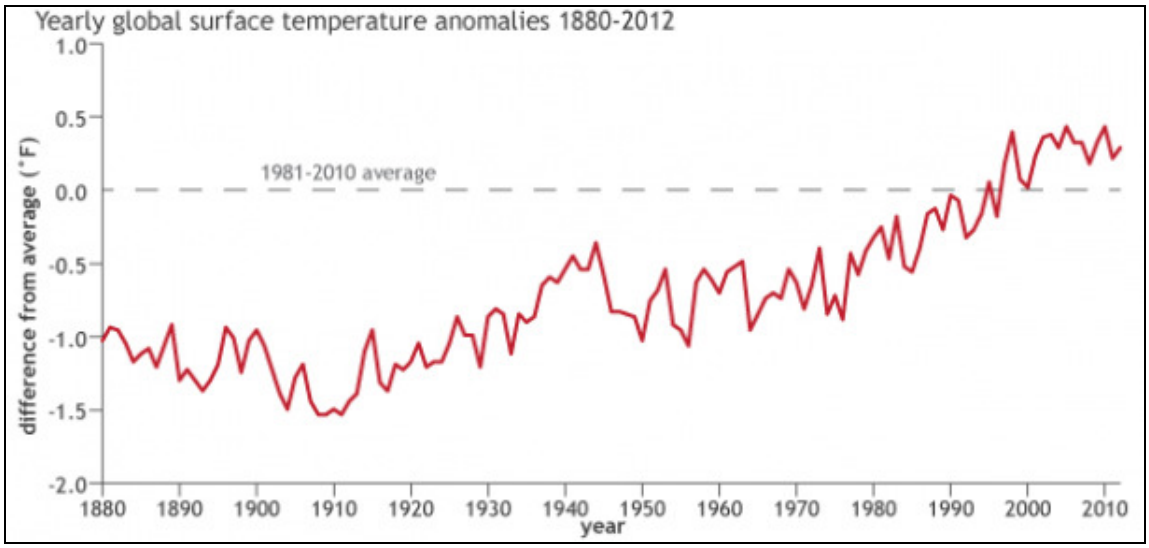

Figure 3: Yearly global surface temperature anomalies 1880-2012 (Blunden & Arndt, 2013)

In South-West, Nigeria, there is a rapid growth of the domestic and service sectors. The service sector comprises of all commercial and public buildings such as hotels, schools, offices, hospitals and museums. Office buildings are seen as key contributors to the growth of the service sector as almost all layouts of commercial and public institutions are designed with administrative blocks as an integral part. Thus, they can be seen as contributors to increased energy rates.

2. Office Buildings and Reduced Energy Consumption

Office buildings are structures that house activities of an administrative nature. The Dictionary of Architecture and Building Construction specifically defines an office building as 'a building containing offices used primarily for commercial, administrative or clerical work'.

As a means of practicing sustainable architecture through active contribution to the reduction of energy use in the rapidly growing service sector, it is of importance to consider other options apart from the well addressed issue of using various design elements to reduce energy consumption rates. An aspect that has not been fully explored is the idea of office buildings which will have maximised service lives (whether purpose built or recycled i.e. 'change of-use') thus ensuring the assurance of maximum usefulness and profit as a result of minimal operation cost, maintenance cost and energy costs.

The theory behind this approach is the fact that in the process of design, construction and operation of a new office building great amounts of energy are consumed through mechanical devices used to support the process of bringing the building to reality.

3. Service Life and Office Buildings

Service life refers to how long a building could be kept in a functional state. This, in totality, is determined through three areas, namely, Design Working Life, Technical Service Life and Functional Working Life. R. Block et al. (2002) define these three areas as indicated:

3.1. Design Working Life

The design working life is the assumed period for which a structure is to be used for its intended purpose (with anticipated maintenance but no major repairs).

3.2. Technical Service Life

The technical service life is the period for which a structure can actually perform according to the structural requirements based on its intended purpose (possibly with necessary maintenance but without major repair).

3.3. Functional Working Life

The functional working life is the period for which a structure can still meet the demands of its (possibly changing) users (may be with repairs and or adaptations).

Based on these three definitions, we could deduce that the service life of office buildings refers to how long that building could maintain its intended purpose of an office building, perform according to its structural requirements as an office building and functionally meet the demands of its original user and possibly changed usage as an office building all with maintenance excluding major repair works.

4. Factors Affecting Service Life of a Building

It has been discovered that the length of a building's service life is affected by the following:

Building design (structure, joints and components), Quality of individual materials and components, Construction standard, Physical actions on the structure, Environmental effects on the structure (wind, rain etc), The use and changes in use of the building and Methods of maintenance, repair, adaptation and demolition (R. Block, F.V. Herwijnen, A. Kozlowski, S. Wolinski, 2002). These factors are general but upon a more detailed investigation, certain peculiarities can be observed based on the location of the building. South-West Nigeria is the location in focus for this paper and proposal on how to maximise the service life of office buildings in this location will be put forth.

4.1. Design of the Office Building

From general observation, in South-West Nigeria, corporate bodies, institutions and companies with their own property or permanent site usually construct purpose built office buildings to suit their peculiar needs (see Figures 4 – 7) while rented/leased structures are mostly not purpose built for specific needs of the tenant (see Figure 8).

When an office is purpose built, arrangement and flow of spaces would fit the use of that building. Likewise, its structural design and specified components would be determined based on the expected function, use and users of that office building. When specifications are properly chosen, the office building will become more durable and accommodating to the users thereby lending the building a longer service life with minimum maintenance measures.

On the other hand, office buildings which are not purpose built would have to undergo major design changes in order to accommodate its new use. For the delivery of such, the designer should ensure that all functional needs are well planned to facilitate proper flow and maximum useful life.

4.2. Quality of Individual Materials and Components

The Nigerian Government acknowledges and accepts the use of materials that comply to documented standards e.g. British Standard (BS) specifications. Through the available documented information, accurate specifications of materials and components can be made. For example, clear specifications for reinforcement of foundations, floor slabs and lintels can be given through the guidance of documented standards. When materials and components used in the construction of an office building are according to standard, the service life of the building would be longer than if the materials and components are fake or sub-standard.

Figure 4: Senate Building – Covenant University, Ota, Ogun State, Nigeria(recordbreakergroup.com)

Figure 5: Built Senate Building – University of Lagos, Akoka, Lagos, Nigeria (unilag.edu.ng)

Figure 6: Guinness Nigeria Administrative Building, Ogba, Lagos State (ibtimes.com)

Figure 7: Broking House, a.k.a. Femi Johnson Glass House, Ibadan Oyo State (nigeriavillagesquare.com)2ws

Figure 8: Kingsway Mall converted to Banking Hall, Ibadan, Oyo State, Nigeria (nigeriavillagesquare.com)

Figure 9: Collapsed office building, possible result of poor Construction standard, Lagos, Nigeria (bbc.co.uk)

4.3. Standard of Construction

In South-West Nigeria, there are two broad classifications of construction consultants and contractors – Registered Professionals and Quacks. There have been instances where clients deliberately consult quacks because their fees/charges are acclaimed to be much lower than those of the registered professionals.

At the points of design, specification and construction, these imitators could employ construction methods that would adversely reflect on the service life of the office building leading to early decay or even collapse of the building (see Figure 8). Examples of such reduction in construction standard are poor concrete mix, improper foundation specification/construction, commencement of construction on a sand-filled site that has not fully settled, poor joinery of ironmongery, woodwork and aluminium works etc. These and many more sharp practices and poor construction standards adversely affect the service life of office buildings.

4.4. Actions on the Office Building During Life

Internal and external actions on the office building could lead to the maintenance or reduction of its original expected service life. Some forms of these actions are:

Pollution, Population of users and Usage.

4.5. Environmental Effects on Office Buildings

South-West Nigeria is a Tropical Region where high volumes of rainfall, high humidity coupled with high temperature and intense glare from the sun is experienced. It should also be noted that development of cities is the South-West come with some form of noise and air pollution.

4.5.1. Temperature

For a large part of the year, temperatures are high (sometimes up to 32°C). Though there are no drastic drops in temperatures, the high temperatures bring about some significant form of expansion of metal components of the office building. For example, aluminium framed windows if not installed properly with the consideration of temperature; the panes could fall off causing damage.

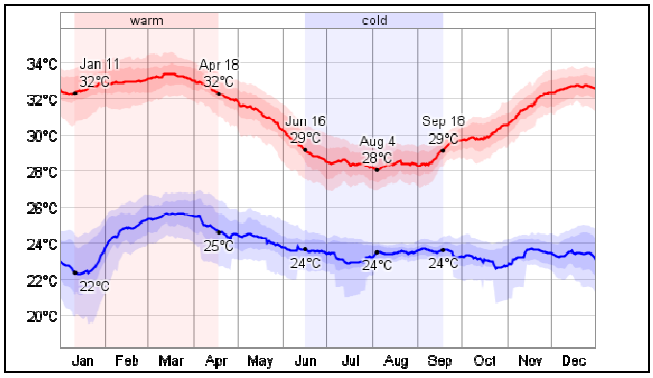

Figure 10: Daily High and Low Temperature: The daily average low (blue) and high (red) temperature with percentile bands (inner band from 25th to 75th percentile, outer band from 10th to 90th percentile). (weatherspark.com, 2012)

4.5.2. Humidity

High levels of humidity is recorded in South-West Nigeria therefore office buildings are prone to mould, mildew, algae and insect attacks. Also, the closer an office building is to the coast, the higher the salt content in the humid air that reaches it. This in turn

produces adverse reactions on the building elements. Therefore choice of construction materials to counteract or prevent these attacks should be employed in order to contribute positively to the service life of office building.

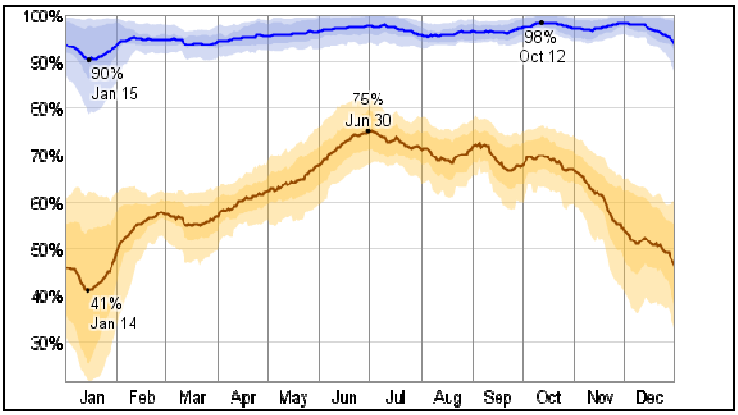

Figure 11: Relative Humidity: The relative humidity typically ranges from 41% (comfortable) to 98% (very humid) over the course of the year, rarely dropping below 21% (dry) and reaching as high as 100% (very humid). (weatherspark.com, 2012)

4.5.3. Precipitation

South-West Nigeria has high precipitation records with the highest occurrences around June and lowest occurrences around January. Roof and site drainage are high priorities in order to avoid flooding incidents which would help to maximize the service life of that office building.

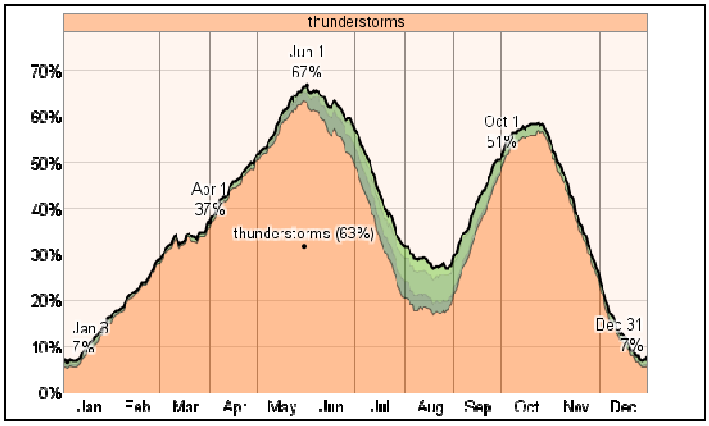

Figure 12: Probability of Precipitation at Some Point in the Day: The order of severity is from the top down in this graph, with the most severe at the bottom. (weatherspark.com, 2012)

4.5.4. Wind

Winds have been recorded to move with average speed from 0 m/s to 9 m/s (calm to fresh breeze), rarely exceeding 25 m/s (storm). In South-West Nigeria, two main types of winds are experienced – South-West Trade wind notable for carrying rainfall with humid air and North-East Trade wind that comes with dry air and dust. The more influential of the two in this context is the South-West Trade wind as it is closer; its impact is also felt stronger as it sometimes comes with rainstorms. Hence the design of office buildings in South-West Nigeria should be resistant to the actions of these winds.

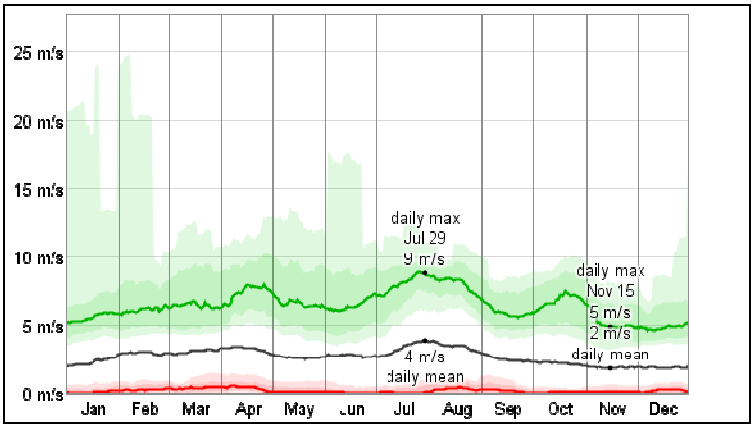

Figure 13: Wind Speed: The average daily minimum (red), maximum (green), and average (black) wind speed with percentile bands (inner band from 25th to 75th percentile, outer band from 10th to 90th percentile). (weatherspark.com, 2012)

4.6. Use and Changes in Use of Office Buildings during their Service Life

When an office building is designed and maintained for a certain scope, it serves its function better provided the scope is not enlarged. As that office building's use is changed or the functional scope is increased, modifications will have to be made. There are common instances of public office buildings which were originally designed for other purposes other than office use and converted (e.g. residential to office) and after conversion, some spaces have been 'forced' or 'managed' hence, putting some form of strain on that structure. Thus, the service life of that structure is dependent on how well and successfully the "change of use" was made.

4.7. Decision Processes Regarding Maintenance, Repair, Adaptation and Demolishing of Office Buildings

As implied earlier, professionals in the construction industry have a better insight on matters of design and construction related issues. Therefore, decision processes on maintenance, repair, adaptation and demolishing should be passed through such individuals as they would use a combination of experience, standard measures and best practice to arrive at profitable directives which would maximize service life.

5. Recommendation and Conclusion

From the literature, many different aspects contribute to the maximization of the service life of office buildings in South-West Nigeria. Despite maintenance, with age, the office building would change in quality. In order to prolong and ultimately maximize the service life of such buildings, it is recommended that:

i. A synergy of functional working life, technical service life and design working life should be strived at.
ii. Appropriate specifications of materials and components should be made to counteract the negative implications of the factors affecting the service life of office buildings.
iii. Care should be taken not to over-populate an office building (beyond the capacity designed for) so as not to put undue pressure on the building's facilities.
iv. Qualified and registered professional should be involved in the design, construction and related decision making processes of the office building.

When service lives of office buildings in south western Nigeria are maximized, the constant need to construct new structures to replace buildings that have expired service lives will be greatly reduced, thereby lending a brand of environmental sustainable practice that not only conserves limited resource, but also significantly reduces energy consumption levels that would have taken place should there have been a new building procurement process.

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