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STRATEGIES FOR ACHIEVING SUSTAINABILITY IN THE NIGERIAN BUILDING DESIGN AND CONSTRUCTION INDUSTRY

[1]A. Mohammed and [2]M. Abbakyari
[1]Civil Engineering Department,
Abubakar Tafawa Balewa University, PMB 0248, Bauchi, Bauchi State, Nigeria.
[2]MSc Candidate in Architecture & Sustainability,
De MonfortUnivesrity, Leicester, UK
Corresponding Author: A. Mohammed

ABSTRACT
Sustainable development has been in the forefront of debates because of the far reaching effect of climate change on this earth. This is principally due to the activities of industries that pollute the atmosphere and use up non-renewable resources to fuel our growth and development. As a consequence of this, it has become necessary for all major consumers of resources including the building industry to adopt sustainable development measures as a way of prudently using our scarce resources. Nigeria does not have a sustainable development action plan that encapsulates strategies for attaining sustainability in the built environment. This is an attempt at proposing some strategies of achieving sustainable building design and construction focusing on the principles of sustainable design and construction and the technologies for their achievement. These strategies revolve round the five principles of Sustainable Site Design; Water Conservation and Quality; Energy and Environment; Indoor Environmental Quality; and Conservation of Materials and Resources.

KEYWORDS: Sustainability, Buildings, Climate Change, Environment, Energy

INTRODUCTION
Climate change is real, it is happening now, affecting us more and will impact us greatly until urgent and holistic interventions are carried out to mitigate as well as to adapt to its disastrous consequences. This is the summary of the much anticipated report from the United Nation's Intergovernmental Panel on Climate Change (IPCC, 2013). This implies that how we live and impact our environment has a direct bearing on the quality of life we live as individuals and societies. This explains the drive towards more energy efficient and sustainable resources, materials and processes in order to preserve our fragile ecosystem in light of the climate change question. The main culprit in this change is attributed to emissions from fossil fuel based industries which has given rise to the greenhouse effect and resulted in a warming of global temperatures and altering the weather pattern all over the world (Mohammed et al, 2011).

One of the consequences of global warming is seen in desertification. Deserts worldwide have grown by over 50% between 1980 and 2000, affecting energy demands for cooling, increasing water consumption to compensate for rising evapotranspiration, and raising morbidity and mortality in regions adjacent to deserts, and even rather far away from them (Meir and Pearlmutter, 2010).

The importance of buildings to our lives cannot be over emphasised because it is estimated that we spend 90% of our time in some form of building; as a home, office, school, leisure centre etc. (Plank, 2005). As a result of this, the building industry is the biggest energy consumer in the society using up about 40% of all energy produced, through the manufacture of building materials like steel and cement, construction of buildings and their eventual demolition. Additionally, almost 60% of the world's electricity is consumed in residential and commercial buildings (Berge, 2009). A breakdown of energy use in tropical buildings is shown in Figure 1. It shows that most of the energy is used in cooling the building in order to achieve a comfortable indoor environment. This suggests, that if passive solar cooling techniques where incorporated in the design and construction of buildings, a substantial quantum of energy would have been saved and used for various other needs like in small and medium scale enterprises industries in order to create jobs in the economy.

Sustainable construction is thus one of the greatest challenges that we face as a planet so as to mitigate some of the detrimental effects of climate change. To this end, sustainable development principles in the built environment are necessary if Nigeria were to realise her goal of reducing the huge housing deficit currently put at around 16 million houses in a manner

that does not negatively impact the environment and result in more carbon emissions in to the atmosphere.

AIM AND SIGNIFICANCE

This paper focuses on the need for sustainable development through the use of sustainable design and construction strategies in the Nigerian building industry. The significance of this cannot be over emphasised seeing that as signatory to the recent Paris agreement, Nigeria has a commitment to all measures outlined towards climate change adaptation and mitigation as outlined in articles 7 and 4 (COP21,2015). The United Nation Environment Programme (UNEP) has climate change as its top most thematic area. Under climate change mitigation housing and the construction industry in general is given a prominent role; being responsible for a third of all greenhouse gases emissions globally. The strategies outlined in this paper is aimed at achieving that central objective of mitigating climate change throughout the construction process. Sustainable or Green construction can also have a positive effect on productivity, public health, and even employment: according to estimates, every US $ 1 million invested could give rise to ten to fourteen jobs (UNEP, 2016).

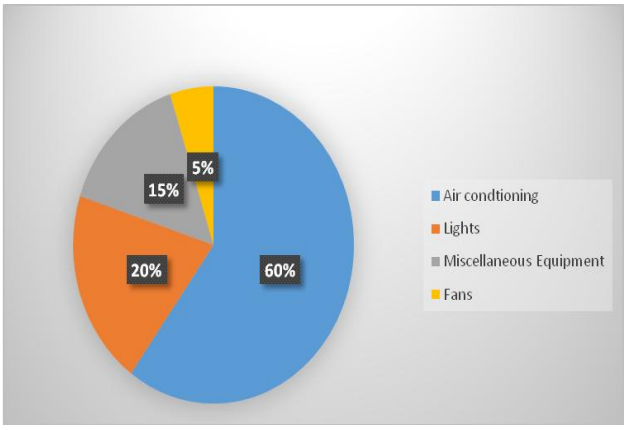

Figure 1- Breakup of energy use in Buildings, Adapted from (CII, 2005)

Sustainability/Green Buildings

Sustainability is defined as the ability of a development to meet the needs of the present without compromising the ability of future generations to meet theirs (Institution of Structural Engineers, 1999).

A green building is one whose construction and lifetime of operation assure the healthiest possible environment while representing the most efficient and least disruptive use of land, water, energy and resources. The optimum design solution is one that is effectively in tune with all of the natural systems and conditions of the pre-developed site after the completion of construction (GGGC, 2014).

Sustainable construction is an integration of the building materials and construction methods to promote and benefit social and environmental quality and economic vitality throughout all stages of the building life cycle. Sustainable construction merges sound environmentally responsible practices into one discipline that looks at the environmental, economic and social effects of a building or building project as a whole (Grabar and Dailey, 2003).

STATEMENT OF THE PROBLEM

Architectural Design

Sustainability is not currently taken into consideration in the design of buildings in Nigeria. As a result no effort is made to incorporate aspects of the environment or climate that could enhance the design of the buildings in a sustainable way. For example most buildings do not have shading devices and other passive solar cooling considerations in order to naturally cool the building interior for human comfort in Nigeria's tropical climate.

Building Materials

The most widely used walling material are hollow sand-cement blocks. Because the walls are hollow they have a low heat mass consequently resulting in a higher heat transmittance. This makes the buildings unbearable hot during most of the year in the northern part of the country.

Furthermore, the roofing materials and design do not take the climate and environment into consideration. The roofing materials of choice are long span aluminium and galvanized iron roofing sheets. Both of these materials are very good conductors of heat, thus resulting in a considerable built of heat in the roofing space. Also, because there are no vents and outlets for the heat to be expelled from the roofing space, the heat absorbed can only be dissipated downwards to the living areas of the building thus creating a very uncomfortable indoor environment.

Policy

There is a lack of clear policy for encouraging sustainable building design and construction practice in Nigeria presently. This is corroborated by findings of (Dahiru et al, 2012) that the National building code of 2006 does not sufficiently address the issue of sustainability.

Strategies of Sustainable Design

For sustainable development, the design, specification, supervision and management of buildings and the building process must make efficient use of resources and ecological processes. This is good practice common to most engineers who follow the basic laws of engineering to minimise waste of resources. All decisions need to be taken to ensure the development attains a plateau with a

reasonable level of sustainability (Institution of Structural Engineers, 1999).

The five major elements of green building design are: Sustainable Site Design; Water Conservation and Quality; Energy and Environment; Indoor Environmental Quality; and Conservation of Materials and Resources. This information supports of the use of the United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) Green Building Rating System, but focuses on principles and strategies rather than specific solutions or technologies, which are often site specific and will vary from project to project. (GGGC, 2014)

The strategies outlined here are principally the purview of the building professionals; architects, engineers and builders. The role of government and other stakeholders are not discussed here.

Sustainable Site Design

Principles:

This is achievable through minimizing urban sprawl and needless destruction of valuable land and habitat, which are the usual consequences from inefficient low-density development. Encourage higher density urban development, urban re-development and urban renewal, and brownfield development as a means to preserve valuable green space.

Preserve key environmental assets through careful examination of each site. Engage in a design and construction process that minimizes site disturbance and which values, preserves and actually restores or regenerates valuable habitat, green space and associated eco-systems that are vital to sustaining life.

Strategies:

a) Make more efficient use of space in existing occupied buildings, renovate and re-use existing vacant buildings, sites, and associated infrastructure and consider re-development of brownfield sites.
b) Nigeria's cities and towns should be well planned to include valuable green spaces in the form of greened play grounds, parks, etc. in all neighbourhoods. This green landscape not only helps in keeping the environment beautiful it also acts as a carbon sink by absorbing Co2 from the atmosphere. (CABE, 2005)
c) When new development is inevitable, avoid sites that are important in the local or regional ecosystem. Identify and protect valuable green field and wetland sites from development.
d) Recognize that allowing higher density development in urban areas helps to preserve green space and reduce urban sprawl.
e) Evaluate each site in terms of the location and orientation of buildings and improvements in order to optimize the use of passive solar energy, natural daylighting, and natural breezes and ventilation.
f) Help reduce the urban heat island effect by reducing the building and site development footprint, maximizing the use of pervious surfaces, and using light coloured roofs, paving, and walkways. Provide natural shading of buildings and paved areas with trees and other landscape features (RCAC, 2009).
g) Minimize the boundaries of the construction area.
h) Use landscape design to preserve and restore the region's natural habitat and heritage while emphasizing the use of indigenous, hardy, drought resistant trees, shrubs, and plants (GGGC, 2014).

Water Conservation

Principles:

Preserve the existing natural water cycle and design site and building improvements such that they closely follow the site's natural "pre-development" hydrological systems. Emphasis should be placed on retention of storm water and on-site infiltration and ground water recharge using methods that closely follow natural systems. Minimize the unnecessary and inefficient use of potable water on the site while maximizing the recycling and reuse of water, including harvested rainwater, storm water, and grey water.

Strategies:

a) Site and storm water management design should use the existing natural flows and features of the land, instead of designing the building and site improvements with total disregard for the site, which results in needless, extensive, disruptive, costly and time consuming excavation and earthmoving.
b) Conduct a thorough site assessment and strategically locate buildings and site improvements so as to preserve key natural hydrological features. Preserve existing forest and mature vegetation that play a vital role in the natural water cycle by absorbing and disbursing up to 30% of a site's rainwater through evapo-transpiration.
c) Minimize the building's footprint, site improvements and construction area, and minimize excavation, soil disturbance and compaction of existing topsoil as this soil in its natural uncompacted state serves a vital role in absorbing and storing up to 80% of natural rainfall until it can be absorbed by vegetation or enter the site's natural sub-surface ground water system.

d) Design and locate buildings and site improvements to optimize use of low-impact storm water technologies such as bio-retention, rain gardens, open grassy swales, pervious bituminous paving, pervious concrete paving and walkways, constructed wetlands, living/vegetated roofs, and other technologies that support on-site retention and ground water recharge or evapo-transpiration.
e) Implement a design that minimizes the use of potable water by using low-flow plumbing fixtures and toilets and waterless urinals. Harvest, process and recycle rainwater, site storm water, and building grey water and identify appropriate uses within the building and site.
f) Conserve water and preserve site and ground water quality by using only indigenous, drought resistant and hardy trees, shrubs, plants and turf that require no irrigation, fertilizers, pesticides or herbicides.(PTI, 1996)

Energy and Environment

Principles:

Minimize adverse impacts on the environment (air, water, land, natural resources) through optimized building siting, optimized building design, material selection, and aggressive use of energy conservation measures. Maximize the use of renewable energy and other low impact energy sources.

Strategies:

a) Optimize passive solar orientation, building massing and use of external shading devices such that the design of the building minimizes undesirable solar gains during the summer months.
b) Optimize building orientation, massing, shape, design, and interior colours and finishes in order to maximize the use of controlled natural day lighting which significantly reduces artificial lighting energy use thereby reducing the buildings internal cooling load and energy use.
c) Use high performance low-e glazing, which can result in significant year round energy savings. Consider insulated double glazing, triple glazing or double pane glazing with a suspended low-e film. Selective coatings offer optimal light transmittance while providing minimal solar gain and minimal heat transmission.
d) Use state-of-the art, high efficiency, heating, ventilation and air conditioning (HVAC) and plumbing equipment, chillers, and water heaters, etc.
e) Optimize the use of natural ventilation and where practical use evaporative cooling, solar regenerated desiccant dehumidification or absorption cooling. Identify and use sources of waste energy.
f) Use Energy Star certified energy efficient appliances, office equipment, lighting and HVAC systems.
g) Consider on-site small-scale wind, solar, and/or fuel cell based energy generation and co-generation (Smith, 2003).

Indoor Environmental Quality

Principles:

Provide a healthy, comfortable and productive indoor environment for building occupants and visitors. Provide a building design, which affords the best possible conditions in terms of indoor air quality, ventilation, thermal comfort, access to natural ventilation and daylighting, and effective control of the acoustical environment.

Strategies:

a) Use building materials, adhesives, sealants, finishes and furnishings which do not contain, harbour, generate or release any particulate or gaseous contaminants including volatile organic compounds.
b) Maximize the use of natural daylighting. Optimize solar orientation and design the building to maximize penetration of natural daylight into interior spaces.
c) Maximize the use of operable windows and natural ventilation. Provide dedicated engineered ventilation systems that operate independently of the buildings heating and cooling system.
d) Design building envelope and environmental systems that not only treat air temperature and provide adequate ventilation, but which respect all of the environmental conditions which affect human thermal comfort and health. This include a well-ventilated overhanging sloping roof, well shaded openings and windows, using trees to provide shade, etc.

Materials and Resources

Principles:

Minimize the use of non-renewable construction materials and other resources such as energy and water through efficient engineering, design, planning and construction and effective recycling of construction debris. Maximize the use of recycled content materials, modern resource efficient engineered materials, and resource efficient composite type structural systems wherever possible. Maximize the use of re-usable, renewable, sustainably managed, bio-based materials. Remember that human creativity and our abundant labour force is perhaps our most valuable renewable resource. The best solution is not necessarily the one that requires the least amount of physical work.

Strategies:

a) Optimize the use of engineered materials which make use of proven engineering principles such as engineered trusses, composite materials and structural systems that have been proven to provide high strength and durability with the least amount of material.
b) Encourage use of timber, bamboo, straw bale, and other earth based construction that have proven low carbon imprint in order to have buildings with low embodied energy and reduced carbon emissions.
c) Identify ways to reduce the amount of materials used and reduce the amount of waste generated through the implementation of a construction waste reduction plan. Adopt a policy of "waste equals food" whereby 75% or more of all construction waste is separated for recycling and used as feedstock for some future product rather than being landfilled.
d) Identify ways to use high-recycled content materials in the building structure and finishes. Consider everything from blended concrete using fly ash, slag, recycled concrete aggregate, or other admixtures to recycled content materials such as structural steel, ceiling and floor tiles, carpeting, carpet padding, sheathing, and gypsum wallboard.
e) Explore the use of bio-based materials and finishes such as various types of agriboard (sheathing and or insulation board made from agricultural waste and byproducts, including straw, wheat, barley, soy, sunflower shells, peanut shells, and other materials).
f) Evaluate all products and systems used for their ability to be recycled when they reach the end of their useful life. Preference should be given to products and systems that facilitate easy, non-energy intensive separation and recycling with minimal contamination by foreign debris.
g) Recognize that transportation becomes part of a product or building materials embodied energy. Where practical, specify and use locally harvested, mined and manufactured materials and products to support the regional economy and to reduce transportation, energy use and emissions.

Example of Green Buildings in Nigeria

One of the best examples of green building in Nigeria is a commercial building located in Ikoyi, Lagos. Comprising 15,736 sq m of office space over eight floors, the large floor plates offer great flexibility and efficiency to the modern occupier and are fitted to internationally recognised Grade A standards, available from 450 sq m to 2,000 sq m. They are serviced by a double-height reception, meeting and dining area on the ground floor and over 350 private car parking spaces. It holds the distinction of the first commercial building in Lagos and possibly the whole of Nigeria to achieve LEED certification in both design and construction (Act is group, 2016).

Some of its prominent green credentials are:

a) Water is recycled throughout: from rain water harvesting to water re-use in the irrigation of the gardens, condensate recovery from the building's cooling units and accurate control systems in the bathroom facilities to reduce wastage
b) Automatic presence detectors and high-efficiency lighting reduce and resupply energy when and where it is needed
c) The building's orientation maximises natural light and ventilation, and minimises solar exposure, reducing the energy requirements for cooling, heating and air quality systems
d) High efficiency glazing and external thermal envelope also reduce demand on cooling requirements.

The green features of this building which correspond to the strategies that have been outlined, show that if there is the will for change, the Nigerian building industry can by themselves be the main drivers for a shift towards sustainable building design and construction.

CONCLUSION

The foregoing has illustrated the perilous climate emergency facing us all and the need for concerted efforts aimed at mitigating its effects. The particular case of the building industry is quite challenging because of the need to provide shelter to a rapidly increasing population and also to limit its environmental impact in order to preserve our fragile ecosystem.

The proven strategies discussed provides an opportunity for meeting the goal of rapid development while ensuring sustainability in building design and construction. This is the surest way of providing buildings that are in tune with the environment and fit for purpose and the future. The government and other stakeholders in the industry must be the main drivers of these efforts if this vision is to be realised. This has already started with the construction of the first commercially certified LEED building in Nigeria, but more needs to be done if Nigeria was to achieve the mitigation of the impact of climate change through sustainable construction methods and materials.

Figure 2 – The Heritage Place in Ikoyi Lagos (Actis Group, 2016)

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