

RESPONSIVE BUILT ENVIRONMENT

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CLIMATE CHANGE INDUCED ARCHITECTURE: RESPONSIVE INNOVATIONS FOR SUSTAINABLE ENVIRONMENT

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ABSTRACT

Submissions of the Inter-Governmental Panel on Climate Change (IPCC), Assessment Reports Four and Five (draft), paint an unpleasant picture of the negative impacts of anthropogenic induced climate change phenomenon, with a compelling need to halt the progressive trend of carbon emissions, for protection and preservation of the biodiversity. A global response informed interventions from diverse sectors of human endeavours with a particular reference to the 'Built Environment' in this context, for appropriate mitigation and adaptation strategies. Through a literature review, this paper therefore examines the responses within the confine of the Built Environment, particularly, evolving pragmatic roles of the Architects in addressing the menace. In doing this, Architects' responsive roles in form of a stand-alone approach as well as collaborations with others, within and outside the professional enclave particularly, joint integration of technological innovations for overall dwelling comfort and sustainable environment are discussed.

Keywords: Anthropogenic, Architecture, Building Simulation, Carbon Emission, Climate Change.

INTRODUCTION

One of the global issues dominating the centre stage relates to the anthropogenic induced Climate Change adverse effects, largely due to increasing amount of carbon emissions into the atmosphere ((IPCC, 2007; Milly et al, 2008; Desonie, 2008). The construction industry is concerned with climate change via the energy used by the construction, occupation and operation of buildings and thus, has a crucial role to play in carbon efficiency. In this case, building professionals; particularly, architects are conscious of their design decisions from inception through ingenious passive design approach and use of appropriate materials integrated with collaborative incorporation of evolving technology, with a view to creating sustainable environmentally responsive designs. This submission in form of a literature review therefore addresses these key issues in a four-way sustainable approach of *Adoption of Passive Design Solutions; Integration of Renewable Energy Sources; Integration of Building Information Modelling* and; *Application of Building Environment Simulation and Analyses*. With these, attendant risks associated with climate change are curtailed by making choices that reduce greenhouse gas emissions.

LITERATURE REVIEW

Over the past centuries, human activities, inclusive of building construction and operation, have released large amounts of carbon dioxide and other greenhouse gases into the atmosphere. These gases in turn act like a blanket around the earth, trapping energy in the atmosphere and causing it to warm the earth, thereby resulting into the 'greenhouse effect'. This is natural and necessary at a reasonable quantity to support life on Earth. However, its build-up adversely affects climate processes, thereby resulting in environmental degradation such as extreme weather events, sea level rise, altered stream regimes, rise in sea surface temperatures, violent winds as well as threats to food security and potential

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poverty among others (Elona *et al.*, 2013; Desonie, 2008; Harold, 2014). Locally, this was well played out in 2012 in Nigeria, a nation of over 150 million people, as 256 local government areas of 13 states of the federation were affected by flood. This led to 363 deaths as over two million victims were displaced with its attendant millions of Naira for their relocation and other compensations by the Federal Government (The Punch, 2013).

Environmental management is an essential element of sustainability and sustainable development (Evan *et al.*, 2005) as Construction Industry is largely connected to climate change. This which includes changing land use patterns (Kam-din and Qing, 2013), utilisation of natural resources, energy consumption, among others, have direct impacts on the environment.

Thus, the construction industry has a crucial role to play on carbon efficiency and its measurements throughout the construction life cycle. Adapting to climate change and reducing carbon emissions represent challenges, but also benefits, for the industry and the environment at large.

APPROACHES TO RESPONSIVE INNOVATIONS

Sequel to the afore-stated and the need for drastic reduction in carbon emissions within the context of the built environment, the following approaches ranging from a stand-alone promotion of passive design to a more collaborative integration of technological innovations are presented. In this case, building professionals; particularly, architects are conscious of their design decisions from inception through ingenious passive design approach and use of appropriate materials as well as incorporation of relevant technology, with a view to creating environmentally responsive designs. Thus, four sustainable approaches are presented as follows:

a. Adoption of Passive Solar Design Solutions

This is a stand-alone approach from the primary designer, the architect. It involves efficient working with natural resources to evolve well insulated buildings, primarily designed to avoid heat gained through adequate shading and window orientation, with a view to limiting any cooling load which might otherwise be required. It takes best advantage of the local climate using window placement and glazing type, thermal insulation and natural shading (Sanja, 2013), applicable to both new buildings and existing structures (i.e. retrofitting). A passive solar house is a very economical low-energy house as it provides high quality internal environment while allowing significantly reduced energy consumption for running at all times. It does not require conventional heating or air conditioning and saves the economy of its natural resources as it reduces carbon dioxide emissions (PHIUS, 2013; NZEB, 2013)

With the exception of passive house design, other approaches below involve collaborations between architects and other professionals from within and outside the Built Environment:

b. Incorporation of Renewable Energy Sources

Renewable Energy refers to the energy from naturally available sources, which include the sun, the wind and tides, among others, that is continually replenished and harnessed for human benefits (John and Tony, 1986). At the global level, interest in renewable energy has surged due to impressive technical advances and environmental pressures (particularly climate change), among others (Ottinger and Williams, 2002). Of the two major related Renewable Energy Sources at this level are:

- **Solar energy:** This is derived from the sun through active solar applications. This involves conversion of sunlight into direct electricity by installing free standing or roof mounted framed 'photovoltaic solar panels'. This may also entail using 'concentrated solar power'

which uses lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam for electric power production, applicable in heating swimming pools, water or air for residential and commercial use. For ease of integration within building fabrics, panels/modules may replace building components such as curtain walls, roof tiles, atria, structural glazing or vertical walls;

- **Wind Power:** This is a technique through which airflows are utilized to run 'Wind Turbines' for power generation in areas where winds are stronger and constant, such as offshore and high altitude sites. Provisions can be made for medium sized installations directly in buildings.

c. Application of Building Information Modelling (BIM)

This is a technology based rich integrated information model, consisting of multiple data sources, the elements of which can be shared across all building stakeholders and maintained across the life of a building, from inception to recycling. It offers significant benefits such as cost reduction, compliance checking, better project management and entire carbon impact analysis, to name a few (Stephen, 2010; Drury et al., 2008). It is an innovative technology, suitable for collaborative delivery of information needed for improved sustainable building design and performance through integrated project delivery and design optimization using relevant BIM-based analysis tools such as TRACE700, eQUEST, etc. It is more than geometric information from a CAD model (Kam-din and Qing, 2013). Through a more automated approach to quantity take-off and efficient management of design changes, feedback can be more rapid and cost effective; particularly, for overall sustainability (Adrian Malone, 2013). It should be pointed out that the use of BIM is just on the rise in some advanced countries as about 13% of the people sampled in the United Kingdom in 2010 were aware and engaged in it (Stephen, 2010).

d. Application of Building Environment Simulation and Analyses

In order to address Climate Change effects through development of low carbon buildings, proposed design is evaluated as early as at its conceptual design stage using *Building Environment Simulation and Analyses* softwares with a view to creating environmentally responsive Architecture (Drury et al, 2008; Hassan et al, 2008). It involves assembling a virtual replica of a proposed building thereby estimating the energy use and operating cost by simulating its performance through the weather of an entire year in the specified location as shown in figures 1a & 1b. It is a collaborative way to quantitatively predict the future performance of a building with regard to carbon emissions. This allows architects, engineers and other building professionals to compare alternative design solutions and select the best with regard to annual carbon di-oxide emissions and life cycle payback. This is achievable through its *Load Design* mechanism which determines cooling/heating energy need, volumetric air flow requirements, equipment capacities, supply temperatures, etc. and, *Energy-Analysis* tool which predicts annual/monthly energy consumption and cost. Several appropriate softwares inclusive of *Ecotect*, *Anthermc*, *DesignBuilder*, *eQUEST*, *TRACE 700*, *IES*, *TAS*, etc., can be used for these simulation purposes. In doing this, relevant information in respect of the anticipated location, building materials/components (i.e. walls, windows, u-values, shading coefficients), operational pattern, interior load values (Lighting, Plug Loads, Occupant numbers and Activity Level), among others, must be adequately provided (Stephen, 2010; Wang et al, 2011; Pau et al, 2014).

Figure 2 represents typical results of analyses as obtained from DesignBuilder energy tool. In this case, the results represented in forms of graphs, Charts and Tables are interpreted for necessary actions. This involves repeated cycles of critical evaluations of building components' behavioural patterns with a view to replacing any (if necessary), for overall anticipated improved building performances.

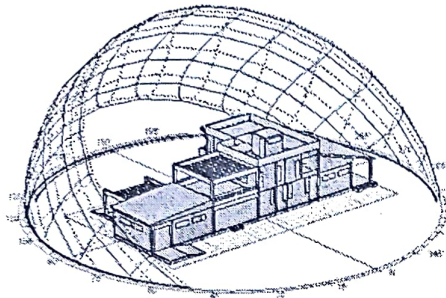


Figure 1a

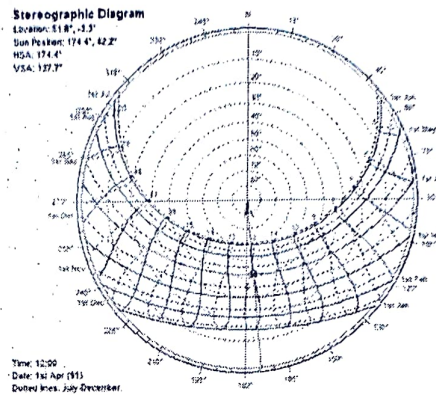


Figure 1b

Figures 1a & 1b: illustrating Annual Sun-path and Annual Stereographic Diagram of a typical location respectively, using *Ecotect interface* source: Olaniyan, 2012

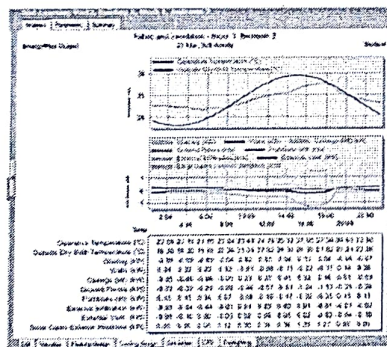


Figure 2a

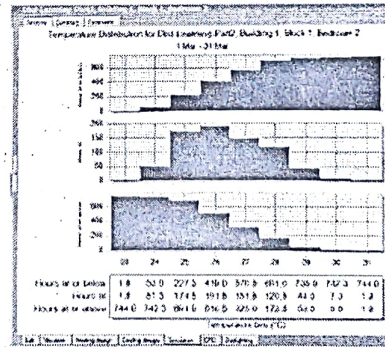


Figure 2b

Figure 2: Typical results of a simulation as captured on *DesignBuilder Interface* Source: Olaniyan, 2012

CONCLUSION

Submissions of the Inter-Governmental Panel on Climate Change; particularly, Assessment Reports Four and Five paint a gloomy picture of the negative impacts of anthropogenic induced climate change phenomenon with a compelling need to halt the trend. Within the confine of the Built Environment, this paper, in form of a review, has highlighted some contributory advances in line with the global trend with a view to addressing the scourge. These range from architects' stand-alone approach to collaborative involvements of associated building professionals in particular, overwhelming integration of technological innovations. As we live in a world where there are growing concerns regarding human induced climate change, today's building designers; particularly, architects, need to provide high quality, comfortable buildings that comply with current building regulations, minimise upfront costs, curtail running expenses and reduce environmental impacts for overall sustainable development as demonstrated in this submission. This is a reflection of the on-going innovations on the part of the architects in responding to the unpleasant phenomenon called Climate Change.

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