EXPLORING ENERGY EFFICIENCY THROUGH NATURAL VENTILATION AND AIR-CONDITIONING IN TROPICAL HALLS

ABSTRACT

Exploring energy efficiency through natural ventilation and air-conditioning simply means minimizing the energy consumption of a building with its local climate. Understanding energy use in building design is of great gain to the developer, architect or users in our modern-day meeting facilities. Building designers are looking to optimize building efficiency and then incorporate renewable energy technologies, leading to the creation of zero-energy buildings. This paper seeks to dissertate important points on how our local climate can be used to enhance the internal comfort of large halls in the tropical region, especially in Nigeria, through passive cooling techniques. This is a response to the discomfort been experience in our meeting halls in Rivers state, Nigeria. The study revealed several significant findings including that the total annual energy consumption of a conference building in Nigeria may be reduced by up to 20 % when a building uses passive cooling strategies.

INTRODUCTION

Looking at the vast development either through technology, economically, politically, etc. our present-day statuses have been achieved through successful gathering and coming together of people; men, women, younger folks sharing and exploring ideas, thoughts, methods in a day to day conferencing or say meetings of different format. With this, critical consideration and concern should be put into the designing and development of any sure of these structures that will be accommodating a large number of people. If meetings are to be effective, appropriate conditions must be provided to create an environment for creative discussion. Mohammad (2012), noted that the growing trend of energy depletion and environmental problems can only be corrected by the adoption of passive (natural) cooling techniques of achieving comfort in buildings (climate responsive designs). Similarly, Ajibola (2001) also stressed that buildings in Nigeria should respond to passive energy and have minimal use of active energy for economic viability and reduced environmental depletion. According to Ogunsote et al (2011), passive cooling designs (climate responsive designs) refer to technologies or design features used to cool buildings naturally without power consumption i.e. without the use of active driven mechanical devices. They are based on the way a building form and structure is designed to moderate the climate for human good and wellbeing.

The key to designing a passive building is to take the best advantage of the local climate. This refers to any technologies or design features adopted to reduce the temperature of buildings without the need for power consumption. Passive cooling uses free, renewable sources of energy such as the sun and wind to provide cooling, ventilation and lighting needs for a household. This additionally removes the need to use mechanical cooling. Applying passive cooling means reducing differences between outdoor and indoor temperatures, improving

indoor air quality and making the building both a better and more comfortable environment to live or work in.

Climatic Condition Of Study Area

The weather variables of rainfall, humidity, temperature, solar radiation in the Niger Delta, specifically in Port Harcourt are primarily as a result of the interplay between two major pressure and wind systems. The moist South-West wind transports its moisture to Port Harcourt (Nigeria) along the coastline. This airstream blows over the area between February and October. This is the wet season in which the region receives its rains (Ayoade et al., 1991). Conversely, the North-East trade winds bring dry conditions, having passed over the hot dry Sahara desert to reach Port Harcourt from the North. This air blows over Port Harcourt between November and February during which the area experiences its dry season (Sheriff, 1991; Ayoade et al., 1991).

Statement of Problem

For the purpose of this dissertation, the basic architectural problem the author intends to solve is THERMAL DISCOMFORT of the internal spaces. Thermal comfort is a conductive temperature degree in an enclosed facility at almost every time in the building suitable to the human senses. Mostly in recent times, a large hall in our tropical area suffers much discomfort, especially during hot weather.

Aim of the Study

The aim of this paper is to test the usefulness of applying selected passive cooling strategies to improve thermal performance and to reduce the energy consumption of public halls in hot regions. It will be showing details and analysis of bringing sure thermal comfort in buildings.

LITERATURE PREVIEW

Energy efficiency simply means using less energy to perform the same task – that is, eliminating energy waste. Energy efficiency brings a variety of benefits: reducing greenhouse gas emissions, reducing demand for energy imports, and lowering our costs on a household and economy-wide level. While renewable energy technologies also help accomplish these objectives, improving energy efficiency is the cheapest – and often the most immediate – way to reduce the use of fossil fuels.

Unlike subtropical regions which are characterized by variations in temperature to different degrees and day length, temperatures in tropical climates, remain relatively constant all year long as variations for different seasons are dominated by rainfall. Tropical climates comprise only two seasons which are the dry season and the wet season.

The Tropical Climate

Much of the equatorial belt within the tropical climate zone experiences hot and humid weather. There is abundant rainfall due to the active vertical uplift or convection of air that takes place there, and during certain periods, thunderstorms can occur every day. Nevertheless, this belt still receives considerable sunshine, and with the excessive rainfall, provides ideal growing conditions for luxuriant vegetation. The principal regions with a tropical climate are the Amazon Basin in Brazil, the Congo Basin in West Africa and Indonesia.

Because a substantial part of the Sun's heat is used up in evaporation and rain formation, temperatures in the tropics rarely exceed 35°C; a daytime maximum of 32°C is more common. At night the abundant cloud cover restricts heat loss, and minimum temperatures fall no lower than about 22°C. This high level of temperature is maintained with little

variation throughout the year. The seasons, so far as they do exist, are distinguished not as warm and cold periods but by variation of rainfall and cloudiness. Greatest rainfall occurs when the Sun at midday is overhead. On the equator, this occurs twice a year in March and September, and consequently, there are two wet and two dry seasons. Further away from the equator, the two rainy seasons merge into one, and the climate becomes more monsoonal, with one wet season and one dry season. In the Northern Hemisphere, the wet season occurs from May to July, in the Southern Hemisphere from November to February.

RESEARCH METHODOLOGY

This part includes the research strategy, the research method, the research approach, the methods of data collection, the selection of the sample, the research process, the type of data analysis, and the research limitations of the project.

Sourcing of information is the backbone of a successful research work.

This project research made use of primary and secondary sources of information.

The research methods used included:

- Direct interviews and inquiries from people.
- Visit to and critical analysis of existing projects.
- Use of existing literature from publications, magazines, and unpublished materials.
- Use of the internet for further information and data collection.
- Consultations with my project supervisor.

ANALYSIS

According to Mohammad (2012), Maintaining a comfortable environment within a building in the tropics depend on how well heat gain into the building can be minimized and dissipating excess heat from the building, i.e. to prevent ingress of heat and swift removal of excess heat once it has entered is the basic technique for accomplishing thermal comfort in passive cooling concepts. These techniques are further stressed below.

Passive cooling through the prevention of heat gains in buildings.

The climate of the warm humid zone (Tropics) is characterized by high rainfall, high humidity and relatively high temperature which was put at between 300c -350c and is fairly even throughout the day and throughout the year, the solar radiation is intense and hence should be prevented from entering into the building SKAT (1993).

Ogunsote et al (2011) further stressed that preventing heat from entering the building should be the first concern and not how to cool down the building i.e., if excessive heat can be minimized, then the problem of cooling down the building will be half solved. The important methods of reducing heat gains in buildings such as shading, vegetation (landscape), building orientation, use of high thermal mass to reduce heat absorption, insulation, etc. are further discussed.

Shading.

Among all other solar passive cooling techniques in the tropical region, shading is considered to be the most effective and should be the first line of defense if the ingress of solar gain is to be minimized in buildings. Kumar, Garg& Kaushik (2005) in their studies revealed that shading reduces the indoor temperature by about 2.50c to 6.80c more than other passive cooling techniques. Mohammad (2012) also posited that shading of buildings is cheaper,

effective and easy to implement than every other passive cooling techniques. Shading can be achieved through the following:

Shading using trees and shrubs

Trees and vegetation are most useful as a mitigating strategy when planted in strategic locations around buildings in the tropical regions; they lower surface and air temperatures by providing shade and through evapotranspiration (Akbari& Kurn, 1997). Evapotranspiration alone can help reduce peak summer temperatures by 2-90f (1-50c) (Huang, Akbari& Taha, 1990). Trees with wide shading crowns protect roofs, walls, and windows from direct solar gains and can reduce surrounding air temperature significantly (SKAT, 1993).

Shading by overhangs and fins.

Fins and overhangs act like caps and help in blocking direct sun rays. Fins and overhangs if properly designed can effectively reduce solar ingress and heat gain in buildings. The effective design of fins and overhangs depends on the solar orientation of the building façade (Mohammad, 2012). Types of fins include horizontal, vertical and egg-crate fins.

Proper landscaping

Incorporating shade through proper landscaping can reduce solar heat gain. Ogunsote et al (2011) affirmed that proper landscaping is an effective means of protecting buildings from direct solar radiation, which helps in minimizing heat gains and redirecting wind flow to enter the house for natural ventilation design. Proper landscape and vegetation create more physically comfortable and energy-conscious buildings in the tropics (SKAT, 1993).

Building orientation.

Orientation is the way a building is positioned on a site. Buildings orientated for passive designs provide good natural (passive) thermal and visual comfort. Proper building orientation in the tropics can be best achieved by positioning the longer side of the building

on the East-West axis; it helps minimize the radiation received by building walls and hence reduces energy use in buildings (Lawal (2008).

Wind orientation

Wind flow is the movement of air in and around buildings. To achieve passive cooling and energy-efficient buildings, wind orientation should be incorporated at the early stage of settlement planning and building design. (SKAT 1993) suggested an open settlement pattern in the tropics to avoid wind flow from being impeded.

Interior rooms should be crossly ventilated and windows should be designed along the windward sides of the site and not the leeward sides

Thermal insulation, reflective roofs, and wall colours.

According to SKAT (1993), thermal insulation has little effect if wind orientation is properly incorporated in designs; but has a great effect in places where solar radiation is received. Reflective ceiling and roof coatings are easy ways of reducing roof overheating and heat transmission into the building through the roof. This goes a long way in reducing the need to cool down the building (House-Energy, 2010). Wall and surface colours also play an important role in absorbing and reflecting heat. Ogunsote et all (2004) stressed that walls should be in light colours to reflect heat, boundary walls and hard landscapes should be in dark colours to absorb heat and avoid reflecting heat and glare. This will mitigate against heat build-up in buildings in the tropics.

Heat storage and time lag.

In the tropical climate, construction with materials characterized by high thermal storage capacity and long time lag should be avoided because it would cause undesirable re-radiation of heat at night thereby causing hot discomfort in buildings (Lawal, 2008).

Wind Tower

Wind towers or wind catchers are small towers installed on top of buildings; they serve as natural ventilation systems by directing the outside air into the building. They have been used for the ventilation of buildings in the tropics and arid regions for centuries (Bahadori& Dehghani-Sanij, 2014).

Air vents

Air vents are used for passive cooling and dehumidification in the tropical regions in areas where dusty wind is severe. Air vents are protected holes provided in the apex of a dome or a tower which helps in introducing ambient air free of pollutants into the space.

The introduction of ambient air will help to improve indoor comfort by providing ventilation and dissipating hot air collected at the top. Other natural means of dissipating heat from buildings include courtyards solar chimney, Radiative cooling, Diode roof, roof pond, rainwater recycling, use of biogas, etc.

CONCLUSION AND RECOMMENDATIONS

Energy-efficient buildings are designed in a way that ensures that energy usage in buildings is reduced to the barest minimum; this will help reduce the capital cost incurred on purchase of mechanical equipment, recurrent cost incurred on equipment maintenance and energy consumed. Several studies have shown that the best possible way by which energy efficiency can be achieved in buildings is by adopting passive design techniques (climate responsive design) - passive designs techniques refers to design features or technology used in heating or cooling buildings naturally without power consumption, this will not only ensure less energy consumption but will also reduce the amount of emitted co2 waste causing environmental degradation and climate change.

This paper has reviewed and discussed several passive cooling techniques that can be imbibed in designs in Nigeria if these techniques are properly used they will significantly reduce building cooling loads and correspondingly reduce the prevalent use of air conditioning and other energy-dependent systems. We are strongly suggesting that:

1. Designers of buildings in Nigeria should make achieving passive solar energy-efficient design their top aim while designing rather than aesthetics, and passive design strategies should be incorporated from the outset.

2. Nigerian government should create awareness on the benefit of energy-efficient buildings over non energy-efficient ones, they should also subsidize energy-efficient materials and create enforceable legislation banishing abusive use of energy as this is the only way environmental problems due to excessive energy use can be avoided.