IMPORTANCE OF CLIMATE TO ARCHITECTURAL DESIGNS IN NIGERIA

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ABSTRACT

Among the basic necessities of life is shelter, after food, housing has always been rightly assumed to be the next essential human need. As a result of this, the construction of buildings in which people live and work has been a major concern since the early times when human being first made huts of stick, mud or rock. It later developed into the use of bricks, stones, timber, organic and inorganic wastes. This paper focused on the need to develop and design an appropriate building suited to their purpose, taking into cognizance the various environmental elements acting on the structures. The research method adopted for this paper was based on an in depth literature review. This paperreiterated the need for architects/designers to design in relation to climate, in order to achieve pleasant, comfortable and conducive structures that ensure physiological and psychological comfort of the occupants. As a result of which, there will be a reduction in substantial amount expended by people to achieve thermal comfort within and around the building, through the use of mechanically controlled measures. This study concluded by giving appropriate design guidelines and recommends that designers/architects should be equipped with the climatic data required for appropriate architectural designs which will help in the evolvement of designs that best suite the various climatic zones of the country identified.

Keywords: *Housing, Environmental elements, Climatic zones, Climatic data, Thermal comfort, Design to climate.*

INTRODUCTION

Environment according to Hornsby (1990) is defined as surroundings, circumstances or influences. Encarta (2005) also defines environment as the physical and material bases of life, including land, air and water as well as the vital material resource and energy in the surrounding of a society. Fadamiro (1998) described environment as "the aggregate of all external conditions and influences affecting the life and development of organisms. It includes living and non-living which influence the life of a man as an organism.

Roaf, Fuentes and Thomas (2002) define Buildings as parts of complex interactions between people, the buildings, the climate and the environments. He stressed further that buildings are only parts of our habitat and are intimately linked to the local, regional and global environments that are all parts of our Ecological Niche. It is the responsibility of our generation to adapt to our buildings to ensure that we can stabilize climate change, that we can live without fossil fuels and that we

do not unsustainably pollute the environments. The natural environment consists of all living organisms which are deeply interdependent on one another for continued survival of life on earth. It does not however preclude those facilities used by these living organisms to enhance their quality of lives. Also, the natural environment has a deep influence upon the thinking of human beings and the way of life, hence human environment is not independent of each other, but are intimately connected and deeply influenced by each other. The concept of Environmental determinism is expatiated thus the effect that the environment has on the actions and character of people and their societies are determined by environmental factors. However, Aribigbola (2000) succinctly describes shelter as the physical shells or the physical elements of housing that protect people from climatic elements such as rain, sun, wind, lighting, among others.

The knowledge of the relationship between these environmental element vis-à-vis buildings is a fundamental requirement for architecture in Nigeria. Olotuah (2001) buttresses this by saying that the design of pleasant buildings that ensures physiological comfort of users is only achieved through an understanding of the climate and environment (the adjacent system) and the human responsive systems. However, the environmental element includes the weather and climate. The variations in the state of the atmosphere from time to time and from one place to another are described by the two word but they are both concerned with temperature, rainfall, pressures, winds and so on. Jennings (1980) defines weather as the actual state of the atmosphere at a particular moment or over a short period of time. Thus, a sudden shower, an unexpected snow-storm or a dense fog are all illustrations of weather conditions. He further describes climate as the state of the atmosphere that may reasonably be expected to occur at a particular place over a long period usually a month or a season. Umoh (2000) states that Environmental parameters, which affect houses, are temperature, humidity, sun radiance and wind speed.

Succinctly put, climate and weather are the major environmental factors which directly affect building forms and designs. Umoh (2000) stresses this building of houses has long been recognized as a function of climatic regimes. In Nigeria, there are different climatic zones which dictate the different architectural design remedies. Ogunsote (1991) identifies six climatic zones which are: the coastal zone, the forest zone, the transitional zone, the savannah zone, the highland zone and lastly the semi-desert zone. These climatic zones help parade a wealth of traditional house forms in traditional architecture, reflect the lifestyle of people and are symbols of heritage of the people, Olotuah (2001) expatiates.

In the process of the efforts of the occupant to achieve and maintain thermal comfort in a faulty/poorly designed buildings; it has been discovered that a lot of resources are continually wasted to acquire mechanically controlled measures (air conditioning, fans, heaters etc.). This leads to increase in domestic energy consumption. This is buttressed by Opoko (2001), thus: in order to satisfy this vital need, modern buildings have had to rely on artificial or mechanical means of indoor cooling, which

increase the cost-in-use of buildings. She furthermore points out that high proportion of energy used in modern building goes towards the moderation of indoor climate, a function which in many cases could have been satisfied at the planning and design stages. It is in this regard that this paper focuses on the importance of climate to design, at the end, functional and well adapted building forms and designs to various environmental zones of Nigeria will be evolved. Hence, saving a lot of money needed to provide the desired environmental comfort.

Passive Solar Housing

Lawal and Makinde (2007) described passive solar housing as that built in tune with indigenous resources as symbolized and exemplified by the sun and the climate. These are self- sufficient buildings which rely on natural principles instead of mechanical systems to provide a non-polluting source of cooling. In the same vain the importance of buildings are as follows:

a) Buildings are used to provide shelter for man and maintain the environmental conditions that determine the quality of life required for his existence.

b) Buildings are used to provide the micro climate required for human existence. To buttress this Olanipekun (2002) observes that buildings are essential modifiers of the micro-climate, a space isolated from environmental temperature and humidity fluctuations, sheltered from prevailing winds and precipitations, and with enhancements of natural light.

c) Buildings should respond to passive energy and have minimum use of active energy for human comfort.

Passive Solar Energy/Design Strategies

Ortner (2001) describes passive solar energy design as architectural means of constructing comfortable interior environments by building with natural equipment, without the use of mechanical equipment. According to Lawal and Makinde (2007), all buildings are expected to be passive to the extents that without the use of mechanical systems driven by remote energy sources all buildings should produce comfortable interiors climate". Passive design is about taking advantage of natural energy flows to maintain thermal comfort. It is about using the appropriate building orientation, building materials and landscaping. The buildings should be properly oriented and the fabric of the building envelope should be specified to prevent or minimize heat gain. Shading should be provided to minimize solar radiation.

However, the selection of materials used in the design of buildings can make a significant impact on reducing green-house gas emission by choosing environmentally preferable products. Practical strategies for reducing greenhouse gas emissions include comparing materials and components, construction systems and products, energy/water saving features and devices. Conclusively, the five things an Architect/Designer needs to know for a good passive solar design according to Roaf, Fuentes and Thomas (2002) are:

- How strong the sun at the site is at different times of the year?

- Where the sun will be at different times of the year in relation to the site?
- How much of the sun's heat a building will or will not need at different times of the year to enable the building occupants to be comfortable?
- How much storage capacity the building should have in relation to the available solar gain at the site to meet those needs?
- What additional requirements are for controlling the heat gain from direct solar radiation, convection or conduction in a design and how they can be met by envelope performances, building form and ventilation?

Nature and its Role in Architecture

Imaah (2008) explaines the effect of nature and its nurturing role in architecture thus: the synthesis of nature into architectural composition and construction comes in various marvelous ways, which are now influencing bionics, bio-mimetic, tectonics and construction technologies globally. He stresses further that the interrelationships of nature and architecture may fall into three broad groups, namely:

(i) Construction techniques and tectonics, which enable people to synthesis the structural arrangements of living organism and plants into architecture.

(ii) Climatology, which studies the reactions of plants, living organisms to climatic conditions such as sunshine, temperature, moisture, relative humidity and wind, enables us to transfer the results to suit man through an acclimatized architecture.

(iii) Aesthetics, as the art and science of the beautification or ugly, which stimulates and rejects the repulsive from the nebulous natural examples of adaptable beauty and repulsive ugliness, enables us to design naturally beautiful architecture.

ADOPTED CLIMATIC ZONES OF NIGERIA FOR STUDY

The examinations of the environmental elements by this paper are done by classifying Nigeria into two major climatic zones. These are:

Warm Humid Zones of Southern Nigeria: The warm humid zone of Nigeria lies within the sub-equatorial rainforest. It has the low-wet climate of the tropics. The warm humid zone encompasses the coastal region, forest and the transitional regions. This zone covers towns like Calabar, Port Harcourt, Warri, Lagos, Ikeja, Ondo, Benin, Ibadan, Osogbo, Lokoja, Ilorin, Enugu and Makurdi among others. Along these areas of the south, the equatorial maritime air mass influences the climate of the zone. This zone experiences heavy rainfall usually between 1000mm and 1250mm and at times above 1250mm for the swampy areas around Niger Delta. The climate is characterized by high humidity and is associated with hot discomfort for about eleven months in a year. The main rain occurs between April and October, and the maximum temperature never falls below comfort limit.

It should be noted that as one moves from the coast to the other interior the rainfalls decrease, until one gets to the North-East around Lake Chad. In addition to

this, the vegetation zones are arranged in sympathy with the rainfalls zone. This is the reason we have the swamp forest, evergreen rainforest and open forest in this zone.

Hot Savannah zone of the Middle Belt and the Northern Nigeria: This zone has a climate that is characterized by a long dry season (and consequently a brief rainy season) associated with cold and dry harmattan wind, high temperature range (owing to hot afternoons and cold nights) and intense sunlight. This zone covers the savannah region, highland region and semi-desert region. It includes towns like Abuja, Minna, Zaria, Yola, Maiduguri, Kano, Sokoto, Yelwa, Kaduna, Katsina, Nguru and other mountainous regions along the Cameroonian border. These areas are associated with cold nights and hot days alternate for six to ten months of the year, and characterized by low rainfall. Hot and humid conditions are experienced during one or two months. There is a cool climate found at high altitudes around Jos Plateau, Manbilla Plateau and other mountainous regions, around here monthly rainfall exceeds 200mm for three or more months.

In related developments, the vegetations in this zone comprise the Guinea, Sudan Savannah and Sahel Savannah. These come as a result of long dry season. The vegetations in Guinea savannah are thicker than the Sudan because the rain there is heavier. In both places, the rain is just sufficient for fairly tall grasses and scattered trees. In the North Eastern part around Lake Chad is the presence of Sahel Savannah due to lightness of rain. The rain is less than 500mm a year. Both the short grasses and the few trees found here are thorny.

HUMAN THERMAL COMFORT

Comfort is the maintenance of thermal balance between human body and the environment. Opoko (2001) submittes that the fundamental function of buildings is the protection of man from the vagaries of inclement weather while Ogunsote (1991), explaines that knowledge of nature of comfort is essential in design with climate with the aim of maintaining comfort within buildings. In his views, six major factors exist that affect thermal comfort: (i) Air temperature, (ii) The mean radiant temperature, (iii) The air velocity, (iv) The relative humidity, (v) The intrinsic clothing, and (vi) Level of activity.

The Air Temperature: This is an important factor affecting thermal comfort. When the temperatures are low, people feel cold and when they are high people feel hot. Comfort can approximately be achieved between 16^0C and 28^0C. Umoh (2000) expatiates thus Nigeria experiences high temperature all the year round. The highest air temperature is normally in April in the Northern Nigeria and a little earlier in the South. Minimum temperature on the other hand decreases northwards with the lowest mean of 21.1^0C on the coast less than 12.8^0C in the North.

The mean Radiant Temperature: Comfort can be achieved if the globe temperature is between 16^0C and 28^0C and if the differences between the mean radiant temperature and the dry bulb temperature are less than 5^0C.

Air Velocity: Air movement is very effective in increasing heat loss from the body at high temperature when sweating occurs. The air movement enhances the evaporation of sweat from the body thereby cooling down the body. Air velocity of up to 0.1 meter per second may lead to a feeling of stuffiness indoors. Air velocities of up to 0.1 to 1.0m/s are comfortable indoors when air movement is required but above this level there is discomfort. Out doors wind speeds of up to 2.0m/s lead to considerable discomfort.

The Relative Humidity: Adefolalu (1981) states that Relative Humidity (RH) is an important factor in human comfort and discomfort indices especially in hot climate. When there is low humidity the air is very dry and sweating is more effective in cooling down the body. On the other hand, when the humidity is high the air is damp and sweating is no longer very effective in cooling down the body. Umoh (2000) stresses further that in the coastal region, the months of June to October have monthly means over 90% while in the North during January to April mean values are close to 20% or 25%. Thermal comfort can be achieved when the relative humidity is between 20% and 90%.

The Intrinsic Clothing: The range of intrinsic clothing for thermal comfort is taken to be from 0.5 to 1.0 clo.

The Activity: the activity represents the metabolic rate. The higher the activity, the more heat is produced by the metabolic rate. Comfort can be maintained with metabolic rates from about 0.7 to 2.5 met.

CLIMATIC ELEMENTS IN FOCUS

The need to design architectural structures with climatic suitability parameters must be taken into cognizance in ensuring thorough organization and judicious use of space, the comfort of the users, and the functionality of the total environment in meeting the physiological, protective and social needs. The physiological conditions of comfort that constitute criteria in design, especially in the hot-wet climatic region include the followings:

Ventilation and Thermal Balance of Buildings: Ventilation is the replacement of used inside air by the outside air. The ventilation condition inside building is among the primary factors determining health, comfort and well being. Umoh (2000) buttresses this saying that primary factors have a direct effect on the human body through the physiological effect of air purity and motion and an indirect effect through their influence on the temperature and humidity of indoor air and surfaces.

However, Natural Ventilation is the ventilation achieved without mechanical aids, but by stacks effect and wind pressure. Cross ventilation is the ventilation achieved by placing openings in opposite walls of an enclosure. Olotuah (2001) cautions that the dwelling units should be planned so as to facilitate thorough ventilation as the deterioration in the physio-chemical properties of the indoor atmosphere can adversely affect the comfort of the occupants. He stressses further that ventilation has three distinctly different functions.

Supply of Fresh Air: The supply of fresh air is necessary in order to remove odour, excessive heat and smoke from room interiors which may cause suffocation. The requirement is governed by the type of occupancy, number and activity of the occupants and by the nature of processes being carried out in the space.

Convective Cooling: Convective cooling is a practical proposition in warm climates when the internal heat gain or solar heat gain through windows raises the indoor temperature higher than the outdoor air temperature. This can also be referred to as structural ventilation. The exchange of indoor air with fresh out-door air can provide cooling if the latter is at a lower temperature than the indoor air

Physiological Cooling: The movement of air past the skin surfaces accelerates heat dissipation by increasing convective heat loss and accelerating evaporation Szokolay (1973). This is to provide thermal comfort due to moist skin (thermal comfort ventilation). Encarta (2005), states that the Engineers estimate shows that for adequate ventilation, the air in a room should be changed completely from one and a half to three times each hour, or that about 280 to 850 litres (10 to 30cuft) of outside air per minute should be supplied for each occupant.

Thermal insulation: Thermal insulation is a device to ensure that the rooms interior are kept at reasonable temperature for comfort. Olotuah (2001), lists factors to be considered in achieving thermal comfort to include:-

a. The use of appropriate building materials
b. Volume of space enclosed
c. The number, type and size of window openings

Wind Pressure: A designer must determine the direction and speed among other things towards maximizing the wind in a building for the following reasons:

i Wind affects ventilation
ii Wind causes driving drain
iii Wind carries dust
iv Wind can be used for cooling effects
v It requires structure to be strengthened against wind-load.

Essentially, the primary aim of design is usually to maximize wind pressure for air movement, especially in the warm humid climate in the southern part of the country. The exception to this includes situations where the wind is dusty, cold and unwelcome, such as experienced during the harmattan. There are also cases where the wind is so strong that it causes destruction, tearing roofs off buildings for example in the Northern part of the country. Umoh (2000) points out that the pressure of wind upon buildings is very important for consideration. The building should be designed to withstand the maximum likely wind-speeds. According to him, the pressure of wind is proportional to the square of the wind speed, multiplied by a factor depending upon the shape of the construction. For a house, the dynamic wind pressure is about $14g/m^2$ for a wind of 1km/hour. It uses about $25kg/m^2$ in a 50km/hour.

SOLAR RADIATION AND DAY LIGHTING

Solar Radiation: Sunlight falling on a building raises indoor temperature in two different ways first by indirect radiation when incident solar radiation falls on external envelop of a building. The comprising energy that is absorbed raises surface temperature which in turn causeS heat to be conducted inward through the wall, roofs and openings. Secondly, by direct radiation whereby solar radiation falls on an opening. Depending on the material break, almost all the energy passes directly through the opening into the interior. Transparent materials absorb, reflect and transmit radiation, whereas all opaque materials only absorb and reflect. During cold weather, the radiation is a valuable free source of heat, but interior temperatures are above the comfort range, it only adds to the occupants discomfort; hence need to control, so as to reduce the impact of solar radiation on buildings especially in hot climates. Four main principles applied in the exclusion of solar radiation from buildingS include:

- Shading.
- Thermal properties of materials.
- Ventilation.
- Forms and orientation.

Umoh (2000), highlights that the solar radiation level in Nigeria is between 110kg - cal in South and 190kg - cal in the North

Day lighting: Daylight must be incorporated into the building design in such a way that the building and its indoor spaces would provide satisfactory visual and thermal environment. Daylight affects the Architect's choice of the basic building section, the building in indoor space and architectural elements to be incorporated into the design. Plant et al (2002), stressed that the following design factors must be taken into account in order to use daylight to an advantage.

- Variations in the amount and directions of the incident daylight.
- Luminance (photometric, brightness) and luminance contribution of colour, partly cloudy and over cast skies.
- Variation in sunlight intensity and direction.

Precipitation: Precipitation refers to rain, snow, hail and frost and is usually measured daily. In our climate, precipitation is usually equated to rainfall. The rainfall in Nigeria decrease both in duration and amount from the coast to the interior except where altitudinal effects create island of higher rainfall for instance, the Jos Plateau. The coastal region receives over 4,000mm spread over 8-10 months while the extreme north receives less than 250mm spread over 3-4 months. Rainfall has an appreciable effects upon the exterior of buildings, affecting the materials, water proofing damp courses. The mean monthly rainfall taken over a long period is very useful, especially for the determination of adequate roof slopes (Ogunsote, 1991).

Material Selection: The selection of material for construction is very vital in hot-humid climatic region of Nigeria for achieving optimum in and out comfort. In relation to this, a good knowledge of thermal properties is required before selecting the materials. The thermal properties of materials which affect the rate of heat transfer in and around the building and consequently affect the thermal condition and comfort of the occupants include the following:-

i ***Thermal conductivity:*** this is the ability of materials to conduct heat.

ii ***Thermal stability:*** the ability of materials to retain its basic physical and mechanical properties and inner structure when heated.

iii ***Thermal resistance:*** this is the ability of material to resist heat flow.

iv ***Heat capacity:*** this is the ability of material to absorb heat when its temperature is raised.

v ***Surface coefficient:*** this determines the rate of heat exchange between the surface and the surrounding air.

vi ***Surface characteristics:*** this determines reflectivity, absorptive and emissive of a material, for example, colour, texture, etc.

EFFECTIVE DESIGN SOLUTIONS TO CLIMATIC ZONES

The warm humid region of southern Nigeria: In this region, main requirements necessary for the physiological comfort of occupants are:

Cross-ventilation: As a result of intense solar radiation leading to an increase in temperature, the relative humidity of the atmosphere also increase, thus the air becomes saturated with solar vapour and the air becomes moist. Hence, cross ventilation is necessary to ensure adequate comfort.

Thermal Insulation: Thermal insulation prevents the room interior from being heated up by the hot tropical sun, thus preventing it from being unduly uncomfortable. This is resolved through the use of wide openings. This indicates that the openings should be large and situated preferably in the North and South walls. Olotuah (2001) emphasizes that the use of wide opening in rooms which all require privacy and security makes it expedient to group rooms around a central country and with a wide verandah running around it. This is one of the factors responsible for the evolution of the courtyard, a dominant feature in Yoruba tradition architecture. Since maximum monthly temperature never falls below comfort limit, no special precaution need to be taken against cold discomfort. Also, despite the warm and humid nature of the climate, thermal storage is still needed for two months of the year.

Site Planning (Forms and Orientation): The layout of buildings should expose a small port of the building surface to the western sun as much as possible. Hence, the building should be oriented in North-South with the longer axis-facing East-West direction. This will enable the building to make best use of the south westerly wind which is favorable to the occupants, thereby minimizing the effect of solar radiation on the building. Also, spacing of buildings should allow breeze penetration and single banking should be used.

Protection against heavy rainfall: Rainfall has an appreciable effect upon the exterior and interior of buildings in this region, as it affects the materials, water proofing, and proof damp courses. Buildings in this region should be protected from heavy rainfall as a result of heavy down pours. The consequence of this is the high pitched roofs with wide roof overhangs of buildings facilitating quick rainwater disposal and protect the exterior house walls from brunt of rainfall. Design that guard against rainfall effect should be adopted; this dictates the discouragement in the use of flat-roofs (roof-slope of angle less than 10 degrees).

Adequate drainage: is also necessary as a result of erosion and flooding which are functions of excess surface rainwater.

Protection against solar radiation: Sun-shading device is one of the design recommendations that are applicable to all regions all over Nigeria, because of the nature of climate that is being experienced. Shading device shields buildings surfaces and interior space from solar radiation. Their effectiveness depends on their location, orientation and form. Exterior shading devices are more efficient than those within building walls. This is so because they intercept the sun's radiation before it can reach the building surface. However, the design of external shading device in warm humid areas of the southern Nigeria is desirable to exclude the sun throughout the year for thermal comfort. External shading device include curtains, glass, solid or louvered shutter, security bars and mosquito screens, all performing the following functions.

- Allowing a view out
- Protection from rain
- Protection from direct solar radiation
- Protection from sky glare

The use of outdoor space like overhangs, verandahs, balconies may be adopted for sun protection. Others may include the use of vertical devices, horizontal devices or combination of both (Egg-crate devices).

CHOICE OF APPROPRIATE CONSTRUCTION MATERIALS

The climatic requirements can be met through the use of appropriate construction materials and methods. Apart from the envelope, the materials within the internal space for example, floors, partitions, furniture, requirements, luggage etc. also modify the indoor temperatures by affecting their respective thermal properties. When the indoor thermal conditions are not controlled, the materials affect the temperature of both indoor air and surfaces, thereby affecting the occupancy comfort significantly.

Ogunsote (1991) reiterates that walls and floors should be of lightweight and short-time lag. Roofs should be light with a reflective surface and cavity. Wall and roof finishes should be light in colour. Wall should be adequately protected against driving rain. Lesiuk (2002) also identifies special problems of materials choice and assemble details because of high humidity in the warm insects and pests must be

included in materials tasks. Choice of building materials should recognize that high humidity accelerates mould and aid algae growth, rusting, rotting and organic decay.

Hot Savannah of the Middle Belt and the Northern Nigeria: The climate of this region, calls for design solutions that can vitiate cold and biting winds while providing a cool respite from the intense heat of the mid-day sun. The impact of solar heat is enormous and has to be contended with in achieving comfortable room interiors. Meanwhile, the main design task in this region is to reduce the impact of solar radiation vis-à-vis heat gain and glare. Also, adequate control of ingress of hot, dust and sand laden air into the built environment especially the building interior is equally important for comfort. The following are the main requirement in this zone.

Ventilation: Though, there is need for ventilation in this zone, but it is not a primary design consideration when compared with the southern zone of the country. Agarwal and Komolafe (1983) add that deliberate effort should be made to reduce the inflow of air into the building, because inflow air introduces sand into the building interiors. For this reason, window areas should not be more than 40% of the floor area they serve. Window areas as small as 15% of floor areas they serve are considered adequate for indoor thermal comfort. Olotuah (2001) emphasizes further that cross-ventilation is not a design consideration in this zone because the air outside is rather hot and introducing this will lessen the advantage gained during the day from the massive heavy weight construction of the building.

Thermal Insulation: The design solution sought for circular building form with minimum wall openings. Due to circular form, thermal radiation is concentrated in the central enclosed interior space. Thermal conditions therefore dictate that openings should not exceed the minimum size needed for good day-lighting. Thus, the openings are usually small and situated high in the walls of the building. The size also helps in curtailing the incursion of dust and sand, in addition, the more the size of opening the greater the need for shading. Opoko (2001), while explaining the benefits of thermal insulation states that thermal storage is needed for cooling interiors in the day and for providing warmth at night. Other essential features of houses in this zone which will make for thermal comfort include roof overhangs, verandahs and loggias. These will shield the building interior from direct sunlight and glare part from providing out-door relaxation spots.

Site Planning (Forms and Orientation): The design of buildings should be compact and inward looking; provisions should be made for courtyards. These should be small in order to obtain maximum shading and retain coolness within the compound. Air movement is not a prerequisite for comfort. So compact planning will economize land usage and help conserve heat. For the same reason double banking should be used. It is very important to provide shade trees, water bodies, shrubs etc. North-South orientation is recommended for buildings in this zone of Nigeria. Since the sun-path across this zone is East-West, this orientation reduces the amount of solar radiation which external walls are exposed to. Though in practice, it may not be

feasible to achieve the North-South orientation due to other design considerations. In such instances, the best compromise orientation should be adopted.

Protection Against Solar Radiation: Opening in this zone should also be protected against sun and rain penetrations. Hence this calls for sun-shading devices. Other areas that need to be shaded include all outdoor spaces like courtyard, verandah, patio etc.

Choice of Appropriate Construction Materials: The selection of appropriate construction materials is essential in Architectural design. Opoko (2001) affirms that a good knowledge of thermal properties is required before selection of materials for this zone. What is required are materials which can minimize heat transfer into the building interior. These are essentially materials, which are poor conductors of heat or have good reflective capacities. Thermal properties of building materials can further be enhanced by coating them with white and other colors which possess high reflective qualities.

The aforementioned had explained why mud has been used indigenously for walls in hot Northern Nigeria, because of its heat resisting properties. Mud is a dense (heavy weight) material and has a very high heat storage capacity. It takes a considerable time to heat up and it takes long time as well to cool down again. It has a great advantage in hot dry regions, particularly because of temperature differences of the afternoon and the night. The heat absorbed slowly in the afternoon is dissipated slowly into the room interior warming it up at night. Walls, floors and roofs in this zone should be heavy with high thermal capacity and a time lag of over eight hours.

CONCLUSION AND RECOMMENDATIONS

One of the primary functions of any building is to counteract at least some of the main disadvantages of the climate in which it is situated. The buildings regardless of the climatic zones found should be able to filter, absorb or repel climate and other elements according to their adverse or beneficial contribution to the thermal comfort of its inhabitants or users. Hence, in designing to achieve thermal comfort, determination of the relationship between climate and architecture as well as the formulation of the guides for architects in the different climatic zones should be given adequate attention.

Conclusively, all architectural designs according to Roaf, Fuentes and Thomas (2002) should be based on (i) design for a climate, (ii) design for the environment, (iii) design for time, be it day or night, a season or the lifetime of a building and (iv) design for a building that will adapt overtime. It is therefore believed that, if all the design guidelines discussed in this study are strictly adhere to, cost of creating a conducive interior through the mechanical control measures like air-conditioning, extractor fan, heater etc. to maintain a thermal comfort in Nigeria will be reduced to the barest minimum. At the end, healthy buildings will always be evolved by the new generation Architects for any climatic zones of Nigeria. To create effective architectural designs, this study recommends the following:

(i) Appropriate considerations should be given to location, climate, culture, available local resources and expertise among others while designing for the designers/architects to provide the fundamental function of buildings.

(ii) Architects/designers are advised to obtain basic climatic data from meteorological stations nearer to the proposed site and analyze such data for climatic design.

(iii) Climatic site analysis should be carried out which will provide design guidelines for layout, orientation, spacing, cross ventilation, treatment of spaces between buildings, shade trees, courtyards, shape and height of the buildings as well as house form. The site climate deals with ground cover and the topography which differs from that obtained from the meteorological stations.

(iv) Security bars and screen should be installed for security reasons. Though screens reduce the ventilation and day lighting, this could be compensated for in the window design adopted.

(v) Equally, proper sensitization programmes in the rural communities should be organised for the rural architects who build local (mud) houses using local resources. Such programmes should be simplified and translated in their local vernacular.

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