EXPLORING BUILDING ENVELOPE DESIGN FOR WARM HUMID ZONES TO OPTIMIZE INDOOR THERMAL COMFORT IN THE DESIGN OF A PROPOSED LEKKI FREE TRADE ZONE RESORT, LAGOS

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NIGERIA.

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA

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NIGERIA.

APRIL, 2018

Declaration

I declare that the work in this Dissertation entitled 'EXPLORING BUILDING ENVELOPE DESIGN FOR WARM HUMID ZONES TO OPTIMIZE INDOOR THERMAL COMFORT IN THE DESIGN OF A PROPOSED LEKKI FREE TRADE ZONE RESORT, LAGOS.' has been carried out by me in the Department of Architecture. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this Dissertation was previously presented for another degree or diploma at this or any other institution.

Toyeeb Arowona		
Name of student	Signature	Date

Certification

This Dissertation entitled 'EXPLORING BUILDING ENVELOPE DESIGN FOR WARM HUMID ZONES TO OPTIMIZE INDOOR THERMAL COMFORT IN THE DESIGN OF A PROPOSED LEKKI FREE TRADE ZONE RESORT, LAGOS.' by Toyeeb AROWONA meets the regulations governing the award of the degree of Master of Science of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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Dedication

I dedicate this research work to Allah (S.W.T) for everything he has done for me. Alhamdulillah and thanks for everything Ya Allah.

Abstract

It is the responsibility of Architects to design buildings to achieve a comfortable indoor environment. In a bid to achieve this, Architects cannot neglect any part of the building envelope design. This is the reason why it is important to study the ways of achieving thermal comfort through envelope design in resorts. The aim of this project is to achieve an envelope design in terms of roofing and walling materials to give optimum indoor thermal comfort. The study was conducted by collecting climatic data from similar resort in the same climatic zone and checking the factors of thermal comfort and also simulating the indoor thermal comfort using different envelope designs. Conclusion drawn from, findings from this study indicate that though burnt bricks has an advantage of giving off heat as compared to sandcrete blocks in increasing comfort hours. Resort Buildings with bricks as wall material and clay tiles as roofing material showed a better performance in achieving optimum indoor thermal comfort by up to 7.14% more than the conventional sandcrete blocks and long span Aluminium roofing sheet. The implication of the study is that professionals especially architects could minimize the use of active means to achieve thermal comfort in indoor spaces by a good design and specification of thermal friendly materials.

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1.0 INTRODUCTION

1.1 Background of Study

Tourism and recreation are key aspects of human existence. The United Nations World Tourism Organization (UNWTO), (2010) reports indicate that tourism is amongst the fastest growing industries in the world. Tourism has benefits ranging from social to economic gains. Nigeria is blessed with abundant tourism potentials which are yet to be developed. Facilities such as resort centres can help in developing such potentials for Nigeria. A resort is a full-service facility that provides access to or offers a range of amenities and recreation facilities to emphasize a leisure experience and are characteristically located in vacation-oriented setting. (Brey, 2009)

Resort centres should therefore be optimized for thermal comfort .Thermal comfort was defined by the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE, 2009) as the "state of mind which expresses satisfaction with the thermal environment". Though it is difficult to satisfy everyone in a space due to physiological and psychological variation from person to person, thermal comfort is still one of the most significant factors affecting environmental satisfaction (Nazanin, Jones, & Knight, 2008).

It is important for architects and professionals of the building industry to consider the type of building material(s) to be used for buildings and the climate of the location under consideration in order to develop buildings which are optimized for thermal comfort. By doing this, there would be Comfort, good health and productivity of the building occupants. In the design of the built environment, good thermal comfort concept(s) should be adopted to allow for energy efficiency in order to meet the requirement of sustainable development. Thermal Comfort involves control of temperature, humidity, air motion and non-environmental factors such as dress and activity level of the occupants (McQuiston, Parker, & Spliter, 2005). Thermal comfort is maintained when the heat produced by human

metabolism and other components of the building are allowed to disperse, thus maintaining thermal balance with the surroundings. The users of the indoor environment generally feel better when the humidity is kept at about 50% RH. Higher humidity causes the building feel 'stuffy'. Furthermore, high humidity can contribute to the development of bacterial and fungal growth, especially in sealed buildings (ASHRAE, 2009).

This thesis collected and analysed data through simulation to help designers to improve indoor thermal comfort in resort which are recreational facilities.

1.2 Problem Statement

Resorts are part of tourism activities which have become a source of negative environmental and social impact by destroying the ecological system. Resorts are energy-consuming due to the adoption of foreign ideas that are alien to the environment, people and culture in order to achieve maximum leisure. This problem is compounded by non-functional designs which hardly cope with the climatic conditions and design requirements of their regions (Bromberek, 2009). It has therefore become a necessity to optimize passive thermal comfort systems in our buildings.

1.3 Aim and Objectives:

1.3.1 Aim

This work aims at exploring building envelopes that could be improved to achieve thermal comfort in resorts in the warm humid climate.

1.3.2 Objectives

i. To determine through literature, which materials are suitable for improving thermal comfort in the warm humid climate resorts;
ii. to study resorts and their designs within the context of building envelope for improving indoor thermal comfort; and
iii. to demonstrate through design, the application of these envelopes in designing a resort.

1.4 Research Questions

The research intends to answer the following questions:

i. Which materials help to achieve the best building envelope to optimize indoor thermal comfort in resorts located in the warm-humid zone of Nigeria?
ii. Can thermal comfort be achieved through envelope design to attain a comfortable indoor environment?

1.5 Scope of Study

The scope of this research would be restricted to a study of the roofing and walling materials of resort in the warm humid zone of Nigeria.

1.6 Justification for The Study

Resorts are for the purpose of relaxing from the Hustle of life. More than half of the activities in resorts are indoor activities which consume much energy in terms of achieving a thermally comfortable environment. There is therefore, a need for self-sustaining buildings with excellent performance that maximizes natural ventilation and natural sources of energy without relying on artificial energy for cooling, heating and lighting. This has inspired the researcher to embark on this research in order to come up with the best type of building envelope to improve thermal comfort which will in turn increase occupant's satisfaction.

2.0 LITERATURE REVIEW

2.1 Introduction

Based on literature that already exists, on enhancing Envelope Design for Resorts, this chapter aims at exploring concepts about the subject matter (Resort centres in Warm-humid zones) and other issues that relate to it.

2.2 Resorts

A Resort is a place established for activities such as holiday, entertainment and recreation. They provide an avenue of escape from the struggle of life. Resorts are located within tranquil environment that have natural attraction. Environments such as sea sides, mountains and rocks are good for the location of resorts as they pose as an attraction to people who need a place of tranquillity and security to relax and ease stress (Bonnier travel group, 2014).

A Resort is not usually operated by one company. Many organizations come together to contribute to the development of resorts by owning different sections of the resort. In the twentieth century, Resorts have evolved to be owned by individuals (Brey, 2009). Plate I shows one of the oldest seaside resorts in Europe which is an example of a type of resort.



Plate I: Heiligendamm in Germany, the oldest seaside resort in continental Europe.
Source: Wikipedia, 2015.

Towns that have resorts are called resort towns such as Sharm el Sheik in Egypt, Marrakech in Morocco, Dubai in the United Arab Emirates, and Cape Town in South Africa amongst others (Brey, 2009). Disney land world resort is a modern resort. Resorts increasingly attract visitors from around the globe.

Despite the advantages of recreation to other countries, lack or unavailability of funds has been identified as one of the major factors militating against the development of recreational/tourism culture. Recreational attitude surveys reveal that 60% of Nigerians interviewed indicated that they are hardly meeting up with the provision of basic needs (food and shelter) for their families (Igbojekwe, Okoli, & Ugo-Okoro, 2013). Basic economic principles tell us that most consumers have a limited income over any period of time they must therefore balance their needs and the costs of various products and services. Leisure is regarded as one aspect of "good life" hence, it is not on the priority list of most Nigerians. Most Nigerian families today, can hardly provide three meals in a day, the question of saving towards visiting places of historical importance and tourist attractions is not a priority". Therefore most resorts are targeted at the high income earners and foreigners (Igbojekwe, Okoli, & Ugo-Okoro, 2013).

Location of resorts is very important as this determines how much revenue is generated by such facility. Tourism in Nigeria booms mostly during festive periods therefore, keeping resorts in an operational state implies that the energy consumed by the facility is less than the revenue generated when there are no activities (Igbojekwe, Okoli, & Ugo-Okoro, 2013).

2.3 Types of Resorts

The main factor that differentiates resorts from each other is the type of activity which is carried out in such a facility (Palmer, 2012).

2.3.1 Destination resort

A Destination Resort is a resort that contains in and of itself the necessary guest attraction capabilities—that is to say that a destination resort does not need to be near a destination (town, historic site, theme park, or other) to attract its public. Plate II shows an example of a destination resort (Palmer, 2012). A commercial establishment at a resort destination such as a recreational area, a scenic or historic site, a theme park, a gaming facility or other tourist attraction may compete with other businesses at a destination. Consequently, another quality of a destination resort is that it offers food, drink, lodging, sports and entertainment, and shopping within the facility so that guests have no need to leave the facility throughout their stay. Commonly, these facilities are of higher quality than would be expected. Some examples are Atlantis in the Bahamas, the Walt Disney World Resort near Orlando, Florida, USA, Costa do Sauípe in Northeastern Brazil, Laguna Phuket in Thailand and Sun City near Johannesburg in South Africa.



Plate II: Destination Resort, Bahamas.
Source: Bonnier group, 2014.

2.3.2 All-inclusive resort

An All-inclusive Resort is a resort that provides the services of a common resort and should include lodging, unlimited food, drink, sports activities, and entertainment for a fixed price (Palmer, 2012). Plate III shows an all-inclusive resort. In recent years, the number of resorts in the United States offering all-inclusive amenities has decreased dramatically; in 1961, over half offered such plans and in 2007 less than ten percent still offer it. Some all-inclusive resorts are designed for specific vacation interests. For example, certain resorts cater to adults, while even more specialized properties accept couples only. Other all-inclusive resorts are geared toward families, with facilities like craft centres, game rooms and water parks to keep children of all ages entertained. All-inclusive resorts are also very popular location for destination weddings.



Plate III: All-inclusive resorts.
Source: Bonnier group, 2014.

2.3.3 Ski resorts

A Ski resort is a facility that provides skiing services and other services of a destination resort. These may include lodging and facilities adjoining a ski area. Some ski resorts offer lodging services on the slopes. Many ski resorts have other activities such as sledging, snow mobiling, horse-drawn sleds, swimming as shown in Plate IV. Ski resorts now incorporate

other activities to balance running cost during other seasons where the snow is not good enough for skiing (Brey, 2009)



Plate IV: Ski resort showing tourist skiing.
Source: Palmer, 2012.

2.4 Yun House Boutique Eco Resort

Is located in Xing ping Scenic area, Yangshuo, China. It was designed by Ares Partners and overs an area of 3000sqm. The facility is presently in a good state, making it fit to carry out its primary functions which includes relaxation, conferences, and a wide range of outdoor activities. Yun House is a boutique eco-resort nestled within a village at North Eastern part of Yangshuo which is situated along the dramatic landscape of the Li River. The site consists of nine renovated old farm houses and one new addition which functions as an all-day dining restaurant for hotel guests. Taking on a sensitive approach to the local culture with villagers still living nearby, the overall planning and landscape design blends into the original village structure without creating new boundary conditions to the villagers



Plate V: Yun House resort aerial view.
Source: Archdaily, 2015.

The Yun house Eco boutique rooms are separated from each other with rectangle shaped buildings as shown in Plate VI.

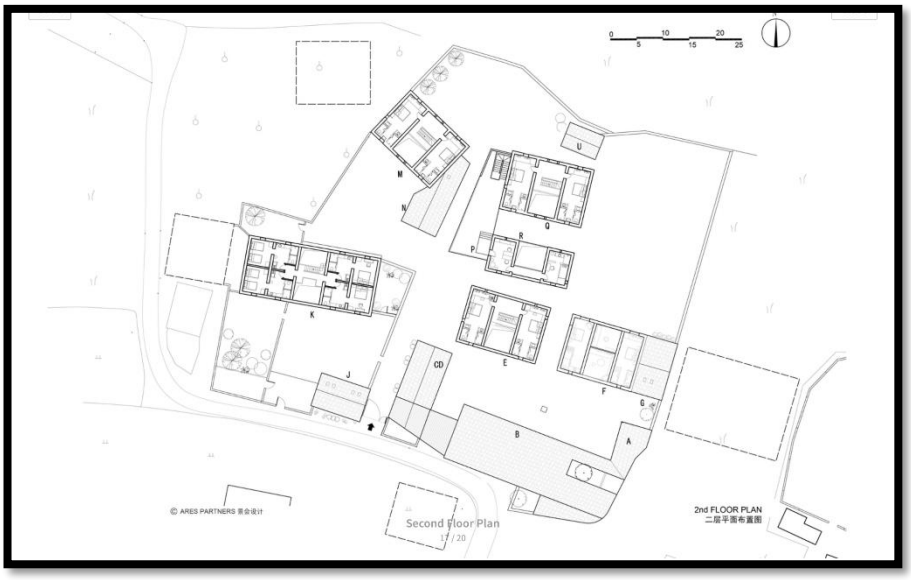


Plate VI: Site arrangement plan showing buildings on the site.
Source: Archdaily, 2015.

Terra-cotta roof tiles to provide a rich tactile experience and provide indoor thermal comfort by acting as an insulation against heat from the sun.



Plate VII: Terra-cotta roof tiles.
Source: Archdaily, 2015.

Brown colour allows for the reflection of solar insolation that in turn improves dissipation of the amount of heat absorbed into the building as seen in Plate VII. The roof has an overhang of about 600mm round the building which shades the building. Plate VIII shows the overhang of the roofs.



Plate VIII: Roof Overhang providing shading against solar insolation.
Source: Archdaily, 2015.

2.4.1 Construction technology /structural system

The buildings were constructed with rammed earth and retrofitted to accommodate refreshing and uncompromisingly contemporary living. The structural system of the building is a column/beam connection system (Arch daily, 2015).

2.4.2 Site planning and landscaping

The use of the soft landscape element has been properly put into consideration as only the vehicular routes and pedestrian walkways are covered with hard landscape surfaces which may also influence the microclimate of the region. There exists a very good relationship between buildings and the site by the provision of walkways (Arch daily, 2015).

2.4.3 Spatial organization

Zoning of the activities was properly done. After gaining access to the building, the car park is the first point of contact and zoned in such a way that vehicles do not have access to the other facilities. The reception is the next point of contact where all enquires are made and customers directed to their various points of interest (Arch daily, 2015).

2.5 Thermal Comfort

The hotel industry is one of the most energy-intensive subsectors of the tourism industry, with about 50% of the overall energy consumption due to space conditioning in a bid to achieve indoor thermal comfort (Bohdanowicz & Martinac, 2010). Thermal comfort was defined by the American society of heating, refrigeration and air- conditioning engineers as that state of mind which expresses satisfaction with the thermal environment (ASHRAE, 2009). Though it is difficult to satisfy everyone in a space due to physiological and psychological variation from person to person, thermal comfort is still one of the most significant factors affecting environmental satisfaction (Nazanin, Jones, & Knight, 2008). Thermal Comfort (TC) involves control of temperature, humidity, air motion and non-environmental factors such as dress and activity level of the occupants (McQuiston, Parker, & Spliter, 2005). TC is maintained when the heat produced by human metabolism and other components such as electrical instrument are allowed to disperse, thus maintaining thermal balance with the surroundings. The users of the indoor environment generally feel better when the humidity is kept at about 50% RH. Higher humidity causes the building to feel

‘stuffy’ (ASHRAE, 2009). Furthermore, it can contribute to the development of bacterial and fungal growth, especially in sealed buildings.

The air-conditioning and mechanical ventilation (ACMV) systems in the tropics can be very different from those of the temperate climate. Heat gain or loss beyond this will generate a sensation of dissatisfaction. The ideal standard for TC can be defined by the operative temperature. Based on ASHRAE Standard 55 (2009), “Thermal Environmental Conditions for Human Occupancy” specifies thermal conditions which will be acceptable to 80% or more occupants in a building if dressed appropriately. According to (ASHRAE, 2009) the acceptable operating temperatures and humidity in summer (light clothing, 0.5 clo) are 24-28°C with 30% RH and 23-25.5°C with 60% RH and air speed of <0.25 m/s (OSH, 2007). Humidity can increase wetness on different areas of the body, leading to a perception of discomfort. The metabolism rate fluctuates when a person performs certain activity, or under certain environmental conditions. The other personal variable that affects thermal satisfaction is the type and amount of clothing that a person is wearing. ASHRAE Standard 55 (2004) gives the conditions for an acceptable thermal environment.

2.6 Thermal Comfort Principles

According to Fangers (1970) the most important variables which influence the condition of thermal comfort are these six factors (Figure 2.1):

i. Activity level (heat production in the body)

ii. Thermal resistance of clothing (Clo value)

iii. Air temperature

iv. Mean radiant temperature

v. Relative air velocity

vi. Water vapour pressure in ambient air.

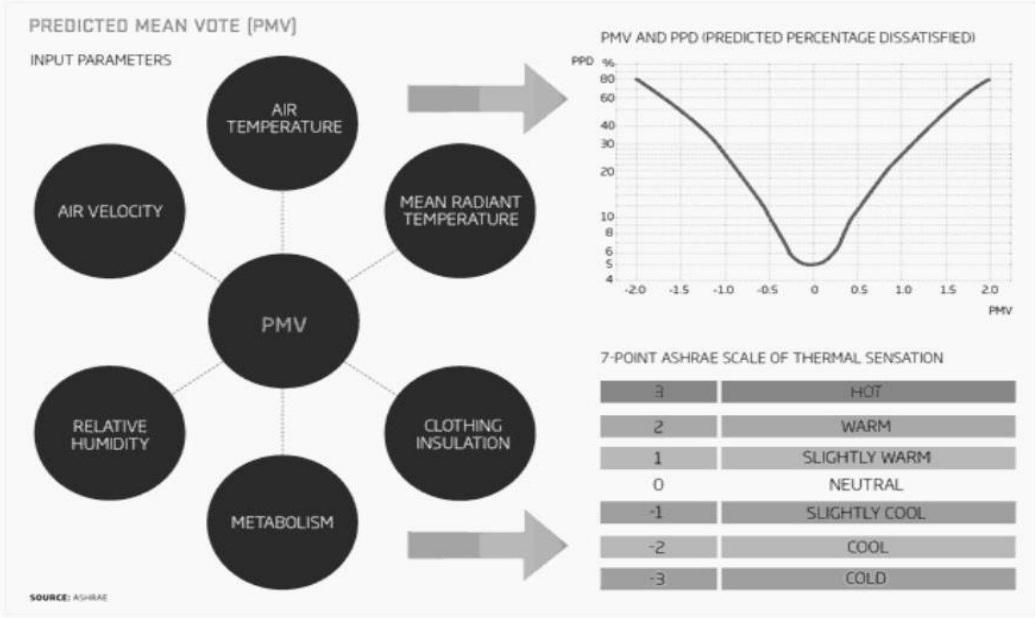


Figure 2.1: Fangers model (Predicted mean vote).
Source: (ASHRAE, 2009).

(Fanger, 1970) claims that if a group of people are exposed to the climatic conditions of the same room, satisfying everyone at the same time will not be possible because of physical variance. Accordingly, this means that thermal comfort for the highest percentage of the group should be aimed at if one wants to create optimal thermal comfort for the group (Fanger, 1970) also reports that the first aim of the heating and air conditioning industry is

to create thermal comfort for occupants. This approach produced a radical effect on the construction sector, the choice of materials and on the whole building industry (Fanger, 1970) . The same author also says that viewed from a wider perspective, the main function of buildings is to create comfortable shelters for their occupants which depend on their thermal surroundings.

Other researchers such as (Szokolay, 2008) and (ASHRAE, 2009) have grouped these variables that influence thermal comfort into three sets which are:

i. Environmental

ii. Personal

iii. Contributing factors

An agreement has been established about these variables in the above researches and the overall conclusion was that "these factors must be considered at an early design stage in the context of the local external climate, the function of the space and its location within the building that is because each building demands its own degree of comfort" (Szokolay, 2008).

The complex interaction between man and the environment has led to numerous studies by researchers from different disciplines; physiologists, psychologists, social scientists, environmental engineers and physicists (Hegger, Manfred, Matthias, Fuchs, Thomas, Stark, Martin, Zeumer, 2008). Each discipline has its own approach to defining thermal comfort. Thus, thermal comfort, as it is based on human subjective perception of a number of external influences such as physiological, psychological, and physical factors, can be perceived as a comprehensive context of the notion of thermal comfort (Figure 2.2).

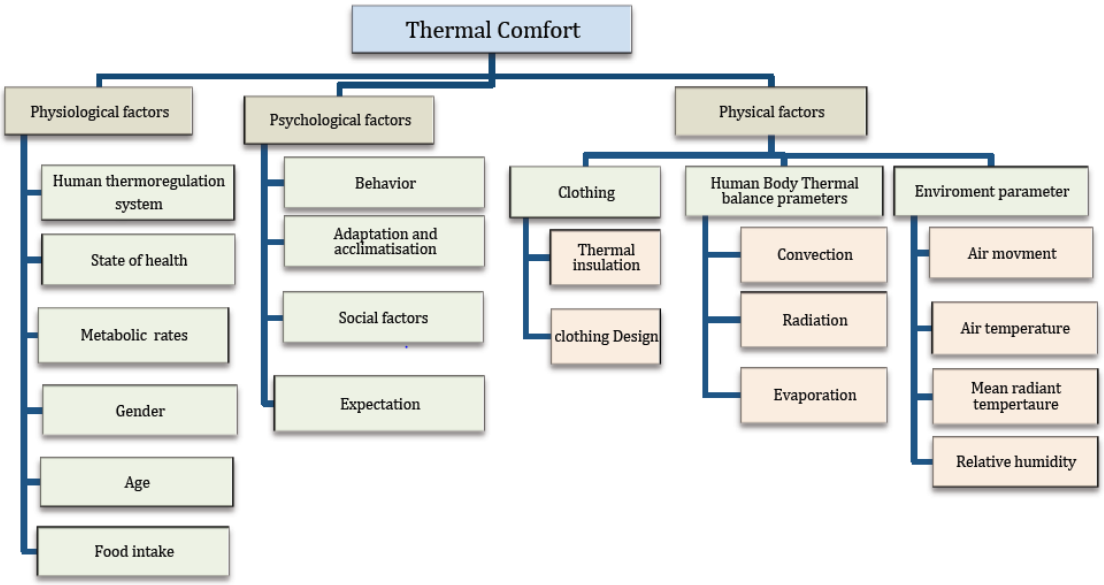


Figure 2.2: Factors affecting human comfort.
Source: (Hegger, et al., 2008).

2.7 Building Envelope

According to (Homeowner Protection Office, 2010), the building envelope includes all the building components that separate the indoors from the outdoors. Building envelopes include the exterior walls, foundations, roof, windows and doors. The performance of the building envelope is impacted by a number of sub-systems, such as heating, cooling and ventilating equipment, plumbing and electrical systems. The interaction of the sub-systems with the components of the building envelope, as well as certain activities of the occupants, can affect the performance of the building envelope.

2.7.1 Functions of the building envelope

According to (Homeowner Protection Office, 2010) The building envelope should keep out:

i. Extreme temperatures
ii. Moisture, as vapour or liquid
iii. Dust
iv. Wind

Additionally, to maintain durability, the building envelope should not permit weather elements to be trapped inside the walls. This may cause wall components to deteriorate and continue to decay. In the early stages, it can usually be remedied relatively inexpensively. However, as time progresses, costs increase exponentially (Homeowner Protection Office, 2010).

2.7.2 Design of building envelope

The overall design can help determine the amount of lighting, heating, and cooling a building will require. Architects and Engineers have developed innovative new ways to improve overall building design in order to maximize light and heat efficiency, for example through passive solar heating, which uses the sun's heat to warm the building when it is cold without relying on any mechanical or electrical equipment (Izzat, 2010). Local climate is an important determinant for identifying the design features that will result in the greatest reductions of energy needs. These may include such things as south-facing windows in cool climates and shading to avoid summer sun in warm climates.

Building envelope materials and product selection

2.7.2.1 Embodied energy

Embodied energy refers to the energy required to extract, manufacture, transport, install, and dispose of building materials, including those used in the building envelope. Efforts to reduce this energy use and associated emissions, for example through the substitution of bio-based products, can be made as part of a larger effort to reduce emissions from buildings (Izzat, 2010).

2.7.2.2 Insulation and air sealing

Heat naturally flows from a warmer to a cooler space; insulation provides resistance to heat flow, thereby reducing the amount of energy needed to keep a building warm in the winter and cool in the summer. Insulation is frequently discussed in terms of its ability to resist

heat flow, or it's R-value (Izzat, 2010). A variety of insulation options exist, including blanket, concrete block, insulating concrete forms, spray foam, rigid foam, and natural fibre insulation.

Adding insulation strategically will improve the efficiency of the building; however, it is only effective if the building is properly sealed. Sealing cracks and leaks prevents air flow and is crucial for effective building envelope insulation. Leaks can generally be sealed with caulk, spray foam, or weather stripping (Izzat, 2010).

2.7.2.3 Roofs

Roof design and materials can reduce the amount of air conditioning required in warm climates by increasing the amount of solar heat that is reflected, rather than absorbed, by the roof. For example, roofs that qualify for energy star are estimated to reduce the demand for peak cooling by 10 to 15 percent (Energy Star, 2010). Proper insulation is also important in attics and building cavities adjacent to the roof.

In addition, roofs also offer several opportunities for installing on-site generation systems. Solar photovoltaic (PV) systems can either be installed as a rooftop array on top of the building or a building-integrated photovoltaic system can be integrated into the building as roofing tiles or shingles (Energy Star, 2010).

2.7.2.4 Walls

Like roofs, the amount of energy lost or retained through walls is influenced by both design and materials. Design considerations affect the placement of windows and doors, the size and location of which can be optimized to reduce energy losses. Decisions regarding the appropriate material can be more complicated because the energy properties of the entire wall are affected by the design. Importantly, material selection and wall insulation can both affect the building's thermal properties (Energy Star, 2010).

A building's thermal mass i.e., its ability to store heat is determined in part by the building materials used. Thermal mass buildings absorb energy more slowly and then hold it longer, effectively reducing indoor temperature fluctuations and reducing overall heating and cooling requirements. (PEW Center, 2011).

2.7.2.5 Windows, doors, and skylights

Collectively known as fenestration, windows, exterior doors, and skylights influence both the lighting and the Heating Ventilation and Cooling (HVAC) requirements of a building (Izzat, 2010). In addition to design considerations (the placement of windows and skylights affects the amount of available natural light), materials and installation can affect the amount of energy transmitted through the window, door, or skylight, as well as the amount of air leakage around the window components (Daniel & Paul, 2010). New materials, coatings, and designs all have contributed to the improved energy efficiency of high-performing windows, doors, and buildings. Some of the advances in windows include: multiple glazing, the use of two or more panes of glass or other films for insulation, which can be further improved by filling the space between the panes with a low-conductivity gas, such as argon, and low-emissivity (low-e) coatings, which reduce the flow of infrared energy from the building to the environment (Homeowner Protection Office, 2010).

In residential buildings, using optimum window design and glazing specification is estimated to reduce energy consumption from 10 to 50 percent below accepted practice in most climates; in commercial buildings, an estimated 10 to 40 percent reduction in lighting and HVAC costs is attainable through improved fenestration (PEW Center, 2011).

2.7.3 Interactions with other building elements

The building envelope can affect the lighting, heating, and cooling needs of the building. These interactions are important to consider when retrofitting or weatherizing buildings to

reduce their energy use in the most cost-effective manner (Daniel & Paul, 2010). For example, with a new building it may be more cost-effective to choose a design with a costlier, high-performance building envelope that significantly reduces the need for heating and cooling with a smaller, less-costly HVAC system. For existing buildings, it may be more cost-effective to add insulation to a building than to install a more efficient heating system (Daniel & Paul, 2010).

2.8 Components of The Building Envelope

According to Daniel & Paul (2010), the basic function of the building envelope is to protect the covered or otherwise conditioned interior spaces from surrounding environment. The components of the building envelope can be grouped into three:

i. Wall
ii. Roof
iii. Floor

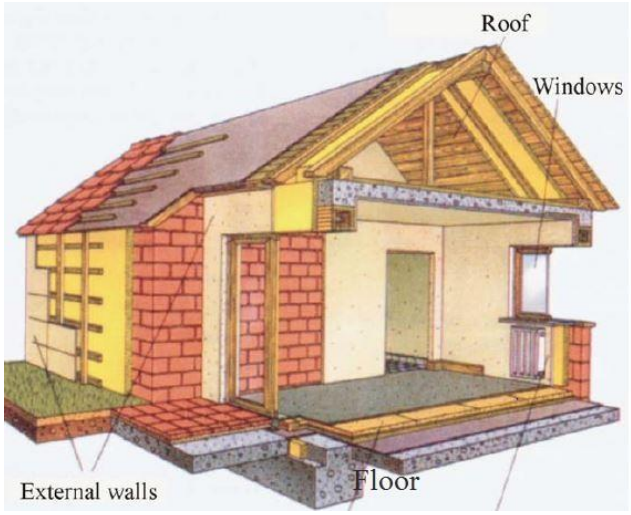


Figure2.3: Building envelope components.
Source: (Sofia Energy Centre, 2008).

2.8.1 Walls

2.8.1.1 External wall:

External walls are one of the most important elements of the building's envelope. They have several functions (Figure 2.3): bearing, enclosing, insulating and shaping (Sofia Energy Centre, 2008).

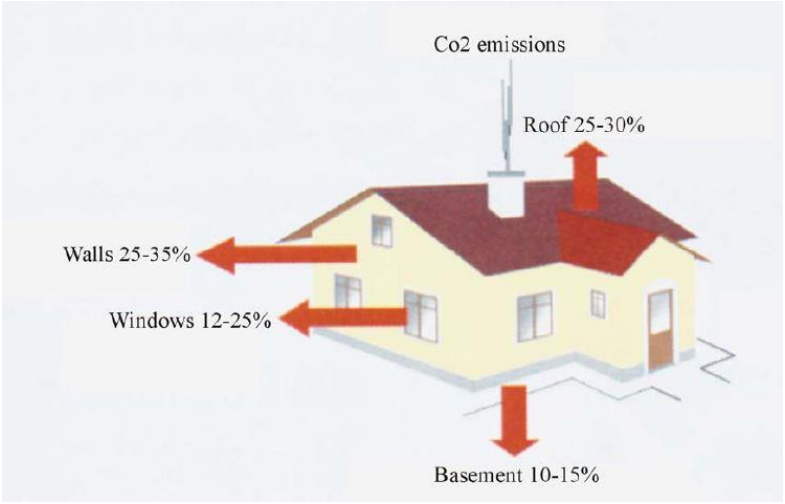


Figure2.4: Thermal losses of a single-family house.
Source: (Sofia Energy Centre, 2008).

As shown in Figure 2.4, external walls can be the cause for 25 to 35% of the heat losses through a building's envelope. The main problem with external walls is their thermal insulation and the connected with it phenomena: heat conductivity, heat absorption capacity, sweat condensation and several others. All these factors determine the thermal-technical characteristic of a building (Daniel & Paul, 2010). The main factor is the thermal protection of the premises, which should ensure constant favourable conditions (internal climate) regardless of the variable external atmospheric conditions. These conditions can be achieved through the heating and the ventilation of the premises and through a suitable structure of the enclosing elements, which should obstruct the exchange of heat between the premises and the external environment. Generally, external walls should have thermal insulating layers that can be:

i. Air insulating layer placed between the structural layers of the wall. Several air layers are more effective than one air layer, with a thickness equal to the sum of the several layers' thickness.

ii. Separate insulating layer placed between the structural elements of the wall. This layer can be from all kinds of plates, blocks, mattresses, etc. made of different materials.

Another aspect of the insulating characteristics of external walls is their heat absorption capacity that depends on the mass and the relative heat absorption of the wall's materials. The more massive a wall is the more heat it absorbs before it lets heat pass through it. But during the evening, when it is cooler, mass wall radiate heat in the premises. The main problem connected with massive external walls is over-heating (Daniel & Paul, 2010). This problem can be solved by means of shading elements or screens, this can be terraces, loggias, eaves, grilles, etc.

Another problem is the sweat condensation. When water's vapour reaches a cold surface, it condenses. The probability of condense depends on the type and the disposition of the external wall's layers. The probability of condense is especially high when effective thermal insulation is placed on the side of the premises (Daniel & Paul, 2010). In this cases the external layers of the wall are highly cooled, because of the thermal insulation and there is a high probability of condense. To avoid the appearance of condense the following measures can be undertaken:

i. avoid the penetration of humidity in the wall's structure through a suitable vapour insulation on the premises' side or through such a thermal insulation on the external side, which ensure a temperature in the wall higher than the condensation temperature,

ii. lead water vapour could get into a wall through ventilation canals and openings or through vapour-permeable layers on the external side.

It is very suitable to put vapour proofing barriers in the elements of the building envelope, which will avoid the penetration of water vapour in them (Hegger, et al., 2008). Vapour insulating material can be asphaltic felt or plastering, synthetic sheet, folio, paint, etc.

2.8.2 Roofs

According to Sofia Energy Centre (2008), 25 to 30% of the heat losses of a house can be through the roof (see Figure2.4). It is very important to insulate them in a suitable way. The covering layers of roofs have several functions:

i. Protection of the building against rainfall, snowfall, hailstorm, atmospheric humidity and condense of internal humidity in the roof,
ii. Protection of the roof against other factors – cold, heat, overheating, wind, noise,
iii. Fire protection.

2.8.3 Windows

Windows and external doors are very important elements of the building envelope in regard to thermal integrity of building (Sofia Energy Centre, 2008). Their thermal insulating qualities depends on three main elements which are glazing, frame, and specification and installation. Fixed windows are not climatically preferable in the warm-humid climates because they don't allow proper air flow. (Koenigsberger, Ingersoll, Mayhew, & Szokolay, 1974).

2.8.3.1 Glazing

Improving thermal performance raises the surface temperature of inner pane of glass and improves the occupants comfort. Most of the new windows and balcony doors are double-glazed but it should be taken into consideration that higher thermal performance glazing

out-performs standard double glazing in a number of areas (Homeowner Protection Office, 2010). These areas are:

i. Heat loss and fuel bills are significantly reduced,

ii. Warmer internal surfaces reduce cold downdraughts and improve the comfort,

iii. this type of window has an even lower risk of condensation, and

iv. in some cases, the heating system may be reduced.

2.8.3.2 Frame and materials

The choice of timber, PVC or aluminium frame depends of factors such as aesthetics and maintenance. All are suitable for use with double glazing systems. However, when specifying aluminium units, care should be taken to avoid thermal bridge problems. The frame must be strong enough to support the weight of the glazing unit. Windows and balcony doors frames should be designed with integral draught stripping. Ideally, two separate draught strips should be installed (Homeowner Protection Office, 2010). Correct specification and installation of hardware is also important for ensuring compression of draught strips.

2.9 Warm-Humid Climate

The warm-humid climate is characterized by hot, sweaty and sticky conditions as well as continual presence of dampness. Air temperatures remain moderately high, between 21 and 32^{o}c, with little variation between day and night (Koenigsberger, Ingersoll, Mayhew, & Szokolay, 1974). According to Ogunsote (1987), Climatic zones for architectural design are defined by boundaries where a change in the thermal comfort requirements should be reflected in changed building elements. Ogunsote (1987) grouped Nigeria`s climate into six: The Coastal Zone, the Forest Zone, the Transitional Zone, the Savannah Zone, the Highland Zone and the Semi-Desert Zone. Further research into the zones were carried out by

Agboola (2011), who classified Nigeria into two major climatic zones which are the warm-humid zone and warm savannah zone.

The warm-humid zone of Nigeria lies within the sub-equatorial rain forest. It has low-wet climate of the tropics. The warm-humid zone encompasses the coastal, forest and transitional regions as classified by Ogunsote, (1987). This zone experiences heavy rainfall of between 1000mm and 1250mm and at times above 1250mm for the swampy areas around the Niger delta. This climatic zone is characterized by high humidity and is associated with warm discomfort for about eleven months in a year (Agboola, 2011). The main raining season occurs between April and October and the maximum temperature does not fall below comfort limit of 21 degrees Celsius.

2.10 Design Solutions for The Warm-Humid Climatic Zone

2.10.1 Cross-ventilation

As a result of intense solar radiation leading to an increase in temperature, the relative humidity of the atmosphere also increases, thus the air becomes saturated with solar vapour and the air becomes moist. Cross-ventilation 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 (Agboola, 2011).

2.10.2 Thermal insulation

Thermal insulation prevents the room interior from being heated up by the warm 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 and a central courtyard and with a wide veranda running around it.

2.10.3 Site planning

The layout of buildings should expose a small part 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 (Agboola, 2011).

2.10.4 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 damp proof courses. Buildings in this region should be protected from heavy rainfall as a result of heavy down pours (Daniel & Paul, 2010). 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 (Homeowner Protection Office, 2010).

2.10.5 Adequate drainage

Is also necessary as a result of erosion and flooding which are functions of excess surface rainwater, therefore drainages must be properly designed to take care of run-off water from a site (Agboola, 2011).

2.10.6 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 (Umoh, 2000). 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 (Umoh, 2000). 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.

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

2.10.7 Wind pressure

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/m2 for a wind of 1km/hour. It uses about 25kg/m2 in a 50km/hour.

2.10.8 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 (Agboola, 2011). 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.

2.11 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(Ogunsote,1991). 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 with wall and roof finishes in light colour. Wall should be adequately protected against driving rain. Lesiuk (2012), 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 (Lesiuk, 2012).

2.12 Summary

Resorts are very important for activities such as holiday, entertainment and recreation. They provide an avenue of escape from the struggle of life. Resorts should be located within tranquil environment that have natural attraction. While trying to design such a facility, indoor thermal comfort should be seriously considered.

Thermal comfort can be defined as that state of mind which expresses satisfaction with the thermal environment (ASHRAE, 2009). Though it is difficult to satisfy everyone in a space due to physiological and psychological variation from person to person, thermal comfort is still one of the most significant factors affecting environmental satisfaction (Nazanin, Jones, & Knight, 2008). Thermal Comfort TC involves control of temperature, humidity, air

motion and non-environmental factors such as dress and activity level of the occupants (McQuiston, Parker, & Spliter, 2005). Indoor thermal comfort can be optimized through proper design of the building envelope. The building envelope according to Homeowner protection office (2010), should separate the indoors from the outdoors. Building envelopes elements such as the walls, foundations, roof, windows and doors. The interaction of the sub-systems with the components of the building envelope, as well as certain activities of the occupants, can affect the performance of the building envelope and the indoor thermal comfort.

3.0 RESEARCH METHODOLOGY

3.1 Introduction

Research methodology refers to the ways by which a researcher plans to achieve the aim of the study. Methodology is basically exploratory and highly investigatory, as it seeks to explore an area with some assumption. Research methodology can be explained in terms of the rules of proof, confirmation and techniques. Ujo (2002), sees methodology as the operational outline of what the researcher plans to employ in achieving the objective of his study. This indicates that some steps must be taken in order to achieve the desired result. It is important for the researcher to know what steps he/she will use.

The purpose of this chapter is to introduce the research strategy and the empirical techniques applied in order to evaluate methods of optimizing building envelope for thermal comfort in resorts. In this research, case studies and simulations were conducted.

3.2 Method of Study

The study entailed the use of case studies and simulations. The research involved a detailed study of various resorts to investigate the types of building envelopes used and how various envelopes have affected thermal comfort in the resorts.

3.2.1 Case study

Case study in architecture begins with a documentation of the physical characteristics of the case (Oluigbo, 2010). This documentation will be based on evaluation of design principles that allow optimizing of thermal comfort in resort buildings to reduce the energy consumption. Case studies allow presentation of data collected from multiple methods (i.e., surveys, interviews, document review, and observation) to provide a comprehensive record of the buildings under consideration.

The assessment will be carried out through visual surveys, observation, and a checklist on the elements of building envelope under consideration.

3.2.2 Simulation in Ecotect® Analysis

The case study building was drawn and tested in the Ecotect® Analysis software. The simulation of the building envelope is done using Ecotect® Analysis by Autodesk©. It is a software package for thermal comfort variables such as wind speed, temperature, humidity amongst others developed by Autodesk© It has a user friendly graphical user interface. It is used for 3D modelling, simulation and analysis of thermal comfort variables which include temperature, humidity, rainfall, sunshine amongst other variables.

3.3 Population

Population is a total of all the elements that share some common set of characteristics and that comprise the entire purpose of the research problem. Population in this study will be three resorts within the warm-humid part of Nigeria.

3.4 Sample Size

Sample size is a portion, piece(s) or segment(s) that is representative of a whole demographic and statistical population. Samples help in understanding and quantifying mathematical probabilities, trends, or relationship within a group. It simply means a limited number selected from a population, which is a representation of the population.

3.5 Sampling Technique

Sampling is taking any portion of a population or universe as representative of that population or universe. In this research work, purposive sampling was used. The purposive sampling method was used to ensure that every element in the population have equal and independent chance of being included in the sample. This method will be used to select the resorts. Thus, it is in a bid to provide a sample that not only represents the entire population but also reflects the general characteristics of the population.

3.6 Instruments for Data Collection

There are many different types of instruments which can used to collect data from a case study. The case studies for theoretical research in Architecture may require the use of general methods for data collection (Oluigbo, 2010). The use of multiple sources of data in order to capture the complexity of cases is one of the defining characteristic of case study methodology (Yin, 2014). For the purpose of this study, the instruments that will be used for the collection and documentation of data are photographs, sketches, and notes.

3.7 Data Presentation Method / Analysis

The data gathered from the field survey would be collated and analysed through a checklist. Also climatic data from the meteorological centre will be collected and imputed in the simulation software then analysed and represented in different forms which include:

3.7.1 Descriptions

This entailed the summary and conclusion of the various selected resorts, showing the extent to which building envelopes have affected thermal comfort of the indoor spaces after the case study analysis was done and also the extent to which the building envelope was optimized for thermal comfort at the design stage.

3.7.2 Tables

It involved the documentation and presentation of data collected from case studies on assessment tables.

3.7.3 Figures and plates

Data collected during the case studies in form of drawings and sketches were documented using figures and plates.

4.0 DATA PRESENTATION AND ANALYSIS

4.1 Selection Criteria

Case study selection is comparable to sampling in a quantitative research and that those cases are usually purposively selected (Oluigbo, 2010).This suggested that cases are identified for study due to their inherent qualities which were in consonance with the phenomenon under investigation (Oluigbo, 2010). The use of case studies as a design learning tool has helped in exposing problems as well as solutions inherent in existing buildings to serve as guide in design formation. Architectural case studies take into consideration such aspects as function, structures, site and economy, with a view to identifying the intricacies inherent in them in order to find ways of incorporating or rejecting some ideas within the pursued project scope. As a measure toward the good planning of a similar project, an understanding of the existing situation would reveal to a large degree the merits and demerits inherent, such that new concepts shall give the much needed direction of a new design.

The case studies selected for this study were sampled purposely on two bases;

i. A destination resort in terms of facilities required to operate as a standard resort facility, and

ii. a facility located in the warm humid climatic zone.

4.2 Whispering Palms Resort

LOCATION: Iworo Badagry, Lagos.

CONSTRUCTION DATE: 1991

CLIMATIC ZONE: Warm-humid climate

4.2.1 Brief description

Whispering Palms is a conference resort centre occupying 0.03sqkm of land in a rural area of Lagos state: Iworo, Badagry local government area. It lies on the lagoon and typifies the beauty of the area-cool, Atlantic breeze, sands, coconut trees and chirping birds. Plate IX below shows entrance to the facility. After gaining access to the premises, vehicles parked at the car park and walk to the reception as shown Plate X.



Plate IX: Whispering Palms Resort entrance.
Source: Author`s field work,2015,



Plate X: Whispering Palms Resort reception.
Source: Author`s field work,2015.

4.2.2 Building form

The Whispering palms rooms are semidetached and have links between rooms in the case of a single family taking a whole unit of the building. The typical unit floor plan is shown in Figure 4.1

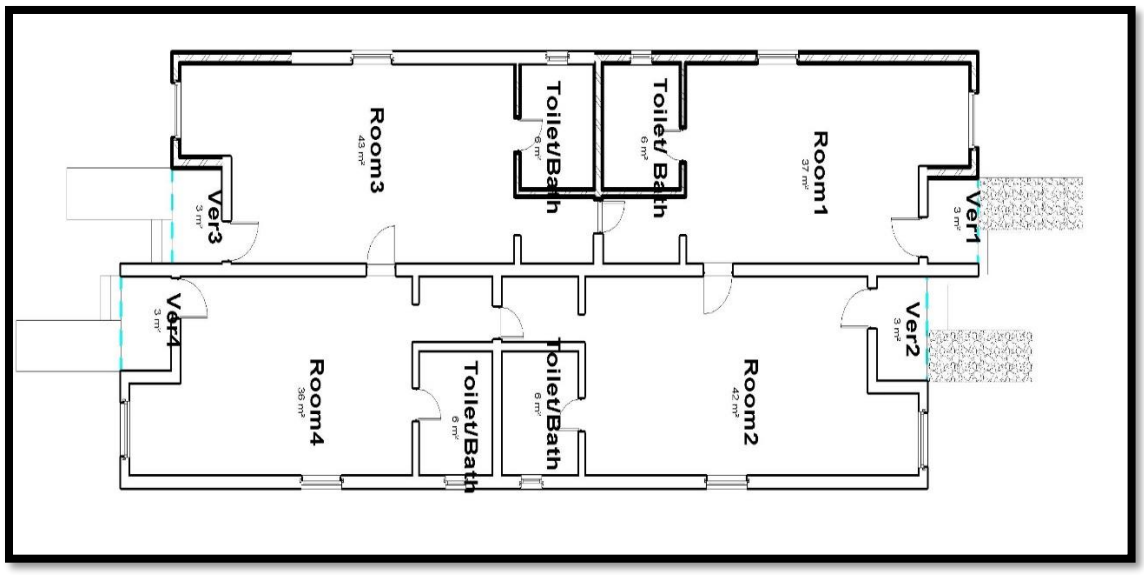


Figure 4.1: Whispering Palms Ground Floor Plan.
Source: Author`s field work,2015

4.2.3 Building envelope

The materials used for the construction are as follows:

4.2.3.1 Roof material: Long Span Aluminium roofing sheet was used as shown in plate XI



Plate XI: Long Span Aluminium roofing sheet.
Source: Author`s field work,2015.

4.2.3.2 Colour: Beige - Beige colour is a bright colour which allows for the reflection of solar insolation which in turn reduces the amount of heat absorbed into the building.



Plate XII: Roof Overhang of about 600 mm.
Source: Author`s field work,2015.

4.2.3.3 Roof overhang: The roof has an overhang of about 600mm round the building which shades the building. Plate XII above shows the overhang of the roofs.

4.2.3.4 Ceiling material: White coloured particle board as illustrated in the Plate XIII below was used for thermal insulation.



Plate XIII: White Ceilings used for thermal insulation.
Source: Author`s field work,2015.

4.2.3.5 Walling material: Sand Crete hollow blocks were used for the walls Bright colours were used which in turn reflect heat. The walls are textured which will absorb some of the heat. This reduces the effect of the bright colour to reflect heat as shinny surfaces reflect heat more than textured surfaces. The paints used are illustrated in Plates XIV and XV



Plate XIV: Wall paint is in bright colour which reflects some heat away.
Source: Author`s field work,2015.



Plate XV: Wall paint is in bright colour which reflects some heat away.
Source: Author`s field work,2015.

4.2.3.6 Window type: Projected Windows were used which regulate the amount of air flow through the building from the exterior to the interior as shown in Plate XVI.



Plate XVI: Projected windows as used in the resort.
Source: Author`s field work,2015.

4.2.4 Construction technology/structural system

Basically, the integrity of the structure is a column/beam connection system. Sand crete blocks were used for most of the buildings with long span Aluminium roofing sheet.

4.2.5 Site planning and landscaping:

The use of the soft landscape element has been properly put into consideration as only the vehicular routes and pedestrian walkways are covered with hard landscape surfaces which may also influence the microclimate of the region. There exists a very good relationship between buildings and the site.

4.2.6 Spatial organization:

Zoning of the activities was properly done. After gaining access to the building, the car park is the first point of contact and zoned in such a way that vehicles do not have access to the other facilities. The reception is the next point of contact where all enquires are made and customers directed to their various points of interest. Outdoor recreation spaces were also clearly distinguished from the indoor activities. Some of the facilities on the site are shown in the Plates XVII and XVIII below.



Plate XVII: River side sit out.
Source: Author`s field work,2015



Plate XVIII: River side relaxation area.
Source: Author`s field work,2015

A checklist was used to assess the building envelope at the whispering palms during the case study visit. The checklist is presented in table 4.1 below.

Table 4.1: Checklist for the Assessment of Building envelope design at the Whispering Palms Iworo, Badagry. -Wall

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
1	Colour of walling materials	Light coloured walling materials reflect back solar heat				✓		
2	Thermal mass/Walling Material	Suitability to the surrounding and climate of the region			✓			
		Low mass material construction for warm-humid zones			✓			
		Availability of local and modern building materials					✓	
3	Window Orientation	Orient window to face trade winds to facilitate natural ventilation			✓			
4	Window Shading	Shading devices for openings protect against solar insolation	✓					

S/N	Variables	Checklist	Level of application				
			1	2	3	4	5
6	Wall Shading	Wall shading reduces solar heat gain on fabrics	✓				
7	Building Orientation	Control shape, form and orientation				✓	

Key rating for the above table 5-Execellent; 4-Very good; 3-Good; 2-Fairly good; 1-Poor

Source: Author`s field work, 2015

A checklist was used to assess the roof at the whispering palms during the case study visit. The checklist is presented in table 4.2 below.

Table 4.2: Checklist for the Assessment of Building envelope design at the whispering palms Iworo, Badagry. -Roof

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
1	Colour of roofing materials	Light coloured roofing materials reflect back solar heat					✓	
2	Roofing Material	Metal roofs loose heat quickly after sun set, tiled roofs radiate heat into buildings as they don't lose heat easily					✓	
3	Roofing Vents	Poorly Ventilated roofs get hot which in turn conducts heat to the ceiling and room below		✓				
4	Roofing Overhangs	Long Over hangs reduce solar insolation getting to the building			✓			
5	Ceiling Material	Ceiling materials could serve as insulation to reduce heat gain within rooms			✓			

Key rating for the above table 5-Execellent; 4-Very good; 3-Good; 2-Fairly good; 1-Poor

Source: Author`s field work,2015

4.3 La Campagne Tropicana Resort

LOCATION: Ikegun village, Ibeju Lekki, Lagos state

SIZE: 6.5 hectares

Climatic Zone**:** Warm-humid climate

Present State**:** The facility is presently in a good state, making it habitable and fit to carry out its primary functions which includes relaxation, conferences, and a wide range of outdoor activities.

4.3.1 Brief description

La Campagne Tropicana is a holiday resort centre occupying 6.5 hectares of land in Lagos state. It lies around the lagoon and typifies the beauty of the area-cool, Atlantic breeze, sands, coconut trees and chirping birds. It has different types of lodges. Plate XIX below shows entrance into the facility to the facility.



Plate XIX: La Campagne Tropicana resort entrance walkway.
Source: Author`s field work,2015.

4.3.2 Building form

The La Campagne Tropicana resort has 3 categories of rooms which range from 1- bedroom to 2-bedroom and 3-bedroom. Most of the rooms are circular in shape as shown in figure 4.2 below.

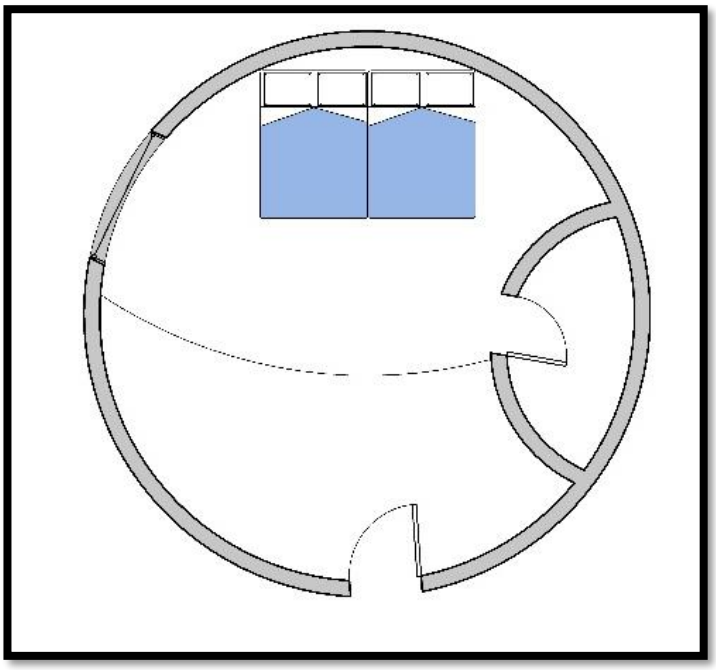


Figure 4.2: La Campagne Tropicana Resort Floor Plan.
Source: Author`s field work,2015.

4.3.3 Building envelope

The materials used for the construction are as follows:

4.3.3.1 *Roof Material:* Long Span Aluminium roofing sheet was the most commonly used material but some chalets had thatch roof as can be seen in Plates XX and XXI below.



Plate XX: La Campagne Tropicana resort Chalets.
Source: Author`s field work,2015



Plate XXI: La Campagne Tropicana resort Chalets.
Source: Author`s field work,2015.

4.3.3.2 *Colour:* Brown colour is a dull colour which does not reflect so much heat from the sun which in turn may heat up the building interior.

4.3.3.3 *Roof overhang*: The roof has an overhang of about 600mm round the building which shades the building as can be seen in Plate XXII and XXIII



Plate XXII: La Campagne Tropicana Resort Roof overhang.
Source: Author`s field work,2015.



Plate XXIII: La Campagne Tropicana Resort Roof overhang.
Source: Author`s field work,2015

4.3.3.4 Ceiling material: The ceiling of the buildings were made from local hand woven mats which give a feel of vernacular. This can be seen in Plate XXIV below.



Plate XXIV: Hand woven ceiling mats.
Source: Author`s field work,2015.

*4.3.3.5 Walling material***:** Sand Crete hollow blocks were used for the walls with fired bricks as a facing material. Plate XXV below shows the construction of an additional chalet.



Plate XXV: Sand Crete blocks used for construction of walls.
Source: Author`s field work,2015.

4.3.3.6 *Colour:* The colour of the brick used is not a good reflector of heat. Brick as an element has a good thermal property. This characteristic would reduce the rate at which heat is transferred to the sand Crete block and in turn the interior space. This is shown in Plate XXVI.



Plate XXVI: Red-brown facing bricks used for wall cladding.
Source: Author`s field work,2015.

4.3.3.7 *Window type:* Plates XXIII and XXIV show the use of sliding windows and use of timber as a supporting element for the roof and to achieve a traditional look. These windows reduce the amount of air flow through the building by about half.



Plate XXVII: Sliding windows used with single glazing.
Source: Author`s field work,2015



Plate XXVIII Timber column used to support the building.
Source: Author`s field work,2015

4.3.4 Construction technology/structural system:

Basically, the integrity of the structure is a column/beam connection system. Also Beam and column system was employed on the construction of the walls of the building.

4.3.5 Site planning and landscaping:

The use of the soft landscape element has been properly put into consideration as only the vehicular routes and pedestrian walkways are covered with hard landscape surfaces which may also influence the microclimate of the region. There exists a very good relationship between buildings and the site.

4.3.6 Spatial organization:

Zoning of the activities was properly done. After gaining access to the building, the car park is the first point of contact and zoned in such a way that vehicles do not have access to the other facilities. The reception is the next point of contact where all enquires are made and customers directed to their various points of interest. Outdoor recreation spaces were also

clearly distinguished from the indoor activities. Plate XXV and XXVI below show a view of the Atlantic Ocean and relaxation area of the facility.



Plate XXIX Outdoor relaxation area.
Source: Author`s field work,2015



Plate XXX Beach view.
Source: Author`s field work,2015

Table 4.3: Checklist for the Assessment of Building envelope design at La Campagne Tropicana Resort, Lekki.

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
1	Colour of walling materials	Light coloured walling materials reflect back solar heat		✓				
2	Thermal mass/Walling Material	Suitability to the surrounding and climate of the region				✓		
		Low mass material construction for warm-humid zones				✓		
		Availability of local and modern building materials					✓	
3	Window Orientation	Orient window openings to facilitate natural ventilation			✓			
4	Window Shading	Shading devices for openings protect against solar insolation	✓					

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
5	Window Glazing	Proper glazing materials and size reduce heat as well as quality of glazing and quantity			✓			
6	Wall Shading	Wall shading reduces solar heat gain on fabrics	✓					
7	Building Orientation	Control shape, form and orientation				✓		

Key rating for the above table 5-Execellent; 4-Very good; 3-Good; 2-Fairly good; 1-Poor

Source: Author`s field work,2015

Table 4.4: Checklist for the Assessment of Building envelope design at La Campagne Tropicana Resort, Lekki

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
1	Colour of roofing materials	Light coloured roofing materials reflect back solar heat		✓				
2	Roofing Material	Metal roofs loose heat quickly after sun set, tiled roofs radiate heat into buildings as they don't lose heat easily			✓			
3	Roofing Vents	Poorly Ventilated roofs get hot which in turn conducts heat to the ceiling and room below		✓				
4	Roofing Overhangs	Long Over hangs reduce solar insolation getting to the building			✓			
5	Ceiling Material	Ceiling materials could serve as insulation to reduce heat gain within rooms			✓			

Key rating for the above table 5-Execellent; 4-Very good; 3-Good; 2-Fairly good; 1-Poor

Source: Researcher.

4.4 Epe Resort and Spa

Location**:** Ikorodu-Epe Road, Epe, Lagos.

Size: 3716sqm

Climatic zone: Warm-humid climate

4.4.1 Brief description

The facility was converted from residences for construction workers to the destination resort in the year 2010. It is located on a land area of about 3700sqm.The spa building was purpose-designed with the input of a Paris based spa consultant. Plate XXVII below shows the reception of the facility.



Plate XXXI Reception to the facility.
Source: Author`s field work,2015

4.4.2 Facilities

It has facilities which include:

I. Administration

II. Accommodation

III. Conference hall

IV. Maintenance

4.4.3 Building form

The Epe resort has gable roof systems with rectangular buildings and plain building facades. Plate XXVIII shows these characteristics as were observed during the case study.



Plate XXXII Epe Resort Site layout.
Source: Author`s field work,2015

4.4.4 Building envelope

The building envelope is a very important factor to be considered in the case study as this is the focus of this thesis.

The materials used for the construction are as follows:

4.4.4.1 Roof material:

The Roofs of the buildings are beige coloured long span Aluminium roofing sheet. The material has a low thermal conductivity but the colour beige reflects off some of the light reaching the building. Plate XXIX shows the use of the roofing sheet on a building



Plate XXXIII Beige coloured Long Span Aluminium roofing sheet.
Source: Author`s field work,2015

4.4.4.2 Roof overhang

The roof has an overhang of about 600mm round the building which shades the building to an extent from the sun as is shown in Plate XXX



Plate XXXIV Large Overhang protecting the building from solar insolation.
Source: Author`s field work,2015

4.4.4.3 Ceiling material

As shown in Plate XXXI, the ceiling of the buildings are made from plaster board which give very good insolation.



Plate XXXV Plaster board used as ceiling insulation.
Source: Author`s field work,2015

4.4.4.4 Walling material

Sand Crete hollow blocks were used mainly for the walls. The buildings are painted off white with emulsion paint. Plate XXXII shows the walling paint used.



Plate XXXVI Light coloured wall paint as used reflects some heat.
Source: Author`s field work,2015

4.4.4.5 Window type

The window type employed here is the fixed window. The window does not allow for natural flow of air as shown in plate XXXIII. The building depends majorly on active means of cooling



Plate XXXVII Large Window openings as used in the Chalets.
Source: Author`s field work,2015

Table 4.5: Wall checklist for the Assessment of Building envelope design at the Epe resort and spa, Lagos.

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
1	Colour of walling materials	Light coloured walling materials reflect back solar heat				✓		
2	Thermal mass/Walling Material	Suitability to the surrounding and climate of the region					✓	
		Low mass material construction for warm-humid zones			✓			
		Availability of local and modern building materials					✓	
3	Window Orientation	Orient window openings to facilitate natural ventilation	✓					
4	Window Shading	Shading devices for openings protect against solar insolation	✓					

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
5	Window Glazing	Proper glazing materials and size reduce heat as well as quality of glazing and quantity		✓				
6	Wall Shading	Wall shading reduces solar heat gain on fabrics	✓					
7	Building Orientation	Control shape, form and orientation				✓		

Key rating for the above table 5-Execellent; 4-Very good; 3-Good; 2-Fairly good; 1-Poor

Source: Author`s field work,2015.

Table 4.6: Roof checklist for the Assessment of Building envelope design at the Epe resort and spa, Lagos.

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
1	Colour of roofing materials	Light coloured roofing materials reflect back solar heat				✓		
2	Roofing Material	Metal roofs loose heat quickly after sun set, tiled roofs radiate heat into buildings as they don't lose heat easily				✓		
3	Roofing Vents	Poorly Ventilated roofs get hot which in turn conducts heat to the ceiling and room below	✓					
4	Roofing Overhangs	Long Over hangs reduce solar insolation getting to the building				✓		
5	Ceiling Material	Ceiling materials could serve as insulation to reduce heat gain within rooms			✓			

Key rating for the above table 5-Execellent; 4-Very good; 3-Good; 2-Fairly good; 1-Poor

Source: Author`s field work,2015

4.5 Analysis of Data

The data collected from the case studies were carefully compared and analysed in table 4.7 below

Table 4.7: Summary for the assessment of Building envelope design in resorts for the overall case-studies

S/N	Variables	Checklist	Level of application			Sum Total
			WP	LCT	EPE	
1	Colour of walling materials	Light coloured walling materials reflect back solar heat	4	2	4	10
2	Thermal mass/Walling Material	Suitability to the surrounding and climate of the region	3	4	5	12
		Low mass material construction for warm-humid zones	3	4	3	10
		Availability of local and modern building materials	5	5	5	15
3	Window Orientation	Orient window openings to facilitate natural ventilation	3	3	1	7

S/N	Variables	Checklist	Level of application			Sum Total
			WP	LCT	EPE	
4	Window Shading	Shading devices for openings protect against solar insolation	1	1	1	3
5	Window Glazing	Proper glazing materials and size reduce heat as well as quality of glazing and quantity	3	3	2	8
6	Wall Shading	Wall shading reduces solar heat gain on fabrics	1	1	1	3
7	Building Orientation	Control shape, form and orientation	4	4	4	12
8	Colour of roofing materials	Light coloured roofing materials reflect back solar heat	5	2	4	11

S/N	Variables	Checklist	Level of application			Sum Total
			WP	LCT	EPE	
9	Roofing Material	Metal roofs loose heat quickly after sun set.	5	3	4	12
10	Roofing Vents	Poorly Ventilated roofs get hot which in turn conducts heat to the ceiling and room below	2	2	1	5
11	Roofing Overhangs	Long over hangs reduce solar insolation getting to the building	3	3	4	10
12	Ceiling Material	Ceiling materials could serve as insulation to reduce heat gain within rooms	3	3	3	9
Total			45	40	42	125

Key rating for the above table 5-Execellent; 4-Very good; 3-Good; 2-Fairly good; 1-Poor

Source: Author`s field work,2015

The data for the case-studies have been summarized in the Table 4.7 in order to compute and analyse the data properly. The level of application of each variable in each case study is shown together with the sum total of the level of application for each of the case study, showing whether it has an impact on the proposed design or not, taking the critical mean or limit as 3.0, which is the mid-way/average between 1 and 5

The following frequencies of scores was established to compute the data in Table 4.8. It shows the number of times the key rating for scores of the case-studies appeared and X stands for the case-studies in Table 4.8 below

Table 4.8: Frequencies of scores for the case studies

X	Excellent (5)	Very good (4)	Good (3)	Fairly good (2)	Poor (1)	Sum total
Whispering Palms	3	2	6	1	2	14
La Campagne Tropicana	2	3	3	3	2	13
Epe Resort	2	5	2	1	4	14
F	7	10	11	4	8	41

Source: Author`s field work,2015

Table 4.8 above gave the total sum of each of the case-study score rating. The above data and tables provided the room for calculating the mean of the case-studies, which will determine whether it is good to adapt some things from the case-studies or not (Oluigbo, 2010).

However, Table 4.9 shows how the mean was established using the sum total of the frequencies and the level of application of each of the cases.

Table 4.9: Frequencies of scores for the case studies

x	f	xf
5	7	40
4	10	28
3	11	36
2	4	12
1	8	8
Total	40	124Mean, $\lambda = xf/f$
		$124 \div 40 = 3.1$

Source: Author`s field work,2015

From table 4.9 above, the mean $\lambda=3.1$. This is above 3.0, the midway between 1 and 5 which is the average. Hence, it has shown that a good result would be achieved regarding the cases that were studied for the proposed design.

A bar chart was also established using data in table 4.9 above which shows the range of the frequency of scores for each case-study in Figure 4.3.

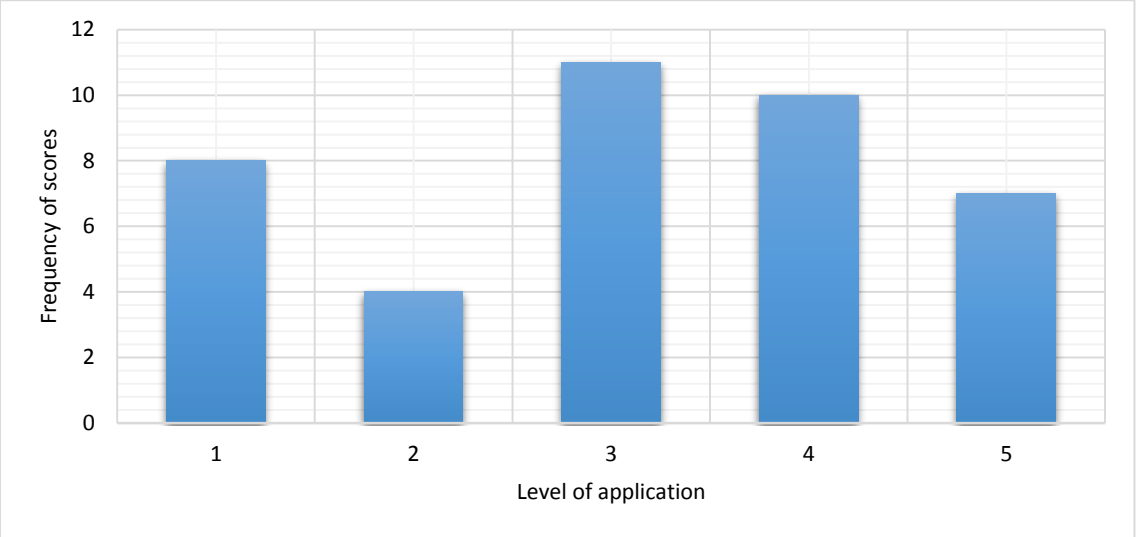


Figure 4.3: Frequencies of scores against of the case studies.
Source: Author`s field work,2015

It can be seen that level 3 and 4 have been applied simultaneously and is above the critical limit. It shows that the case-studies can be adopted for the proposed design, which gives room for further analysis of the case studies.

The rate of performance for the variables has been analysed using charts and bar graphs as shown in Figure 4.3 and 4.4 below. Figure 4.5 is a line chart graph showing the level of application of each of the case study, how good it started and ended, showing the relationship between the whole variables for each case study, whereas the bar graph in Figure 4.7 is a histogram of each of the variable for the group case-study, also showing the rate of performance of the variables and the level to which it has been applied.

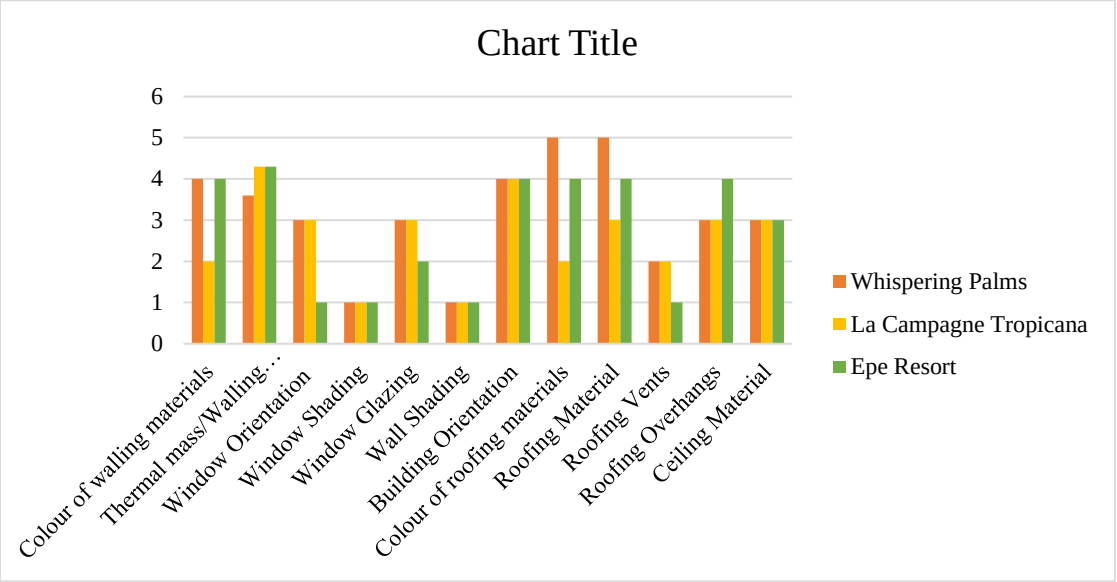
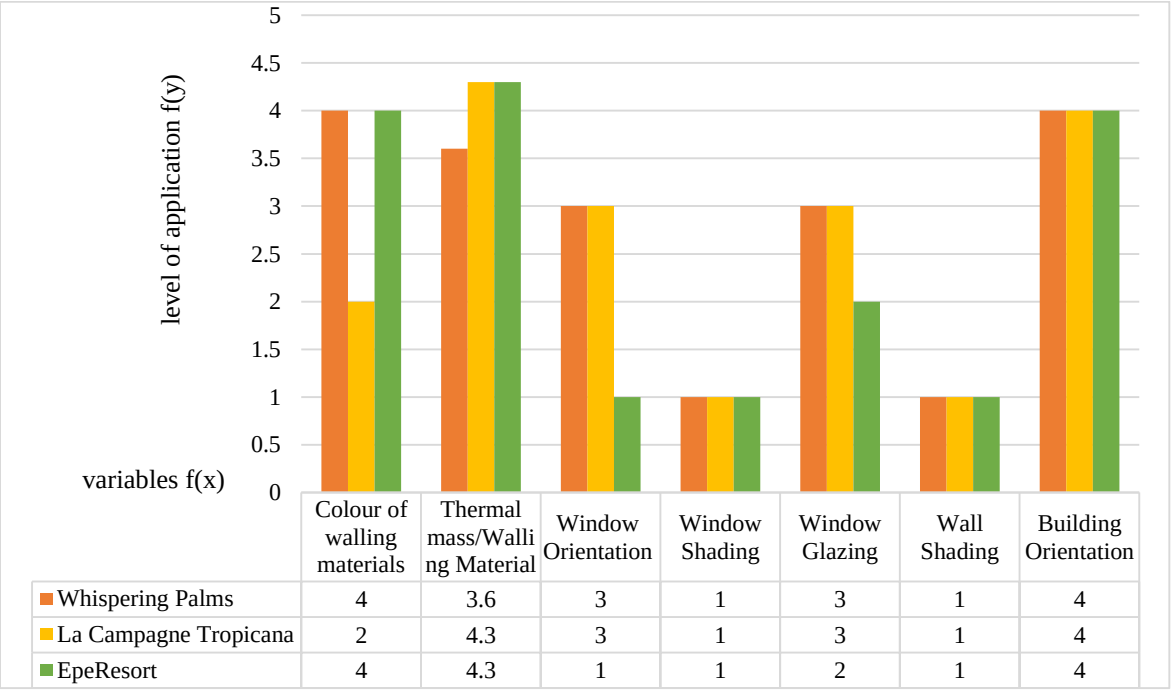


Figure 4.4: Case studies performance line chart graph. Source: Author`s field work,2015

The data used for Figure 4.3 above, 4.4 and 4.5 below were obtained from summary of the checklist in table 4.7. The average of each of the variables were obtained by summing up the scores of the sub-variables of those that have more than one variable and dividing it by the number of sub-variables in each variable in other to analyse the data proper.



	Colour of walling materials	Thermal mass/Walling Material	Window Orientation	Window Shading	Window Glazing	Wall Shading	Building Orientation
Whispering Palms	4	3.6	3	1	3	1	4
La Campagne Tropicana	2	4.3	3	1	3	1	4
EpeResort	4	4.3	1	1	2	1	4

Figure 4.5: Variables performance histogram. Source: Author`s field work,2015

A pie chart is also established in Figure 4.6 below for analysing the percentages of the variables required for the proposed design of the Resort.

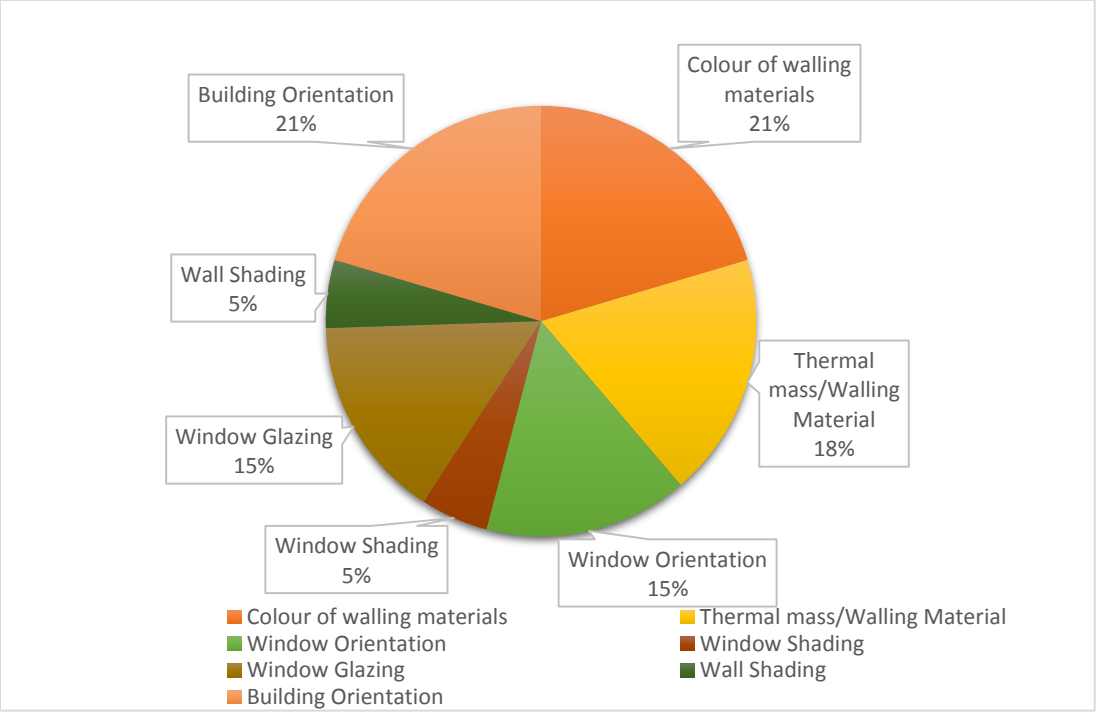


Figure 4.6: Percentage of variables. Source: Researcher

From the pie chart, the building orientation has the highest percentage which can be said to be the one that has been considered the most in the designs, this factor would be worked on. All other variables have slight difference, which means they all need to be assessed on the level for the proposed design.

4.6 Discussion of Results

All the variables for the case studies that have been previously presented and analysed have been summarized in Table 4.10 below showing their general characteristics and recommendation for it.

Table 4.10: Summary of case-study variables

Variables	Characteristics and recommendations
Facilities:	The local case-studies have a number of facilities that are dispersed within the site and not organized properly. They did not take into proper consideration the building envelope materials during the design and construction stages. The resorts have the basic facilities which would make them pass for a standard resort. The envelope materials would be carefully in the proposed design.
Colour of walling materials	From the cases studied, the colours of walling materials were not given so much consideration in a bid to reduce heat absorption within buildings. Bright colours that reflect light and heat would be used in the design proposal.
Thermal mass/Walling Material	The walling materials used in most of the case studies conducted is sandcrete block which has a high heat conductance level. Materials with low conductance would be better used for the walls.
Window Orientation	Proper Window Orientation was not considered to reduce heat. Removal of heat from the East and West would go a long way in reducing the amount of heat getting into the buildings.

Variables	Characteristics and recommendations
Window Glazing	Reflective glass helps reduce the solar insolation, cavity between glasses in the case of double or triple glazing are also good ways of reducing heat gain. The case studies used single glazing and non-reflective glass.
Wall Shading	The case studies carried out did not consider wall shading materials which could reduce solar insolation Shading devices should be used.
Building Orientation	From Case studies carried out, building orientation was a very important factor considered in design and planning of the resort. For the proposal, this factor would be greatly considered.
Colour of roofing materials	Most of the roofs had dull colours which do not reflect heat from the sun. Bright coloured roofs should be used.
Roofing Material	The predominant roofing material used is long span Aluminium roofing sheet. This does not work well in achieving indoor thermal comfort as it allows heat to pass through easily to the ceiling and subsequently the indoor space.

Variables	Characteristics and recommendation
Ceiling Material	The ceilings are mostly made from wood which has good thermal characteristic.

Source: Author`s field work,2015

4.7 Appraisals

4.7.1 Landscape

The landscape scenery present at La Campagne Tropicana and Whispering Palms respectively create a lively environment for relaxation. Hence, introducing good and properly planned landscape in the proposed design, will create a serene environment.

4.7.2 Ventilation

All the case studies made use of more active ventilation systems compared to passive ventilation systems due to improper consideration of passive methods of ventilation.

4.7.3 Building materials

Most of the case studies made use of the locally available material which do not necessarily give the optimum and desired indoor thermal comfort while using passive cooling systems.

4.7.4 Resort characteristics

Most of the resorts are located in the outskirts of the cities in serene environments and close to water bodies.

4.7.5 Fire safety and exits

Fire occurrences in a building cannot be ruled out of possibility. Therefore, safety measures such as creating exit points and routes, providing fire and smoke detectors at strategic points, fire extinguishers and buckets of sand in the resort will help prevent fire outbreak.

4.7.6 General observations for the whole case-studies

I. The buildings are close to water bodies

II. The parking spaces were totally separated from the rest of the resort facilities.

III. Plants were grown near the rooms to create a cool micro climate and beautify the environment.

IV. There was little consideration for outdoor activities.

V. Lighting and ventilation was done mostly by active means.

4.8 Simulation

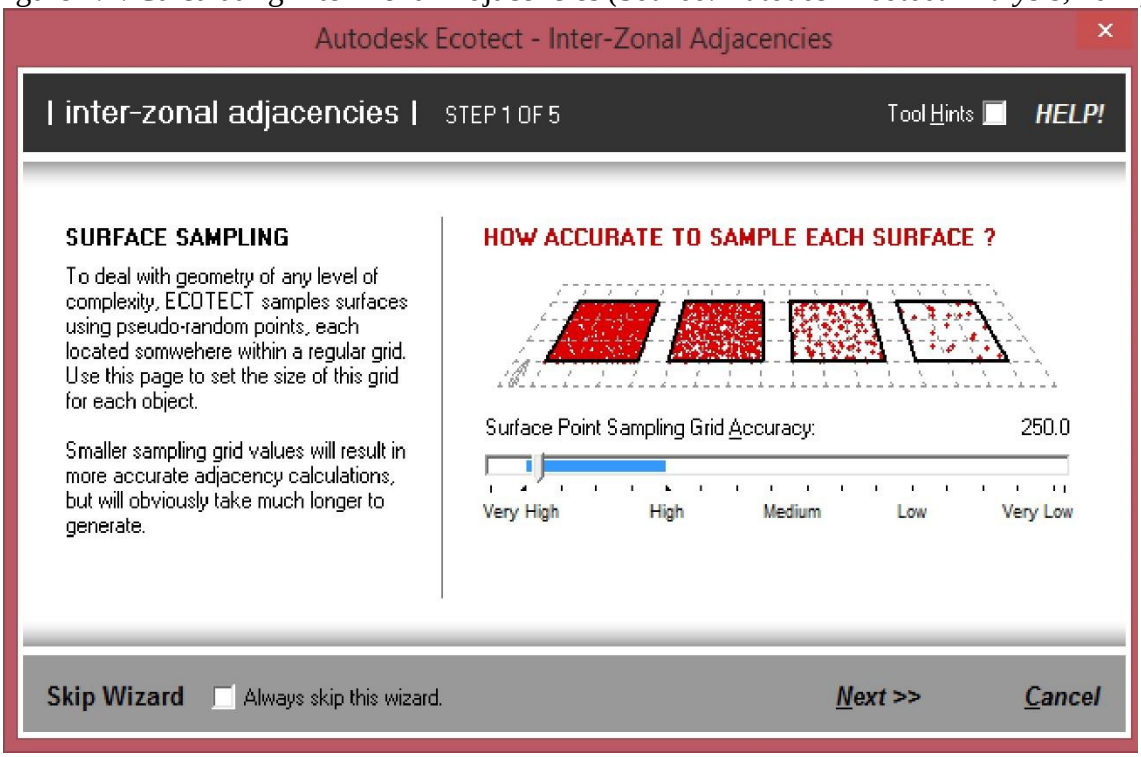
4.8.1 Steps followed for the simulation

The building was modelled in ecotect analysis and simulated for thermal comfort variables.

Step1: Load the weather file of the climatic zone and location

Step2: Calculate the Inter-Zonal Adjacencies. This revealed how accurate to sample each surfaces (Surface Sampling), how far apart can adjacent objects be (Adjacent Surfaces), check object surface normal (Surface Normal) and how to calculate object overshadowing (Shading Masks). These are seen in figures 4.7, 4.8, 4.9 and 4.10 respectively.

Figure 4.7: Calculating Inter-Zonal Adjacencies *(Source: Autodesk Ecotect Analysis, 2011)*



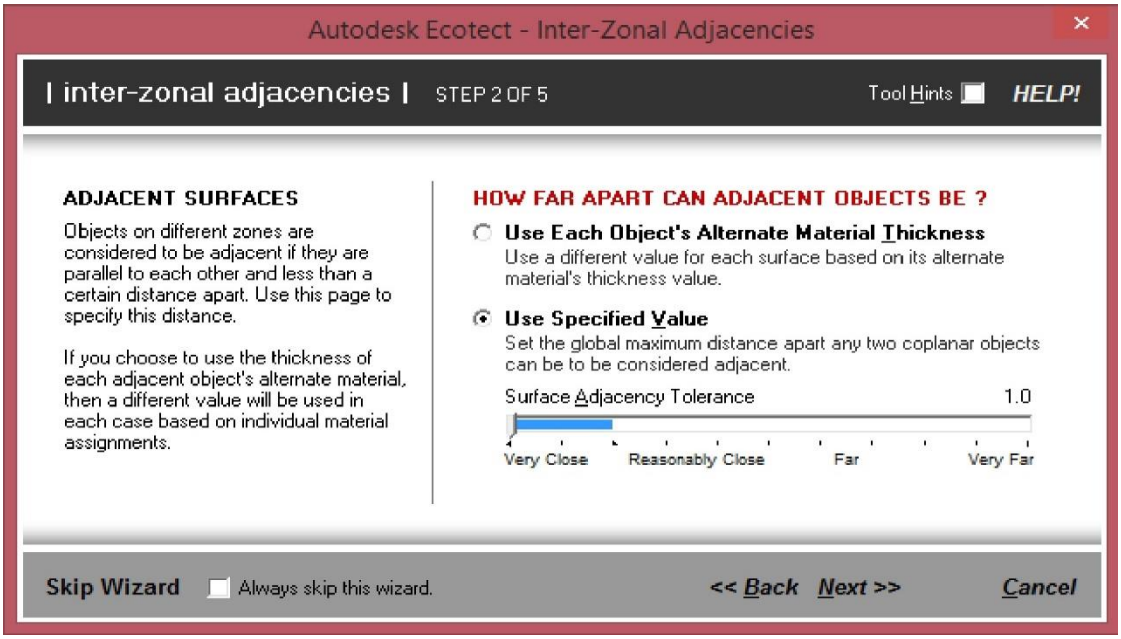


Figure 4.8: Adjacent Surfaces Source: Autodesk Ecotect Analysis, 2011

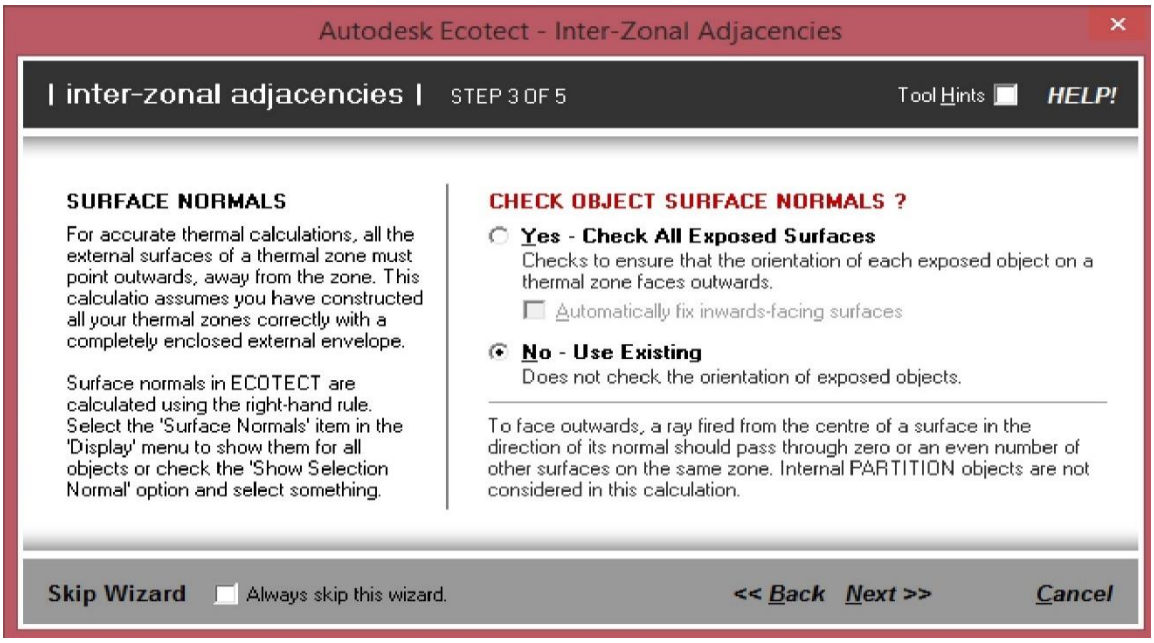


Figure 4.9: Surface Normals. Source: Autodesk Ecotect Analysis, 2011

Adjacent surfaces should have a specified value for the software to know how closely packed or far apart objects within a space are from each other. This can be seen in figure 4.8 above. This is one of the requirements in the software. Surface Normals are also important for all external surfaces of a thermal zone. Selecting Yes as in figure 4.9 makes the software check orientation of the building but this takes a great deal of time.

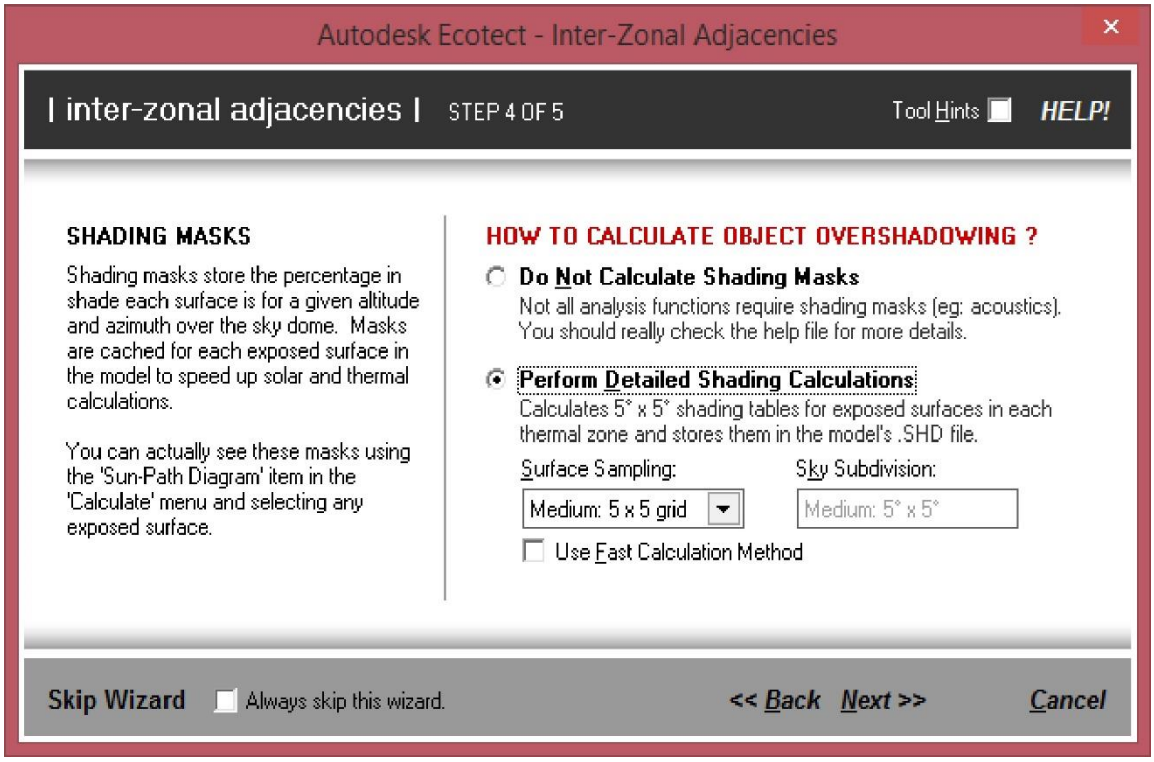


Figure 4.10: Shading Masks. Source: Autodesk Ecotect Analysis, 2011

Step3: Zone management. The icon used for the zone could be seen at the bottom right hand side of the screen work space. It includes the outside, rooms and the external shading. This is shown in figure 4.11 below.

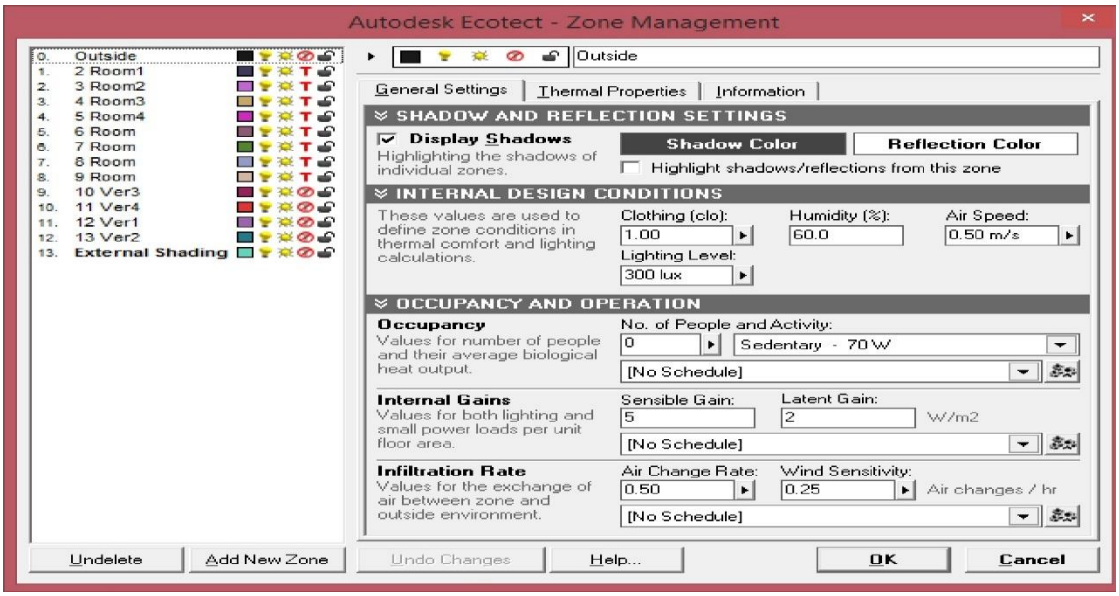


Figure 4.11: Zone management. Source: Autodesk Ecotect Analysis, 2011

At the zone management, the room to be simulated and analysed was selected. In the thermal properties, the type of system to be used was picked. For this study, Natural ventilation was chosen to test how the interior of a building can be naturally ventilated thereby making it thermally comfortable. The comfort band (lower and upper) and hours of operation were imputed. In the general settings, the shadow and reflection; internal design conditions, occupancy and operation were set.

Step4**:** Simulation Analysis. Analysis could be seen at the left hand side of the screen work space. It revealed six (6) options namely thermal analysis, solar exposure, material costs, resource consumption, reverberation times, and acoustic response. However, thermal analysis was used for this study. Under the thermal analysis, thermal calculations were made for hourly temperature. This is shown in the figure 4.12.

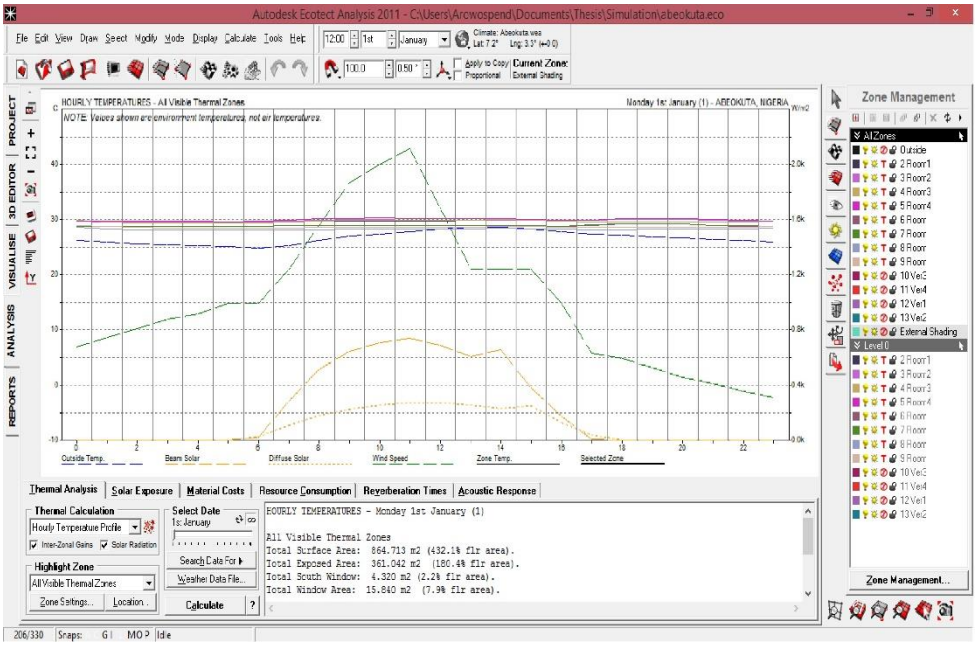


Figure 4.12: Hourly temperature. Source: Autodesk Ecotect Analysis, 2011

4.9 Results of The Simulation

The results of the simulation for thermal hourly temperatures in and around the resorts are as follows:

4.9.1 Comparison of the simulation results and discussion

The comparison of results of the simulation for thermal hourly indoor temperatures of the different building materials are tabulated and their graphs plotted.

4.9.2 Discussion of the materials

The building materials in the building under consideration were altered. The commonly used building materials were tested and the indoor temperature was recorded after which it was changed in the software and other materials were tested. The Table 4.11 below shows a list of the wall materials tested and their u-values and thermal lag in hours while table 4.12 shows a list of the roof materials tested and their u-values and thermal lag in hours

Table 4.11: List of wall materials tested in the simulation

Wall Code	Description	Thickness(mm)	U value (W/M^2K)	Thermal lag (hrs)
W1	230mm concrete block with 10mm plaster either side. • Outside: Plaster • Hollow Concrete Block • Plaster • Paint	• 10mm • 230mm • 10mm	3.11	**3.97**
W2	150mm brick with 10mm plaster either side. • Outside: Plaster • Hollow Concrete Block • Plaster • Paint	• 10mm • 150mm • 10mm	2.62	**4.56**
W3	230mm compressed earth bricks, with plaster either side.	230mm • 10mm • 10mm	2.3	**9.5**
W4	80mm framed wall as air gap, with 10mm gypsum board either side.	100mm	2.2	**7**

4.9.3 Resultant temperature with proposed walls

The resultant temperature (RT) on a hot day was estimated with the implementation of the various proposed walls as shown in Table 4.12. The simulation tests were applied and the following table shows the RT of various walls in each hour of the day (4th April) which is the hottest day of the year. The table also shows the outside temperature of the location.

Table 4.12 Resultant Temperature of various Walls on April 4th

		W1	W2	W3	W4
Hour	Outside	Inside	Inside	Inside	**Inside**
	(°C)	(°C)	(^{0}C)	(^{0}C)	**(^{0}C)**
0	28.6	26.1	24.4	24.6	**24**
1	28.6	26.1	24.4	24.8	**24**
2	28.6	26.1	24.4	24.8	**24**
3	28.5	26	24.2	24.6	**23.8**
4	28.4	26	24.1	24.4	**23.6**
5	28.2	26	23.7	24	**23.3**
6	28.6	26.1	24.4	24.7	**23.9**
7	29.1	26.1	25.2	25.6	**24.7**
8	29.5	26.3	25.6	25.9	**24.7**
9	29.9	26.3	26.3	25.9	**24.6**
10	30.3	26.4	27.1	26.3	**25.3**
11	30.7	26.6	27.7	26.1	**25.9**
12	30.4	27.3	27	25.5	**25**
13	30.2	27.4	26.4	26.3	**24.9**
14	29.9	27.2	25.9	26	**25**
15	29.6	27.5	25.4	26.4	**24.8**
16	29.3	27.7	24.8	26	**24.5**
17	29.1	27.4	24.5	25.7	**24.7**
18	29.1	26.9	24.8	25.4	**24.9**
19	29.1	27	25.1	25.4	**24.9**
20	29.1	26.7	25.1	25.4	**24.9**
21	28.9	26.5	24.9	24.9	**24.5**
22	28.8	26.2	24.7	24.7	**24.4**
23	28.6	26.2	24.4	24.5	**24**

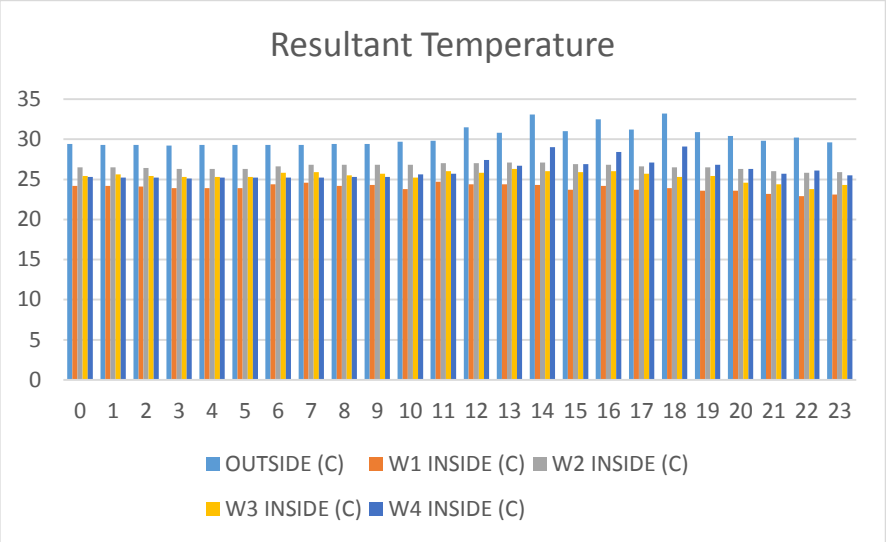


Figure 4.13 Resultant Temperature of various walls
Source: Autodesk Ecotect Analysis, 2011

As indicated in Figure 4.13, the lowest RT in a hot season-day is estimated when applying W3(230mm stabilized compressed earth block) followed by a very close result of using W4 (80mm framed wall with 10mm plaster board on either side). By using W3 or W4, the potential reductions in the resultant temperature ranging between (0.6 to 5.4 °C) is achieved in a hot season day. By using W3 which has a low U-Value, a steadier thermal environment is sustained as the internal temperature swings decrease with an average of about 4.7 °C and 2.6 °C in cold season and hot season respectively. Furthermore, this wall (W3) shows the lowest temperature during night time on the hot season day, while it recorded the highest temperature. During the hot season, the magnitude of potential reduction in temperature is higher than that in cold season and reaches maximum of 4.7 °C. Generally, applying insulation materials on walls has the potential to improve thermal environment in cold season but could make it worse in hot season. Furthermore, the resultant temperature of the case of W1 (the existing wall), in both hot season and cold season shows that the wall has about the highest temperature during hot season and lowest one during cold season which proves that wall enhancement is needed to improve the existing situation. In a comparison between the proposed wall, W3 and W1, it is observed that the best indoor thermal

environment can be achieved by applying the proposed wall W3 in the building especially during the hot season.

4.9.4 Thermal comfort with proposed walls

The percentages of comfort hours, where Predicted mean vote ranges from (+ 1) to (-1), for a year was estimated with the implementation of the various proposed walls as shown in Figure 4.14 below. The potential increase or reduction of the percentage of comfort hours comparing with the existing wall(W1) is provided in Figure 4.15.

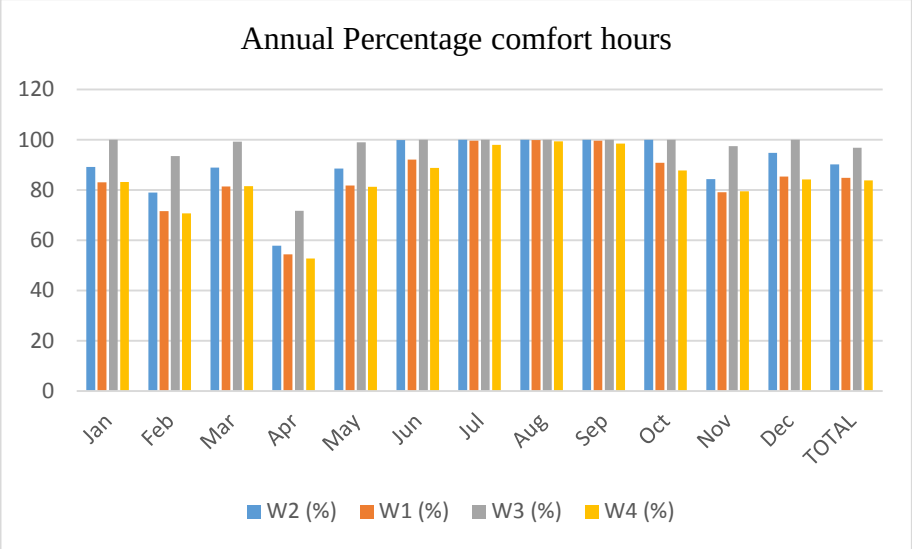


Figure 4.14 The potential increase or reduction of the percentage of comfort hours
Source: Autodesk Ecotect Analysis, 2011

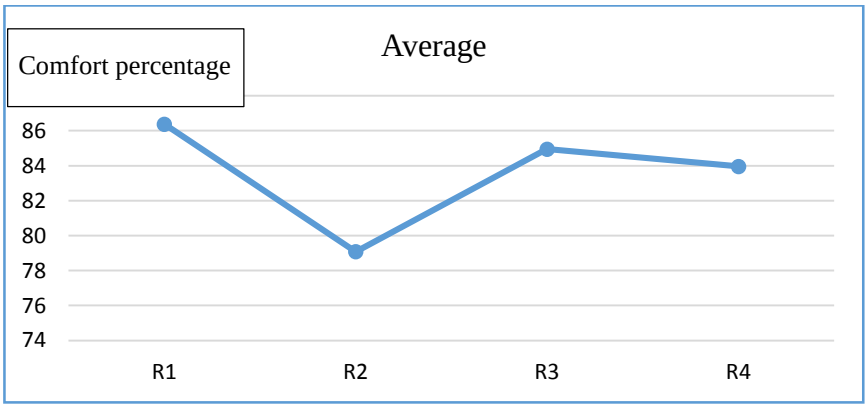


Figure 4.15 The annual average of the percentage of comfort hours.
Source: Autodesk Ecotect Analysis, 2011

The result revealed that by applying W1 which is the commonly used material in the case studies carried out, a very slight increase in the percentage of comfort hours by about 2.5% is achieved as compared to W2. Overall, applying W2 gives the least percentages of comfort hours. By applying W1, similar results are obtained during hot season and at annual level with a potential increase of the percentages of comfort hours of about 4.5%. However, in cold season with same walls types the possible increase of the percentages of comfort hours between these walls are 2.6%, 8% and 3.2% increase in W2, W3 and W4 respectively.

Overall, greater increase in comfort hours is attained with greater thickness and lower thermal conductance of material. Therefore, the highest increase in the percentage of comfort hours is achieved by using 230mm compressed earth bricks and the lowest is achieved by using 150mm bricks. The material used in the case studies carried out is W1R1 as indicated in tables 4.11 and 4.12 above. These materials were combined and tested which in turn gave the result in figure 4.16 shown below

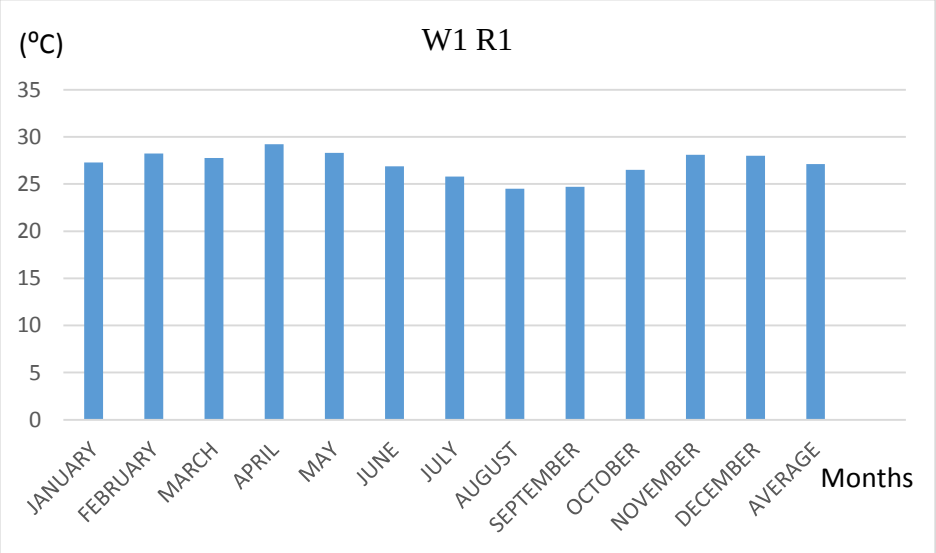


Figure 4.16: Hourly indoor temperature of W1R1 Source: Autodesk Ecotect Analysis, 2011

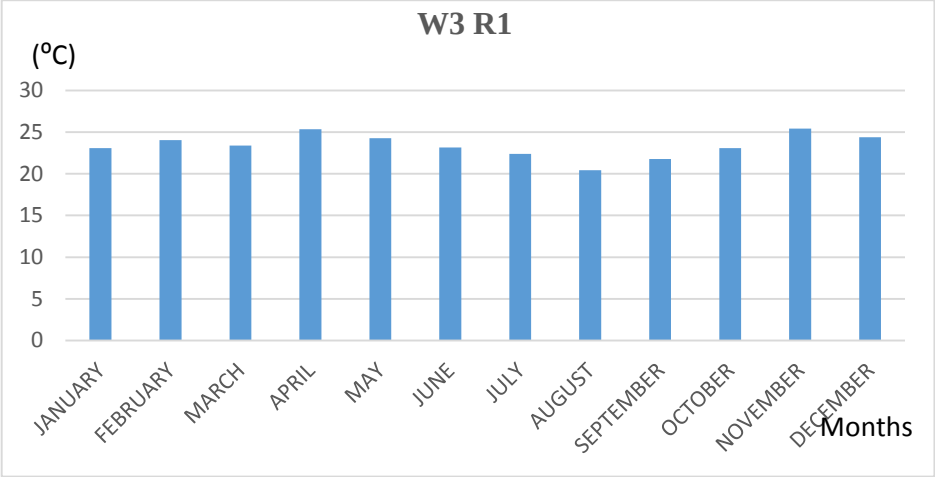


Figure 4.17: Hourly indoor temperature of W3R1 Source: Autodesk Ecotect Analysis, 2011

4.9.5 Temperature with proposed roofs

The hourly Resultant Temperature (RT) in both hot season and cold season day was estimated with the implementation of the various proposed roofs shown in Table 4.13. The following is the result of RT as can be seen in Table 4.14 below

Table 4.13: List of roof materials tested in the simulation.

Roof Code	Description	Thickness(mm)	U value (W/M^2K)	Thermal Lag (hrs.)
R1	Clay Tiled Roof	13	3.1	1
R2	Corrugated Metal Roof	0.55	7.11	0.2
R3	Corrugated metal roof Insulated with 50mm polystyrene insulation.	50.55	3.5	0.8
R4	Shingles	10	3.2	0.9

Table 4.14 Resultant Temperature of various Roofs on August 1st

		R1	R2	R3	R4
Hour	Outside (^{0}C)	Inside (^{0}C)	Inside (^{0}C)	Inside (^{0}C)	Inside (^{0}C)
0	29.4	24.2	26.5	25.4	25.3
1	29.3	24.2	26.5	25.6	25.2
2	29.3	24.1	26.4	25.4	25.2
3	29.2	23.9	26.3	25.3	25.1
4	29.3	23.9	26.3	25.3	25.2
5	29.3	23.9	26.3	25.3	25.2
6	29.3	24.4	26.6	25.8	25.2
7	29.3	24.6	26.8	25.9	25.2
8	29.4	24.2	26.8	25.5	25.3
9	29.4	24.3	26.8	25.7	25.3
10	29.7	23.8	26.8	25.2	25.6
11	29.8	24.7	27	26	25.7
12	31.5	24.4	27	25.8	27.4
13	30.8	24.4	27.1	26.3	26.7
14	33.1	24.3	27.1	26	29
15	31	23.7	26.9	25.9	26.9
16	32.5	24.2	26.8	26	28.4
17	31.2	23.7	26.6	25.7	27.1
18	33.2	23.9	26.5	25.3	29.1
19	30.9	23.6	26.5	25.4	26.8
20	30.4	23.6	26.3	24.6	26.3
21	29.8	23.2	26	24.4	25.7
22	30.2	22.9	25.8	23.8	26.1
23	29.6	23.1	25.9	24.3	25.5

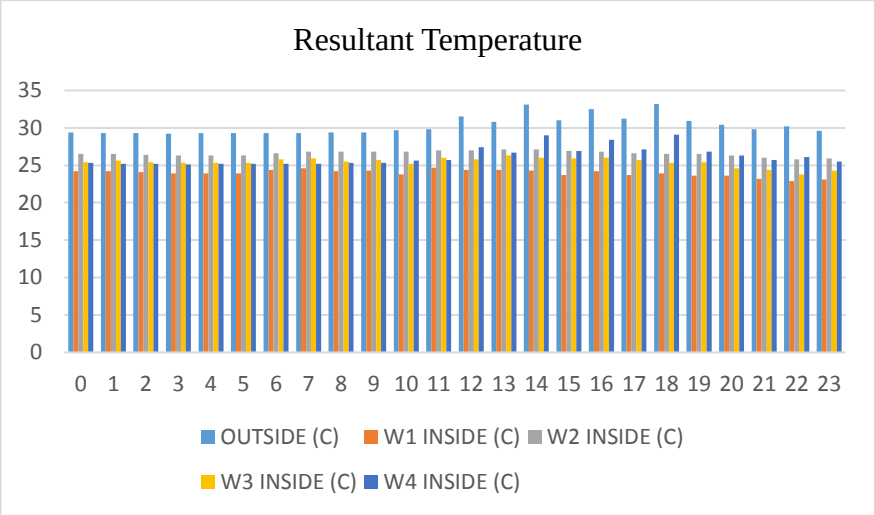


Figure 4.18 Resultant Temperature of various Roofs. Source: Autodesk Ecotect Analysis, 2011

As indicated in Figure 4.18 and Table 4.14, the lowest RT on a cold season-day is estimated when applying R1 followed by a very close result of using R3. By using R3 or R4, the potential reductions in the resultant temperature ranging between (0.8 to 6.5 °C) is achieved on a cold day. By using R1 which has a low U-Value, a steadier thermal environment is sustained as the internal temperature swings decrease with an average of about 6.5 °C and 1.2 °C in cold season and hot season respectively. Furthermore, this roof (R1) has shown the lowest temperature during the cold season. Generally, applying insulation materials to roofs has the potential to improve thermal comfort. Furthermore, the resultant temperature of the case of R2 which was the mostly used in the case studies carried out, gives the hottest indoor temperature during both hot and cold seasons which proves that roof enhancement is needed to improve the existing situation. In a comparison between the proposed roof R1 and roof R2, it is observed that the best indoor thermal environment can be achieved by applying the proposed roof R1 in the building especially during the hot season.

4.9.6 Thermal comfort with proposed roofs

The percentages of comfort hours, where the PMV ranges from +1 to -1 (percentage of dissatisfaction is ± 25%), in hot season and cold season of the year were estimated with the implementation of the various proposed roofs (see Figure 4.8). The potential increase or reduction of the percentage of discomfort hours comparing with the R1 is also provided in Figure 4.19

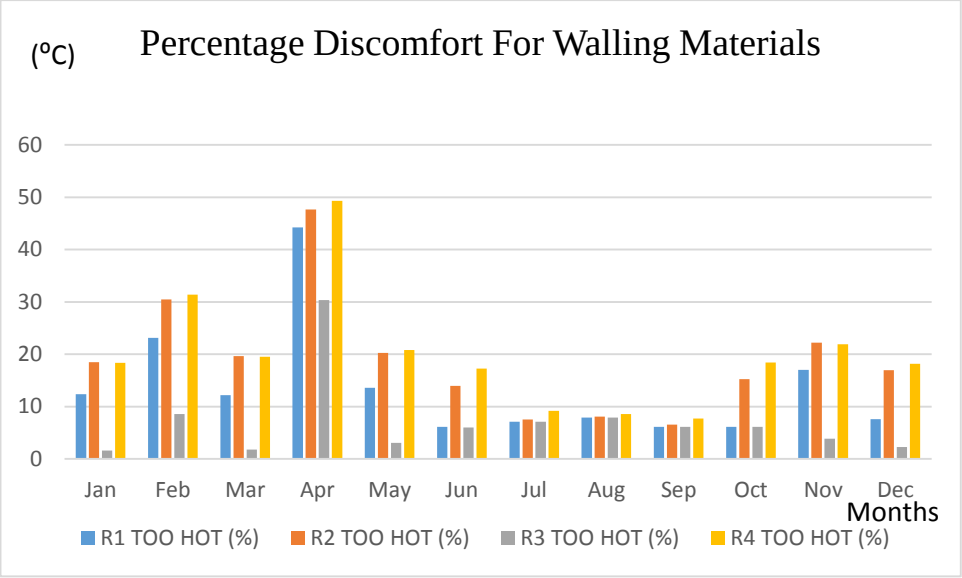


Figure 4.19 The potential increase or reduction of the percentage of discomfort hours Source: Autodesk Ecotect Analysis, 2011

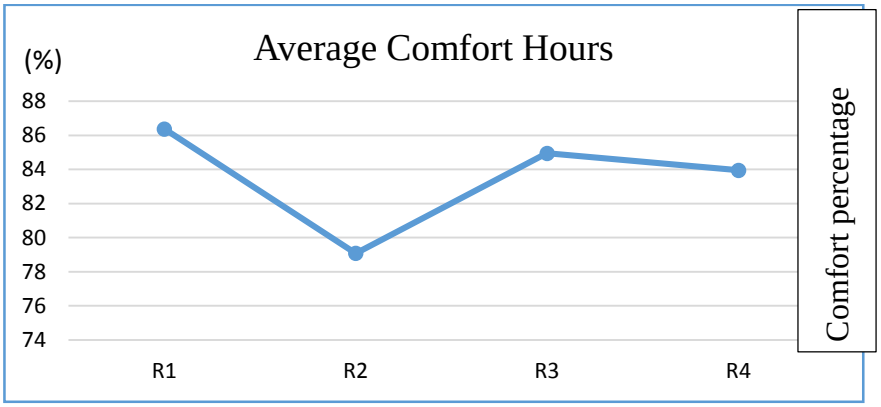


Figure 4.20 The annual average of the percentage of comfort hours. Source: Autodesk Ecotect Analysis, 2011

The result revealed that by applying R2 which is the commonly used material in the case studies carried out, there is little number of comfort hours while compared to roof R1. Generally, applying R1 gives the least percentages of comfort hours. By applying R3, similar results are obtained during hot season and at annual level with a potential increase of the percentages of comfort hours of about 6%. However, in cold season with same roof types the possible increase in the percentages of comfort hours are different between these roofs with (R1)7.3%, (R2)5.9% and (R3)4.8% respectively.

Generally, greater increase in comfort hours is attained with greater thickness and lower thermal conductance of material. Therefore, the highest increase in the percentage of comfort hours is achieved by using clay tiled roof and the lowest is achieved by using the corrugated long span aluminium roofing sheet. A summary of all the simulations carried out on the new materials and old materials can be found in figure 4.21 below.

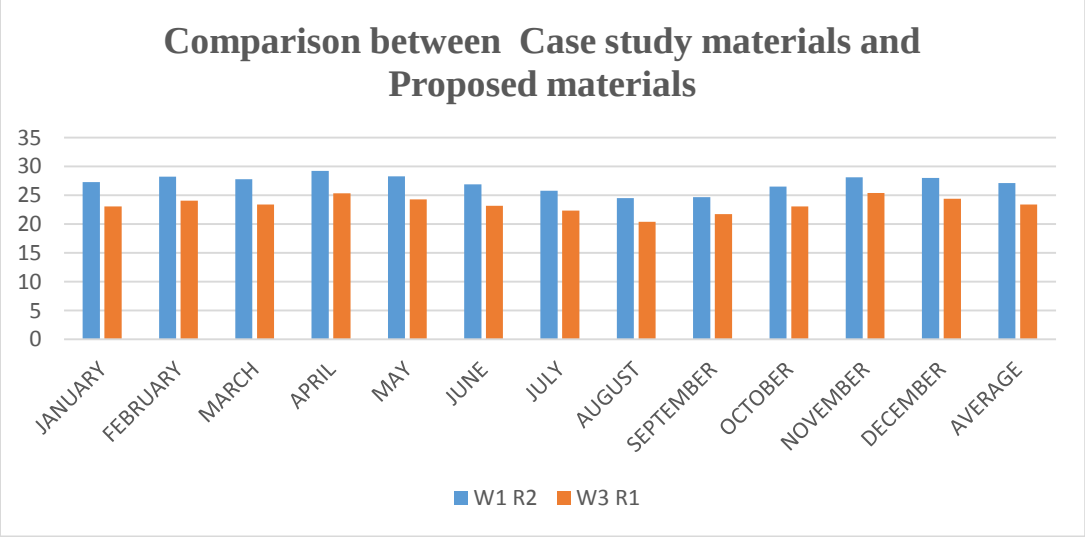


Figure 4.21: Hourly indoor temperature of all the building materials.
Source: Autodesk Ecotect Analysis, 2011

Simulation results show that materials W3R1 gave a consistent temperature range throughout the year regardless of the season. The comfort band in this zone is between 20 and 25^0c. Temperature range using this material falls within this range all through the year unlike other materials in which some fall below the operating temperature and some above

it. It can be said that W3R1 is the best material for building in this climatic zone as a general improvement of 7.14% was observed.

4.10 Summary of Findings From Simulation

i. By applying 230mm compressed earth bricks, with plaster both sides (W3) as opposed to 230mm concrete block with 10mm plaster either side (W1) which is commonly used, there is about 8.6% improvement in the indoor temperature and comfort.

ii. Exterior colour of walls plays a vital role in reducing the amount of heat absorbed by the building as bright colours reflect heat by up to about 12% as compared to dull colours.

iii. By applying 10mm plasterboard insulation on the wall, there is a better indoor comfort level of about 4.7% even though insulation costs more.

iv. By applying 50mm polystyrene insulation on the roof an increase of about 8.97% is gained in thermal comfort.

v. In the warm-humid climatic region, roofs contribute to about 48.2% of the total Solar Heat Gain Coefficient (SHGC).

vi. By applying clay tiled roof (R1) as opposed to corrugated metal roof(R2) which is commonly used, there is about 6.3% improvement in the indoor temperature and comfort.

vii. By applying W3R1 as opposed to W1R2 which is commonly used, there is about 7.14% improvement in the indoor temperature and comfort.

5.0 DESIGN AND STUDY AREA CRITERIA

Design is a complex process that provides solution for specific problems. It involves a lot of creativity and detailed planning. A resort is a place for relaxation and recreation, careful consideration has to be taken to adequately cater for the various design needs eminent in this building type. The envelope design which gives a conducive indoor environment to achieve the main functions in a resort was considered.

5.1 Study Area

The Resort centre shall be located in Lagos state, Nigeria. The state is located in the south-west part of the country which is in the warm-humid zone. It is located between latitudes 6.4531° N and 3.3958° E. The total area of Lagos is 1,171.28 square kilometres and has an altitude of 6m above sea level. It is bounded by Ogun State (Wikipedia, 2011).

5.1.1 Weather and climate

Lagos has a tropical wet and dry climate with two distinct rainy seasons; the more intense one occurs between April and July, with a milder one from October to November. At the peak of the rainy season the weather in Lagos is wet about half the time. Lagos experiences a dry season (when it rains less than two days per month) during August and September, as well as between December and March, accompanied by harmattan winds from the Sahara Desert, which are at their strongest from December to early February. The temperature range in Lagos is fairly small, generally staying between a high of 91°F (33°C) and low of 70°F (21°C). The hottest month is April, when average daytime temperatures reach 84°F (29°C), while July is the coldest month with an average temperature of 77°F (25°C).

5.1.2 Vegetation

The major vegetation of the state is the tropical swamp forest consisting of fresh water and mangrove swamp forests both of which are influenced by the double rainfall pattern of the

state which makes the environment a wetland region, hence the reference to Lagos as an aquatic environment (Wikipedia, 2011). The swamp forests in the state are a combination of mangrove forest and coastal vegetation developed under the conditions of the coastal areas and the swamp of the freshwater lagoons and estuaries. On the seaward sides, wide stretches of sand and beaches exist.

5.2 Site Location

A site for buildings of this nature within Lagos would be suitable if located by the Atlantic Ocean to give a clear view. A space has been already clearly earmarked from the inception of the Lekki Free Trade zone master plan and is still conserved for a resort and golf course. The site is strategically placed, adjoining the Lekki Free Trade zone.

5.3 Site Selection Criteria

Some factors were considered based on specific criteria for the selection of site for the Resort Centre. They include:

I. Proximity of site to a natural landscape element

II. Land-use compliance

III. Proximity to basic amenities

IV. Size of site, possibility for expansion, suitability and availability. The site should be large enough to accommodate the design.

V. Soil on site should be fertile and able to support plant life for the landscape. It should also have a good load bearing capacity.

VI. Site should have drainage and waste disposal possibilities.

Commercial potential of surrounding area as shown in table 5.1 below

Table 5.1: Site selection criteria

Criteria	Site1 Lekki	Site2 Epe	Remarks
Location/accessibility	5	5	Site 1 is centrally located but both sites have good access road
Land-use compliance	5	3	Site 1 is indicated for resort and tourism in the land-use plan
Proximity to basic amenities	5	3	Site 1 has proximity to basic amenities compared to site2
Expansion possibility/ size of site	4	4	Both sites are large enough to accommodate the resort
Soil type/ topography/ vegetation of the site	5	3	The soil in site1 has good bearing capacity
Drainage & waste disposal potential	4	4	Site 1 has a drainage in front & good access to waste disposal
Commercial potential of surrounding area	5	2	Good access to commercial area because most commercial activities are centrally located
Total	33	24	
Key rating: Excellent 5, Very good 4, Good 3, Fairly good 2, Poor 1			

Source: Researcher

Table 5.1 shows the criteria that was considered in selection of the site for proposed design. From the analysis of the criteria, site 1 has been selected based on the fact that it has more advantage and fulfils the selection criteria.

5.4 Site Analysis

A site analysis is a study of the site, it takes into consideration natural and man-made components present above and beneath the site, as well as climatic conditions present in and around the site. (Ogunsote, 2010) For a comprehensive site study; a macro and micro site analysis is carried out, which the former takes into consideration environmental factors affecting a larger area than the site, such as a region, state or zone. For this study, the entire Lagos State is considered for the macro analysis whereas the later analyses the environmental factors affecting the specific site or area as follows:

5.4.1 Climate:

The climate of the site is slightly different from general climatic factors of the rest of Lagos due to its proximity to the Atlantic Ocean and the virgin nature of the site, which consists of trees, shrubs and green area.

(i) Temperature: The temperature of the site is affected due to the presence of the large water body. The average highest temperature occurs in March at about 33^{o}c. The cold season lasts from June to September (Wikipedia, 2011) with an average daily temperature of about 25^{o}c as shown in figure 5.1 below.

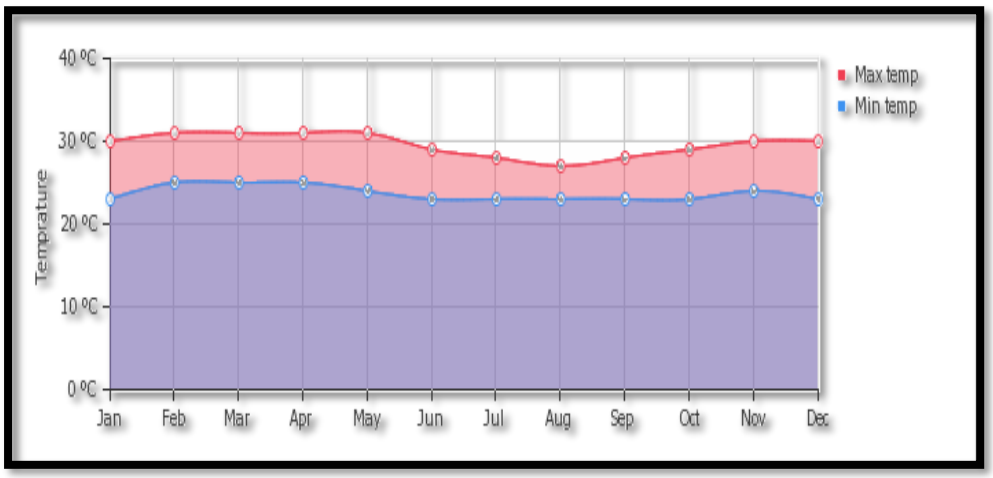


Figure 5.1 shows the average annual temperature of Lagos state
Source: (Wikipedia, 2011).

(ii) Humidity: Figure 5.2 shows a chart of the humidity of Lagos with an average of 82%. The site humidity is slightly higher than other parts of Lagos because it is close to a water body. Large window openings would be used to allow proper air flow through the building in a bid to reduce thermal discomfort from sweating.

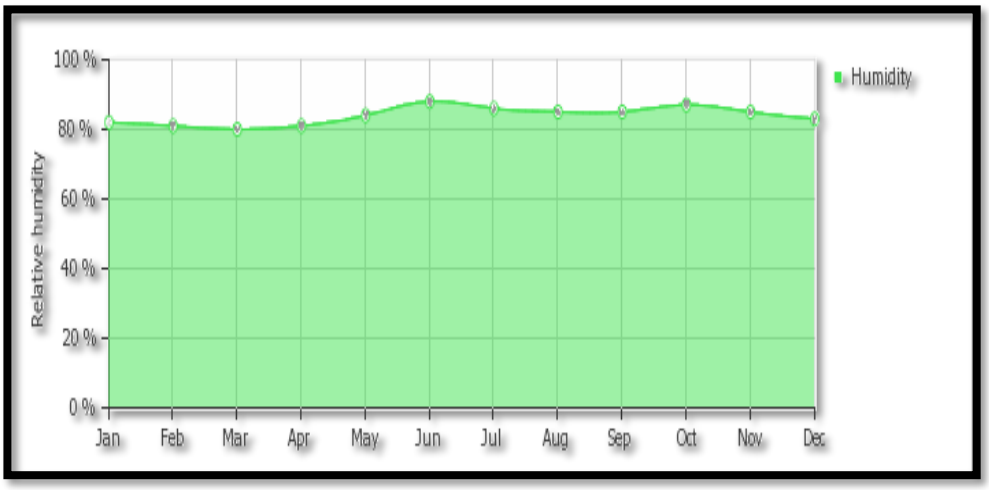


Figure 5.2 The Annual humidity
Source: (Wikipedia, 2011)

(iii)Rainfall: The frequency and amount of rainfall over the site is the same with that of the Lagos Mainland. Rainfall occurs almost throughout the year although it achieves its peak between April and October of about 1506mm per year as shown in figure 5.3 below. High roof pitch would be used to drain water.

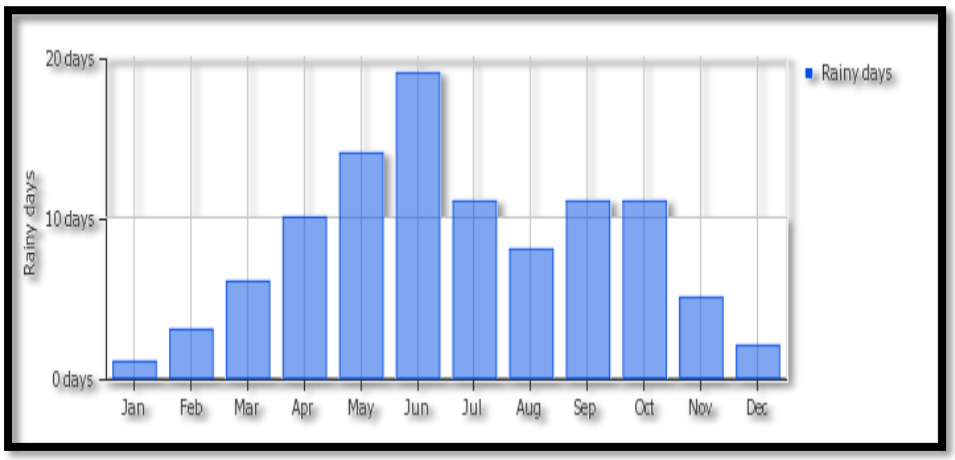


Figure 5.3 Peak rainfall is achieved in the month of June.
Source: (Wikipedia, 2011)

(iv) Wind: Trees in the Vicinity, act as wind breakers, wind speeds are decreased by approximately 20% relative to other places which have no wind breakers. The average wind speed is about 4.8 knots and the highest occurs in the month of August which is about 6.2 knots. As shown in figure 5.4 below. However, very local factors like trees and shrubs can reduce wind speeds over the site. Generally, the major air mass that dominates Lagos blows from the South-West and this is very much influenced by the Atlantic Ocean.

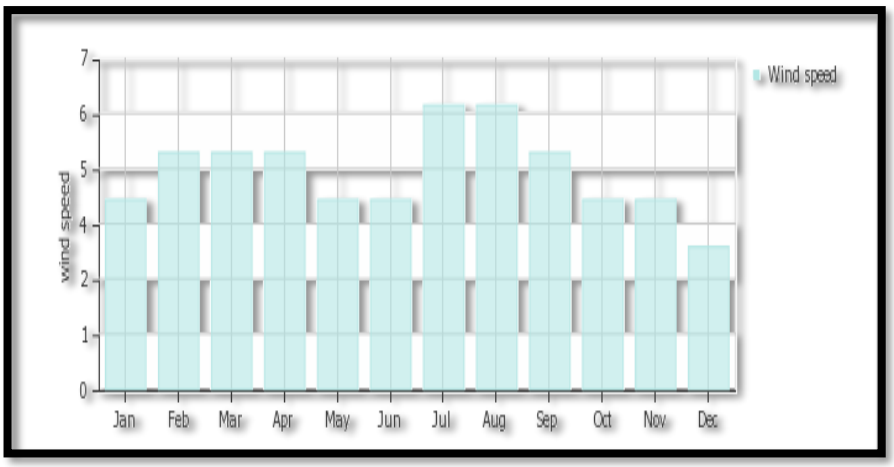


Figure 5.4 Wind speed chart showing annual wind speed.
Source: (Wikipedia, 2011)

(v) Sunlight and Cloud Cover: Due to the presence of trees and shrubs on the site, the impact of solar insolation is less. The trees and shrubs absorb heat, cast shadows and consequently provide shades for human comfort, Figure 5.5 below shows that November has a high amount of sunshine hours.

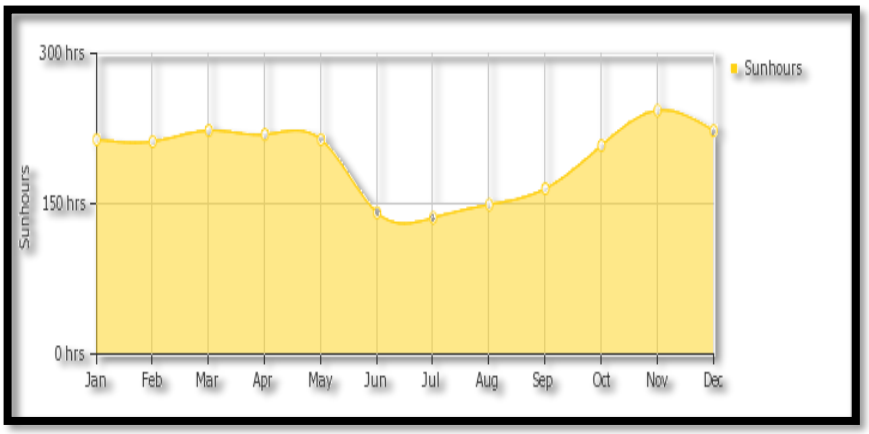


Figure 5.5 Annual Sunshine hours.
Source: (Wikipedia, 2011)

(vi) Dust: The virgin nature of the site, with trees and shrubs tends to reduce the effect of dust on the site. However, during the dry season, dust is raised from the soil on the site. Adequate landscape was used with an intention to reduce the effect of dust

6.0 DESIGN REPORT

6.1 Brief Development

The main consideration in brief development are the client and user requirements which may be identified as a problem. This will form a bench mark for analysis and subsequently design. Lagos, the commercial capital of Nigeria, desires to have an Architectural landmark that will symbolize the cultural richness of a multi-ethnic country. The client is the Lekki Free Trade Zone Development Company. The Lekki Free Trade Zone Development Company plans to invest in tourism by developing resorts within the zone (LFZDC, 2011). Lagos is within the warm humid zone and so the client requests that the resort should be environmentally friendly and thermally comfortable.

6.2 Concept Development

The concept adopted for the proposed design on site follows the evolved site zoning and layout developed while imitating a natural form that depicts an envelope which serves as protection: The "Tortoise shell". The shell provides comfort to the tortoise from external harsh weather conditions as well as predators. The same way the Building envelope protects the building inhabitants from harsh conditions. The Hexagonal patterns on the shell of the tortoise provides as walkways linking different parts of the resort to each other. As shown in figure 6.1, The resort is located close to a water body where it takes advantage of the water body for recreation activities as well as services within the site. The warm air in day

time rises and is replaced by the air from the water body known as sea breeze. However, at night, the water surface is warm and due to low pressure rises and replaced by a denser cooler air from the main-land know as land breeze. This process creates a micro-climatic environment for the resort and thus reduces need for cooling interior spaces through active means at all times.

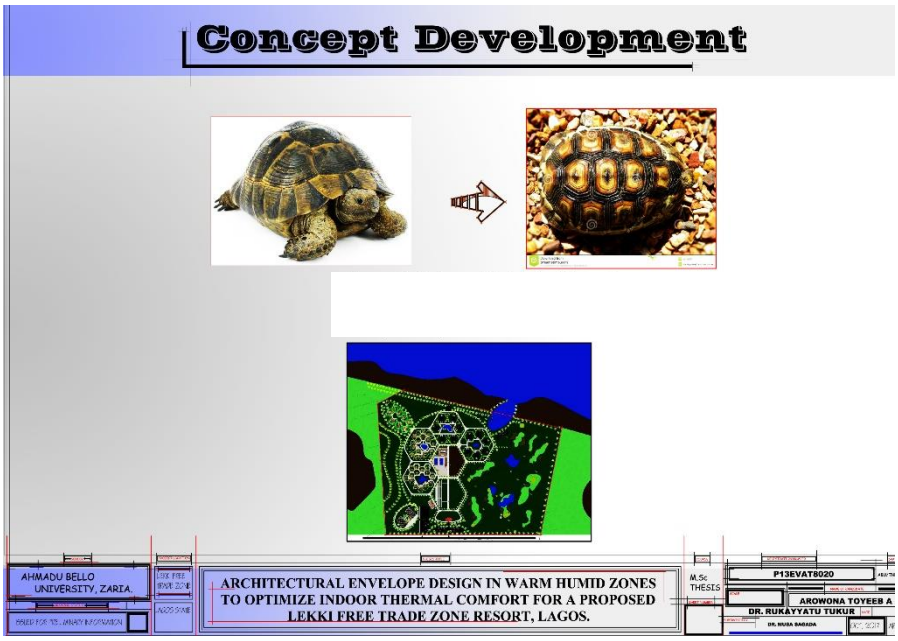


Figure 6.1 Concept development.

Trees and shrubs were planted according to a defined landscape suited to the functional and aesthetic requirements of the resort. The functional requirement for landscape is to minimise the heat gained on site surfaces and building envelopes especially in the day time. This was achieved through proper position of trees, use of stretch lawns and extensive boulevards for outdoor activities,

The prospective users of the proposed resort centre can be grouped into two: The primary and the secondary users.

i. The primary users: This consists of the expected guests who lodge in the accommodation and the visitors who just come in for recreation and leave on the same day in addition to the administrative and service staff. Main spaces are designed to enhance optimum utilization and satisfaction of these users. For the guests, the facility is designed to make them have a feel of nature and serenity which gives a total experience of entertainment and leisure.

ii. The Visitors: These people come during the day and leave on the same day The structure incorporates spaces such as an events hall, golf course, sculpture garden, zoo, and botanical garden amongst others for the use of this category of users. They also are a primary source of income for the maintenance of the facility.

This project will be located within the Lekki Free Trade Zone which makes the facility a centre of attraction especially for the foreign investors within and outside the zone .In the design of the resort centre, several spaces would be considered based on zoning and inter-relationship. Proper zoning arrangement will foster harmonious interactions and allow for smooth and efficient running of activities within the facility.

The resort centre will house the following facilities:

i. A 9-hole golf course
ii. 2 No events hall
iii. Accommodation for guests
iv. A Botanical garden
v. Boating and Hot air balloon services.
vi. Administrative spaces
vii. Services Apartment.

6.3 Architectural Philosophy

Architecture is all about problem solving within the context of the built environment. Spatial organization guided by the basic principles of design geared towards the creation of logically contrived spaces shaped by function, and aesthetic precedents. The design for the resort centre has a primary drive to provide an environment for relaxation and recreation. Underlying this drive is the architectural philosophy which serves as a catalyst for the realization of this facility.

6.4 Design Consideration

6.4.1 Spatial arrangement

The whole facility is designed to relate with each other with proper zoning consideration based on privacy. This makes accessibility easy and quick. The parking space is the first point of contact on arrival to the site from which golf carts are used to move through the site through the reception. The events centre has a separate entrance due to the high amount of traffic it generates at its peak period. The common shared facilities are easily accessed from the parking area for visitors who just come to recreate themselves and leave.

6.4.2 Circulation

Conscious design efforts were made to separate pedestrian and vehicular traffic. Circulation forms an important aspect of the design and can be achieved through the following ways:

i. Vehicular traffic: The site is very accessible based on its strategic location and it's bordered on the south, by an access road. Vehicular Access to the site is restricted to the car park area in a bid to reduce carbon emission within the site as well as

conflict between pedestrian and vehicles. Service access is also provided from the same axis of the site.

ii. Pedestrian traffic: Walkways form an integral aspect of the external and internal circulation scheme. Considering the fact that heavy human traffic would be a peculiar phenomenon to the design, 4m wide walkways were provided while taking into consideration the use of golf carts as a means of transport within the site. Also, walkways link the building to the parking lots and ancillary spaces such as the artificial pool and outdoor sitting and also to the beach.

6.4.3 Site planning and landscaping

Environmentally aware decisions such as retaining most trees on site, use of earth friendly techniques and materials, in order to conserve energy and allowing the building follow the natural terrain all helps to get a sustainable design. Retaining walls were provided along the beach line to reduce the effect of heavy waves on the site. The bye-laws, rules and regulations governing the design have also been put into consideration in proper allocation of accommodation and recreation spaces and building codes and standards e.g. fire standards, setbacks and also functional requirements have been adhered to in the design.

6.5 Building Materials and Technology

The materials intended for use in the proposed design include steel, concrete, fired bricks, bamboo, clay tiles and glass. The choice of these materials is for the following reasons;

6.5.1 Concrete

The fluidity of concrete makes it a good construction material for the floors, lintels and beams. Concrete is flexible, especially when used with moulds and reinforcement, however it is quite heavy (Ugochukwu, 2015)

6.5.2 Steel

Steel is exceptionally strong, extremely flexible in design and very cost effective especially when used for the reinforcement of the beams and lintels.

6.5.3 Glass

The use of glass allows for visual connection with the outside world and nature, as well as to bring in light into the interior spaces to make the structure more power conservative.

6.5.4 Bricks

The bricks would be used as walling material as brick gives very good thermal insulation from heat (Ugochukwu, 2015). It also gives a beautiful look to the buildings.

6.5.5 Bamboo

The use of bamboo as structural members for the roof and as columns was considered due to availability while also giving the buildings a feel of a tropical design.

6.6 Services

6.6.1 Water supply

The water body present is a source of water for the facility. A small treatment plant was provided to purify the water and thereafter distributed within the facility for use. Also, the water body present at the site shall be utilized for landscaping and for the construction purpose.

6.6.2 Power supply

Power shall be tapped from the PHCN National grid. There is provision for a power house, with three generator sets – one working and two standbys, to cater for power failure.

6.6.3 Heating ventilation and air conditioning system

To complement natural ventilation, air conditioning systems shall be installed.

6.7 Schedule of Accommodation

A schedule of accommodation is provided to show the spaces provided and the actual size needed for a space. Space required must not always be the same as spaces provided.

Table 6.1: Schedule of accommodation

S/N	Spaces	Area(m^2)		Quantity
		Area Required (m^2)	Area Provided (m^2)	
1	Administrative Areas			
	Front offices	0.4sqm/person	0.6sqm/person	5
	Staff Areas/ Lounge	0.9sqm/person	1.0sqm/person	2
	Staff conference room	1.2sqm/person	1.5sqm/person	1
	Changing room	0.8sqm/person	1.0sqm/person	2
	Staff conveniences	0.9sqm/person	1.0sqm/person	2
2	Business Spaces			
	Rentable Shops	12-40persons	20-60	3
3	Indoor Services			
	Gym	1.0sqm/person	1.0sqm/person	1
	Fitness/ Health Club	1.6 sqm/person	1.6 sqm/person	1
	Spa	0.8 sqm/person	0.8 sqm/person	1
	Massage Room	3sqm/bench	3sqm/bench	1
	Changing rooms	0.8sqm/person	1.2sqm/person	6

4	Back house facilities			
	Laundry	0.8sqm/person	1.2sqm/person	1
	Kitchen	1.8sqm/person	2.0sqm/person	2
	Restaurant	2.0sqm/person	2.2sqm/person	2
	Bars Bakery/ Pastry	1.6sqm/person	1.8sqm/person	1
	Coffee café	0.8sqm/person	0.8sqm/person	1
	Conveniences	1.4sqm/person	1.6sqm/person	6
	Stores	9sqm	12sqm	4
6	Functional Areas			
	Conference Hall	1.2sqm/person	1.5sqm/person	2
	Banquet Hall	1.5sqm/person	1.6sqm/person	1
	Meeting Rooms	1.2sqm/person	1.4sqm/person	2
	Conveniences	1.2sqm/person	1.4sqm/person	16
	Chalets			
8	One Bedroom			
	Bedrooms	12sqm	16sqm	60
	Living Rooms	16sqm	20sqm	60
	Baths	2sqm	3sqm	60
9	Two Bedroom			12
	Bedrooms	12sqm	16sqm	12
	Living Rooms	16sqm	20sqm	12
	Baths	2sqm	3sqm	12
10	Luxury Chalet			
	Bedrooms	16sqm	18sqm	8
	Living Rooms	16sqm	20sqm	8
	Baths	2sqm	3.5sqm	8

10	Site auxiliary facilities			
	Gate house/ Security	1.2person	1.4sqm/person	1
	Treatment Plant	40sqm	60sqm	1
	Swimming pool	120sqm	120sqm	2
	Gazebo	9sqm	6sqm/person	2
	Bush bar	1.2sqm/per son	1.2sqm/per son	14
	Marina Lake side rest	-	24sqm/boat	2
	Car parking	12.5sqm/car	12.5sqm/car	2

7.0 SUMMARY, CONCLUSION, AND RECOMMENDATION

This chapter provides the summary, conclusion, contributions to knowledge and recommendations of the research. The summary of all six chapters is discussed; the conclusion encompasses how each of the four objectives is achieved; contributions to knowledge establish the significance of the research; while recommendations pose area for further research.

7.1 Summary

The first chapter discusses the importance of tourism from the social to the economic. It is one of the fastest growing industries in the world and has become a source of negative environmental and social impact due to uncontrolled human activity. Nigerian resorts have become part of this problem by destroying the ambience of the natural setting; poor siting and poor designs to cope with the climatic conditions of their regions while efforts are spent on style, features, frills and extras without any understanding of the actual design requirement. The location for the design is the Lekki free trade zone.

Chapter two explores types of resorts and how they operate. It also explores thermal comfort its principles and the building envelope as it relates with thermal comfort. The key components of the Building envelope are the roof, floor, and walls. The components under consideration were the roof and walls dues to the amount of heat gained from them. The Climatic region under consideration; the warm humid climate is known for its high level of humidity, thereby causing a lot of thermal discomfort within interior spaces in the region.

Chapter three cases are selected and based on a list of criteria; resorts within the warm-humid climatic region. The three cases studied include; Epe resort, La Campagne Tropicana

and Whispering Palms Badagry. Method of data collection include; visual survey, and simulation, while instruments used for data collection are; checklist and simulation.

The fourth chapter Presents data collected from the three cases studied, they include Epe resort, La Campagne Tropicana and Whispering Palms Badagry. The variables of the building envelope are evaluated under the following; colour, thermal mass, shading and glazing. The local case-studies have a number of facilities that are dispersed within the site and not organized properly. They did not take into proper consideration the building envelope materials during the design and construction stages. From the cases studied, the colours of walling materials were not given so much consideration in a bid to reduce heat absorption within buildings, the walling materials used in most of the case studies conducted is sand crete block which has a high heat conductance level. Most of the roofs had dull colours which do not reflect heat from the sun. The landscape scenery present at La Campagne Tropicana and Whispering Palms respectively create a lively environment for relaxation. Hence, introducing good and properly planned landscape in the proposed design, will create a serene environment. The buildings are close to water bodies. Furthermore, simulations were carried out which indicate that by applying the proposed brick walls, there is about 16% improvement in the indoor temperature and comfort while exterior colour of walls plays a vital role in reducing the amount of heat absorbed by the building.

Chapter five discusses the site which is within the Lekki free trade zone, Lagos. Some of the criteria for selecting the site include Proximity of site to a natural landscape element, Land-use compliance, Proximity to basic amenities, Size of site, possibility for expansion, suitability and availability. The site should be large enough to accommodate the design, Soil on site should be fertile and able to support plant life for the landscape. It should also have a good load bearing capacity, Site should have drainage and waste disposal possibilities.

Spaces should be zoned into accommodation, administration, recreation and ancillary facilities corresponding with private, semi-private and public zones respectively; an animal imitating the building envelope serves as the design's inspiration; and use of sustainable materials should be reflected in the design. These solutions provide a frame work to approaching the design of the resort.

Chapter six presents a design report for the resort. Tortoise shell serves as a site plan concept. Use of bricks as the walling materials, Use of Bamboo as structural material while also giving a tropical feel to the design. Use of Clay tiles for the roofing materials to enhance indoor thermal comfort. On-site water body as the main water source; Application of hard landscape is reduced in a bid to enhance overall cooling within the resort. Materials used include, brick, concrete, earth tiles, earth blocks and gypsum mortar. Adoption of local labour; Zoning; space requirements, and beach. These features incorporated translate into an 'artificial-natural' environment and establishes the artificial environment to be an extension of the natural one.

7.2 Conclusion

The aim of this research is to explore building envelopes that are optimized for thermal comfort. This was achieved by satisfying the following objectives;

Objectives:

7.2.1 This is done by Identifying the materials currently used in resort designs. This was achieved through the case studies while also reviewing literature. However, all the cases studied didn't take the building envelope into proper consideration as they rely mainly on active means of cooling.

7.2.2 The case study approach to the research was able to achieve this object by documenting existing features of each case studied and evaluating the level of application of suitable envelope design considerations. A check list was designed to check the design considerations in a bid to achieving thermal comfort within the buildings. It was noted however that the designs didn't put the design considerations into use. The use of bright coloured materials to reflect off heat was not in use.

7.2.4 Proposing a design for an eco-resort This is satisfied by applying results and findings, and using them as a framework for the design. The building was designed based on the application of other thermal comfort principles to achieve thermally comfortable interiors. The suitable materials were applied and is reflected in the design

7.3 Contributions to Knowledge

The contributions of this work to knowledge include;

i. By applying 230mm compressed earth bricks, with plaster both sides (W3) as opposed to 230mm concrete block with 10mm plaster either side (W1) which is commonly used, there is about 8.6% improvement in the indoor temperature and comfort.

ii. Exterior colour of walls plays a vital role in reducing the amount of heat absorbed by the building as bright colours reflect heat by up to about 12% as compared to dull colours.

iii. By applying clay tiled roof (R1) as opposed to corrugated metal roof(R2) which is commonly used, there is about 6.3% improvement in the indoor temperature and comfort.

iv. By applying W3R1 as opposed to W1R2 which is commonly used, there is about 7.14% improvement in the indoor temperature and comfort with average indoor temperatures dropping from about 28 degrees Celsius to about 26 degrees Celsius.

7.4 Recommendations

The following are the recommendations suggested by this study

7.4.1 Professional enlightenment

Enlighten professionals especially in the building and tourism industry about proper understanding of the effects of building materials to solve the problem of indoor thermal comfort by applying findings from this work.

7.4.2 Assessment method

Exploring of an assessment method that would serve as a yard stick for achieving thermal comfort. It is important to eliminate the thermal transfer rate between the building envelope and surrounding environment in ways of conduction, convection and radiation in order to maintain the thermal balance. A high vegetation coverage on site is recommended in order to enhance overall thermal comfort requirement

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APPENDICES

APPENDIX A

CASE STUDY CHECKLIST

Walling Materials

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
1	Colour of walling materials	Light coloured walling materials reflect back solar heat						
2	Thermal mass/Walling Material	Suitability to the surrounding and climate of the region						
		Low mass material construction for warm-humid zones						
		Availability of local and modern building materials						
3	Window Orientation	Orient window openings to facilitate natural ventilation						
4	Window Shading	Shading devices for openings protect against solar insolation						
5	Wall Shading	Wall shading reduces solar heat gain on fabrics						
6	Building Orientation	Control shape, form and orientation						
Key rating for the above table 5-Execellent; 4-Very good; 3-Good; 2-Fairly good; 1-Poor								

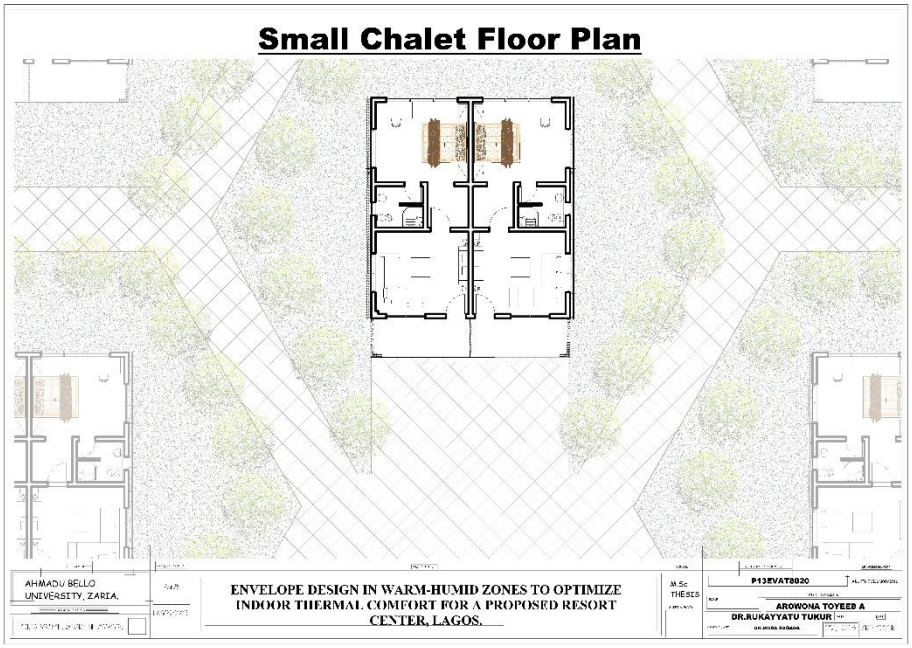
Roofing Materials								
S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
1	Colour of roofing materials	Light coloured roofing materials reflect back solar heat						
2	Roofing Material	Metal roofs loose heat quickly after sun set, tiled roofs radiate heat into buildings as they don't lose heat easily						
3	Roofing Vents	Poorly ventilated roofs get hot which in turn conducts heat to the ceiling and room below						
4	Roofing Overhangs	Long over hangs reduce solar insolation getting to the building						
5	Ceiling Material	Ceiling materials could serve as insulation to reduce heat gain within rooms						
Key rating for the above table 5-Execellent; 4-Very good; 3-Good; 2-Fairly good; 1-Poor								

APPENDIX B

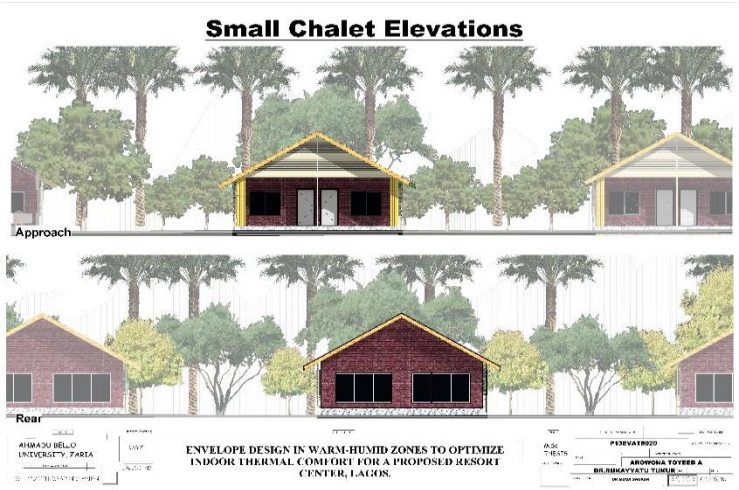
Design



Appendix I: Site Plan of the proposed facility.



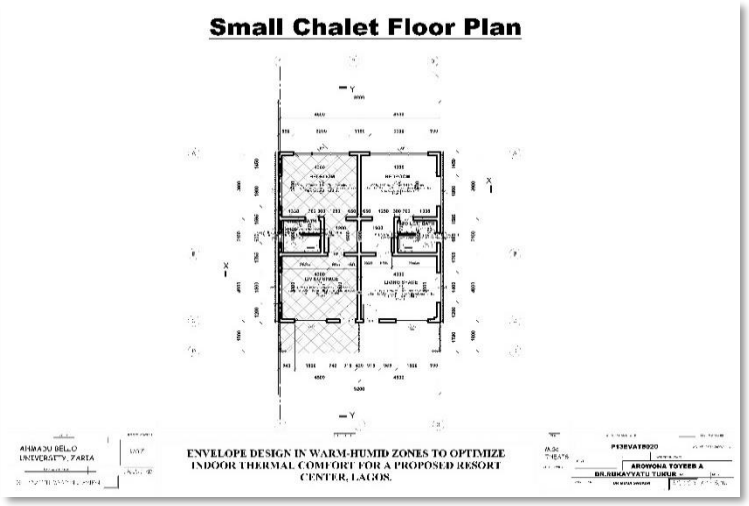
Appendix II: Ground Floor Plan of the small chalet



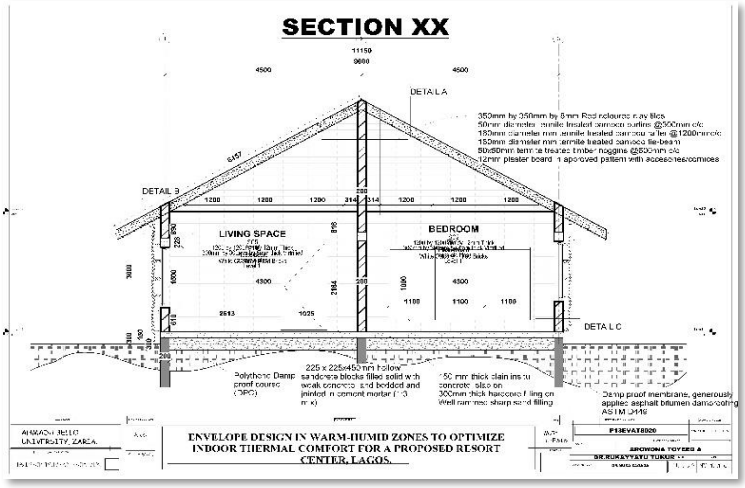
Appendix III: Approach and Rear Elevations of the proposed building



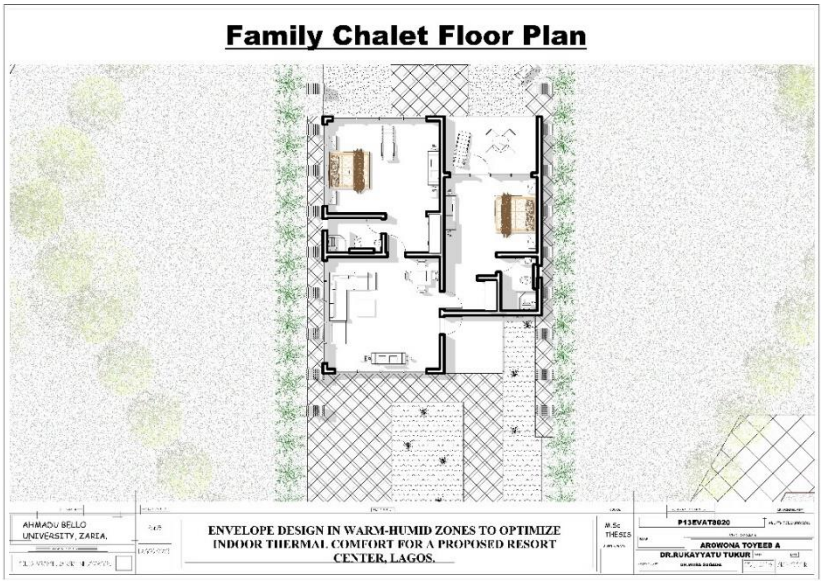
Appendix IV: Left and Right Elevations of the proposed building



Appendix V: Working Floor plan of the proposed building



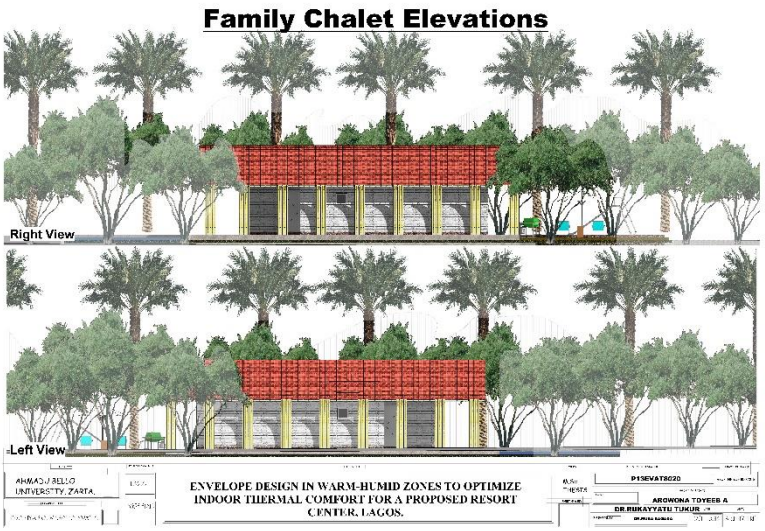
Appendix VI: Section of the proposed building



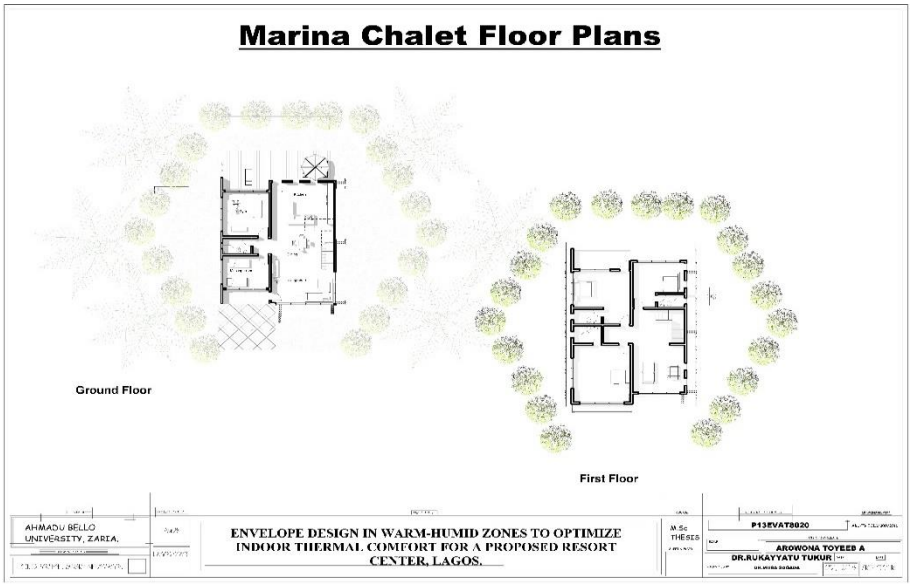
Appendix VII: Ground Floor Plan of the family chalet



Appendix VIII: Approach and Rear Elevations of the family chalet



Appendix IX: Left and Right Elevations of the family chalet



Appendix X: Ground Floor Plan of the Marina chalet



Appendix XI: Approach elevation of the Marina Chalet

Rear Elevation



Appendix XII: Rear elevation of the Marina Chalet

Left Side Elevation



Appendix XIII: Left Side elevation of the Marina Chalet

Right Side Elevation



Appendix XIV: Right side elevation of the Marina Chalet