Effects Of Shading Device On Thermal Comfort Of Residential Building In Northern Nigeria

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Abstract— Thermal Comfort has the powerful ability to create moods and it also affects working conditions of individuals. In order to harness maximum comfort, a conducive environment can be created. The use of shading device is the one of the best means of creating a conducive environment. This research assesses the effect of shading device on thermal comfort in residential building and how effective these sun shading elements are, in reaching a thermally conducive environment. The scope of the study is limited to residential buildings in the Northern part of Nigeria, particularly, Zaria area of Kaduna state. The research identifies the advantages of shading device, and how they influence thermal comfort depending on their orientation, location, type, all of these analyzed and discussed in detail in the preceding chapters. To achieve the set aim of the project, the extent to which shading device affect thermal comfort was measured using simulation software (Ecotect 2011). The research collected the necessary data to conduct the analysis which were inputted into the simulating software; Ecotect 2011. The overall thermal comfort percentage of the structure was simulated for using Ecotect 2011, after being modeled using Autodesk Revit. Conclusively, findings from the research revealed that the presence of shading device in the residential buildings increases the average thermal comfort in the structure. It is recommended that simulation of building models during design stages be adopted as a preventive approach, to avoid poor thermal comfort in buildings.

Index Terms— Global Warming, Thermal Comfort, Sun Shading Device, Residential Building

1 Introduction

Climate is defined as the manner by which the humidity, atmospheric pressure, wind, temperature, precipitation and other meteorological variables change in a specific region over a long span of years. Quite simply, these are several alterations, modifications or changes in the atmospheric nature that occur over a long period. Gradual increase in Earths average temperature, its atmosphere and ocean is referred to as global warming, which is permanently changing the climate of our planet [1]. Over the past 100 years, the change in climate associated with global warming is as a result of Earth average temperature increase from 0.4°C to 0.8°C and scientific consensus on climate change reveal that by the year 2100 it is expected to increase from 1.4°C to 5.8°C. The result of this change from global warming may comprise of polar ice caps melting leading to rise in sea levels, likewise increase in frequency and harshness of storms and hot climates becoming overheated [1]. Thermal comfort is the subconscious state of mind that is satisfactory with the thermal environment and is measured by subjective evaluation; it is also referred to as human comfort, thermal comfort is the contentment of the occupants with the thermal level of the surrounding conditions. The difficult nature of thermal comfort to be measured makes its highly subjective as a result of so many factors to be considered such as humidity, air velocity, air temperature, metabolic rates, radiant temperature, clothing levels and occupants of the same room experience these feeling quite differently as a result of the physiological state of the occupant [2]. Morale, productivity, health as well as safety can be improved by managing thermal comfort in the right manner [3]. Thermal comfort can create moods and feelings and affects the working condition of Individuals; the integration of shading device on residential buildings can help in creating a conducive environment. With the invention of mechanical climate controlling equipment, the need for obtaining thermal comfort and ventilation have seized without use of major machineries that consume energy. Designers should stop having this perspective, because these equipment's are the key contributors for the depletion of the Ozone layer by emitting gases. Non-electrical or mechanical means should be a major consideration when designing for thermal comfort rather than non-considerate design that involve several mechanical climates controlling equipment.

1.2. RESEARCH QUESTIONS

- How important is thermal comfort in building in relation to both the building and its occupants.
- Is thermal comfort in a building enhanced by the integration of shading devices? If so, to what extent?
- What are the other effects of sun shading devices on building aside thermal comfort?

1.3 AIM
The aim of this research is to assess the extent to which shading device affect thermal comfort in residential buildings in Nigeria.

1.4 OBJECTIVES
The objectives of this research are as follows:

- To understand from existing literature, the various concepts to achieving thermal comfort and how shading device can be used to improve thermal comfort.
- To highlight the various methods through which thermal comfort can be enhanced.
- To identify the several types of shading device and how they can be integrated in buildings.
- To identify the other effect of sun shading devices on building aside thermal comfort?

1.5 SCOPE OF THE STUDY
This research examines the condition residential buildings and their thermal comfort in warm sunny climates in Nigeria (Northern Nigeria Kaduna) with emphasis placed on how thermal comfort can be attained through the integration of sun shading device in external building elements.

2. LITERATURE

2.1. UNDERSTANDING THERMAL COMFORT
Thermal comfort is that state of the mind that expresses satisfaction of the occupants with the thermal condition of his/her environment [4]. However Comfort itself is a subjective matter and previously, researchers have carried out several researches to understand what the factors that makes up a comfortable workplace. [5] Stated that comfort can be obtained in the office through the satisfaction of indoor environmental quality (IEQ) with focus on thermal comfort, air quality, lighting, acoustic quality, cleaning and maintenance of workplace. Occupants having satisfaction with their thermal environment is very important as it affects health and productivity. Surveys have revealed that workers in the office who are satisfied with the thermal environment of their work place tend to be more productive. Thermal discomfort is the inverse of thermal comfort, it is known to have cause the sick building syndrome symptoms and affect the productivity of the workers. The main factors that influence thermal comfort are physical and environmental factors. The physical factors are clothing of the occupants and metabolic rate while environment factors include temperature, air movement and humidity.

2.1.1. METABOLIC RATE
People have different metabolic rates as a result of conditions of the environment and the level of activity engaged by each person. Metabolic rate is the degree at which chemical energy is converted into heat and mechanical work by the metabolic activities of an individual, in mathematical expression; it is expressed as unit area of the total body surface

2.1.2. CLOTHING INSULATION
The amount of clothing insulation a person wears significantly affects the thermal comfort of the person, due to the effect it has on heat gain/loss and eventually the thermal balance. The level of layers a clothing insulation has, prevents heat loss, which can result in overheating or making a person depend on the temperature of the external environment. Likewise, the thicker the garment, the more the strength of insulation capacity the garment has.

2.1.3. TEMPERATURE
The level of the intensity of heat in air is described as temperature; also it is the numerical degree of hot or cold. The most important factor in finding out if the occupant have thermal comfort or not is the degree to which a space is hot or cold.

2.1.4. AIR MOVEMENT
The movement of air is basically referred as wind. Changes in temperature and atmospheric pressure usually cause wind, the effect of wind is essentially important in achieving thermal comfort because it aids in reduction of perspiration rate of occupants, providing proper ventilation and exchanging the already heated air with cooler air.

2.1.5. HUMIDITY
The quantity of water vapor in the air is described as humidity; it is also referred to as the atmospheric wetness. High level of humidity of undermines the usefulness of seating in helping to regulate the temperature of the human body as a result it causes thermal discomfort. The body responds to humid air due to its ability to utilize the process of evaporative cooling as the primary mechanism used for the thermo-regulation of the temperature. When the conditions are very humid, the perspiration level on the skin evaporates at a slow rate. The humidi-

ty level in buildings interior should be kept at a low level if thermal comfort is what the occupants want to attain.

2.2. THE IMPORTANCE OF THERMAL COMFORT IN BUILDINGS

Thermal comfort is an essential aspect of design process people from this millennium spend most of their time inside the house. Therefore the importance of proper ventilation and building having good thermal comfort cannot be undermined. The satisfaction level of occupants on the living quality of their life is essentially affected by thermal comfort they have in their buildings. Building that are thermally uncomfortable have resulted in sick building syndrome which is a medical condition that cause efficiency level of workers to drop as a result of poor ventilation, with symptoms such as headaches and respiratory problems.

2.3. THERMAL COMFORT STRATEGIES IN BUILDINGS

The idea of thermal comfort cannot be associated with a few causes; rather it is caused by various factors such as, building condition, environmental factors and the physical nature of the occupants themselves. Thermal comfort cannot be achieved by single methods rather to fully understand thermal comfort problems, several tactics need to be considered. Some of these tactics include:

- In-Depth Knowledge of Proposed Site Environment
- Building Orientation
- Building Massing And Configuration
- Proper Ventilation And Avoidance Of Artificial Lighting When Possible
- Kinds Of Building Materials And Finishes Used
- Integrating Building Elements On Building Designs

2.4 SUN SHADING DEVICES

The performance of solar passive cooling technique such as solar shading, insulation of building components was analyzed by (Kumar, Garg and Kaushin). The research revealed a reduction of inside temperature by about 2.5^{oc} to $4,5^{oc}$ was observed when solar shading devices were integrated. The result was further modified by the use of insulation material and a controlled air exchange rate showed a more significant decrease of 4.4^{oc} to 6.8^{oc} of the indoor temperature. The analysis suggested that solar shading is quite useful to development of passive cooling system to maintain indoor room air temperature lower than the conventional building without shade [6]. The windows are the main element through which the greatest amount of heat enters the building; hence protecting them through the use of shading elements provides the greatest protection [7]. The solar load is made up of three components (direct, diffuse and reflected). To prevent the window from passive solar heating, when it is not desired, it must always be protected from direct solar components and sometimes from the diffuse and reflected components.

Decision on integration of shading elements (where and when) can have an effect on the thermal comfort level of a closed space. Achieving shading from solar radiation can be done in the following ways:

- Recessing the external envelope of the building
- Integration of fixed or automated external blinds or louvers.
- Permanent shading provided by vegetation or existing building.
- Integrating reflective canvas, earthen pot, vegetation on the roof.

2.4.1 SHADING BY USE OF OVERHANGS, LOUVERS AND AWNING ETC.

Shading device and sun control devices that are perfectly designed to integrate either as part of the building or separately placed from a building façade; can decrease heat gain in the building, its cooling demand as well as enhance the quality of natural lighting in the interiors of the building.

Solar orientation of a particular building façade affects the design and type of shading device to be integrated for effective usage.

The following are the classification of shading device:

1. Louvers: They can be fixed or adjustable; it affects air movement to a certain extent and provides shade to the building from radiation of the sun.
2. Movable Opaque: Curtains, roller blinds, awnings etc. reduce solar gain but affects air movement and obstruct the view.
3. Fixed: Overhang of roofs provide protection to the wall and opening against sun and rain.

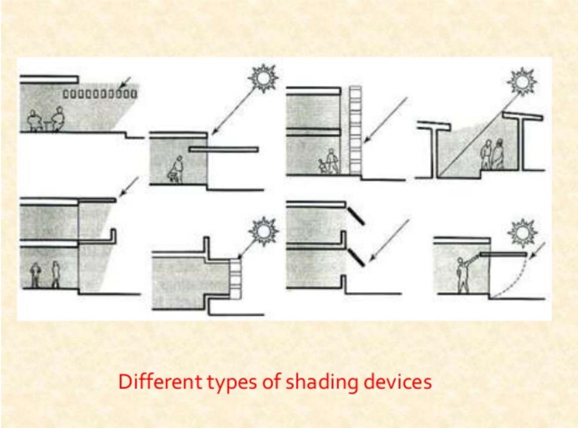

Fig 1. Different types of shading device

Source: https://image.slidesharecdn.com/shading-170206211526/95/shading-6-638.jpg?cb=1486415889

An analysis was conducted by Givoni to find out the effectiveness of various types of fixed shading device in several orientations, and reached the conclusion that the horizontal shading device is more effective than a vertical shading device in any orientation.

Some advantages of horizontal shading device over vertical shading device include:

1. Vertical shading device is not used to shade the whole length of the building.
2. Vertical shading device reduce the amount of daylight that goes into the building.
3. Vertical shading device reduce the extent of external view. [8],

With buildings having different forms and located in different climates, it becomes hard to generalise the design of shading device; nevertheless, these design recommendation can be applied generally [9]

1. Knowledge of the sun angle is important for designing the shading device.
2. The movable blinds help to decrease the convective heat gain in hot and dry climates, in warm and humid climates where the airflow is desirable, they tend to obstruct ventilation. In composite climates, the coloured blinds block the solar radiation effectively.
3. Limit the amount of glazing on the east/west façade. Glass on these exposures is harder to shade from the morning sun coming from east and the evening sun from west.
4. Fixed shading devices using the right size of overhangs or porches or design the building to be self-shading. Fixed shading device must be carefully designed to allow the penetration of the sun only during predetermined times of the year. [10]
5. Internal shading such as curtains or blinds is often used to prevent the unwanted solar gains entering the building. Curtains or blinds with darker colours can reduce the penetration of the sun into the space, yet it is not as effective as exterior shading device because it still convert most of the sunlight into heat within the building envelope since heat has already penetrated the building.

2.5 TREES FOR COMFORT

Trees attributes include determining trees functions, shape, aesthetics, and other growth attributes. Precisely, this study concentrates on trees that saves energy, saves money and improve the air quality by natural shading and evapotranspiration process in summer, allowing solar radiation in winter, and photosynthesis process. Not all tree species have same cooling effect; the lower foliage temperature the greater the cooling, and canopy size; structure and density also influence the extent of shading. Leaf temperature depends on anatomical (leaf mass, size, shape, angle and reflectance), physical (incoming energy, air temperature, wind) and psychological factors (transpiration, stomata conductance) [11].

[12] Demonstrated that trees responded differently to extremes in temperature but, generally, small-leafed species tend to be more effective at cooling by maintaining lower crown temperature than those of larger leafed species.

2.6 THERMAL BENEFITS OF TREES

2.6.1 AIR QUALITY

Poor air quality is a common problem in many urban and affects the health of people and environmental as well. Air quality improvement increases with increased present tree cover and decreased boundary layer heights. Urban vegetation and trees can directly and indirectly influence local and regional air quality by altering the atmosphere [13].

2.6.2 FRESH AIR AND AIR POLLUTION REMOVAL

Trees can reduce atmospheric CO_2 by directly storing carbon (C) from CO_2 as they grow. Large trees store approximately 3 metric tons of carbon or 1000 times more carbon than stored by small trees [14] trees have the special ability to remove gases that pollute the air we inhale through the leaf stomata while other gases are removed by the surface of the plant.

2.6.3 SHADING

The shade cast by trees can reduce glare and block the diffuse light from the sky and surrounding surfaces, thereby altering the heat exchange between the building and its surroundings. Furthermore, this will affect the comfort of people sitting or walking in the shade. During the day, shade trees also indirectly reduce heat gain in buildings by altering terrestrial radiation and ultimately reducing ground surface temperatures [11].

2.6.4 PASSIVE HEATING

Landscaping helps shade south, east or west facing windows from summer heat gain. Mature deciduous trees permits most winter sunlight (60 percent or more) to pass through while providing dappled shade throughout summer [15]. Thus, less fossil fuel is burned to generate electricity for cooling or heating [13]. Best choice of trees species such as deciduous trees help to block solar radiation in summer and let it in in winter, therefore it is very important to reduce energy demand for both cooling and heating in summer and winter [11].

3.0 RESEARCH AND METHODOLOGY

With the aim of accomplishing the set objectives of the research, literature relevant from the internet, textbooks, journals and thesis (published and unpublished) were taken into consideration. Few existing buildings will be examined, with the sole purpose of gathering information on the subject matter. This is carried out in Kaduna State, Zaria of Nigeria. A typical Northern Nigerian building was designed and modeled in Autodesk Revit and later simulated using the software

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Autodesk Ecotect to compare the effect of the thermal comfort in the building with and without shading device.

CASE STUDY 1

PLATE 3.1 RESIDENTIAL BUILDING IN NIGERIA SHOWING ROOF EAVES AND AWNINGS

SOURCE:http://www.loversiq.com/daut/as/f/a/affordablegreen-housing-for-nigeria-heinrich-b-c3-a3-c2-b6ll-stiftung-creator-chinwe-ohajuruka_home-construction-south-africa_home-decor_home-and-decor-pinterest-ideas-decorator-cheap-shabby-chic-liq.png

CASE STUDY 2

PLATE 3.2 RESIDENTIAL BUILDING IN NIGERIA SHOWING HORIZONTAL SHADING DEVICE

SOURCE:https://media-cdn.tripadvisor.com/media/photo-s/01/1e/aa/d6/fire-fighting-the-abuja.jpg

4.0 RESULTS AND FINDINGS

4.1 MODEL DEVELOPMENT

Ground floor plan of the building to be simulated was modeled on Autodesk Revit Architecture 2016, and later on it was exported to Autodesk Ecotect Analysis 2011.

Fig 1: 3 Bedroom Model From Autodesk Revit

4.2 ASSESSING THE EFFECT OF SHADING DEVICE ON THERMAL COMFORT

Two simulations were carried out on the building, one without shading elements were results were obtained and inputted into Microsoft excel. The other simulation carried out was for thermal comfort (indoor air temperature) were shading elements were attached to the building, and eventually results were obtained and recorded. Comparison was made between the two set of results to determine the difference in air temperature inside the structure. The following are some set of results obtained:

4.2 ASSESSMENT OF MODEL WITH SHADING DEVICE

4.2.1 COLDEST DAY AVERAGE; 12TH JANUARY

The result of simulation for both internal and external temperature (degree Celsius) was illustrated in table 4.1 for the date of 12th January (coldest day average) with shading elements (50 cm), 22.8°C marks the maximum temperature and 18.6°C is the minimum temperature for inside, with average temperature being 20.25°C for inside whereas the 21.7°C is the maximum for outside temperature and 10.8°C is the minimum for outside, with an average temperature of 15.92°C for outside. The average temperature difference for inside and outside is 4.34°C.

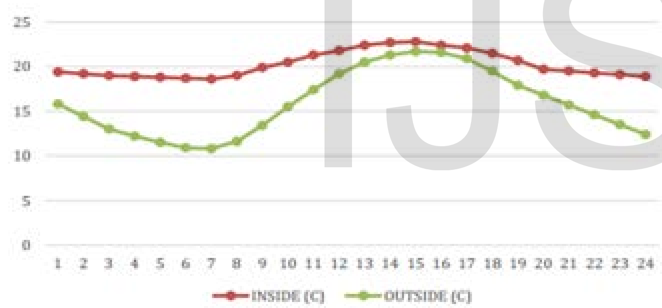
RESULT FOR SHADING DEVICES 50 CM

HOUR	INSIDE	OUTSIDE	TEMPERATURE DIFFERENCE
	(C)	(C)	(C)
0	19.4	15.8	3.6
1	19.2	14.4	4.8
2	19	13	6
3	18.9	12.2	6.7
4	18.8	11.5	7.3
5	18.7	10.9	7.8
6	18.6	10.8	7.8

7	19	11.6	7.4
8	19.9	13.4	6.5
9	20.5	15.5	5
10	21.3	17.4	3.9
11	21.8	19.2	2.6
12	22.4	20.5	1.9
13	22.7	21.3	1.4
14	22.8	21.7	1.1
15	22.4	21.6	0.8
16	22.1	20.9	1.2
17	21.5	19.5	2
18	20.7	17.9	2.8
19	19.7	16.8	2.9
20	19.5	15.7	3.8
21	19.3	14.6	4.7
22	19.1	13.5	5.6
23	18.9	12.4	6.5
AVERAGE	**20.25**	**15.92**	**4.34**

Table 4.1 Coldest day Average,
Source: Ecotect 2011

COLDEST DAY AVERAGE



4.2.2 HOTTEST DAY AVERAGE; 11TH APRIL

The result of simulation for both internal and external temperature (degree Celsius) was illustrated in table 4.2 for the date of 11th April (hottest day average) with shading elements, 39.4°C marks the maximum temperature and the minimum is 33.5°C for the inside. However the average temperature for the inside being 35.88°C while the 40.2°C was the maximum obtained for outside and the minimum being 28.2°C, therefore 33.82°C is the average temperature for the outside. 2.06°C is the average temperature between the outside and the inside.

RESULT FOR SHADING DEVICES 50 CM

HOUR	INSIDE	OUT-SIDE	TEMPERATURE DIFFERENCE
	(C)	**(C)**	**(C)**
0	34	30.1	3.9
1	33.9	29.8	4.1
2	33.8	29.2	4.6
3	33.6	28.8	4.8
4	33.5	28.4	5.1
5	33.5	28.2	5.3
6	33.5	28.3	5.2
7	34.5	30	4.5
8	37	31.9	4.4
9	37.6	34.1	2.9
10	38.2	36.2	1.4
11	39	37.8	0.4
12	39.4	39	0
13	39.3	39.8	-0.4
14	38.3	40.2	-0.9
15	39	40.1	-1.1
16	38.3	39.4	-1.1
17	37.5	38.2	-0.7
18	36.5	36.7	-0.2
19	35.1	35.5	-0.4
20	34.8	34.3	0.5
21	34.5	33.1	1.4
22	34.3	31.9	2.4
23	34.1	30.7	3.4
AVERAGE	**20.25**	**33.82**	**2.06**

Table 4.2 Hottest Day Average
Source: Ecotect 2011

HOTTEST DAY AVERAGE

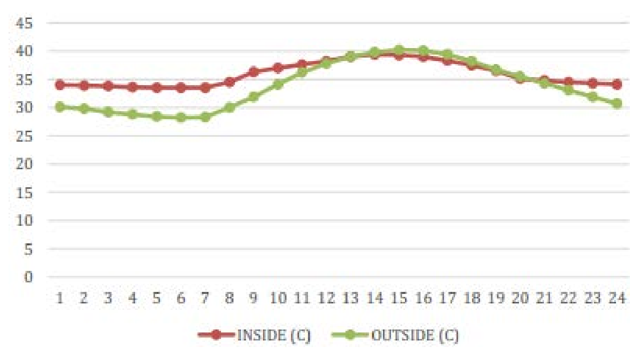


Figure 4.2 Graph showing the average hottest day temperature variance in the model with shading elements
Source: Ecotect 2011

4.3 ASSESSMENT OF MODEL WITHOUT SHADING DEVICE.

4.3.1 COLDEST DAY AVERAGE; 12TH JANUARY

The result of simulation for both internal and external temperature (degree Celsius) was illustrated in table 4.3 for the date of 12th January (coldest day average) without shading elements. 23.5°C is the maximum temperature and 21.2°C is the minimum for the inside, 22.17°C, in the case of the outside temperature 20.9°C is the maximum while 10.8°C is the minimum, 15.92°C is the average temperature for the outside. The average temperature difference between the outside and the inside is 6.25°C.

HOUR	INSIDE	OUTSIDE	TEMPERATURE DIFFERENCE
	(C)	(C)	(C)
0	21.7	15.8	5.9
1	21.6	14.4	7.2
2	21.5	13	8.5
3	21.4	12.2	9.2
4	21.3	11.5	9.8
5	21.2	10.9	10.3
6	21.2	10.8	10.4
7	21.2	11.6	9.6
8	21.9	13.4	8.5
9	22.2	15.5	6.7
10	22.5	17.4	5.1
11	22.8	19.2	3.6
12	23.1	20.5	2.6
13	23.3	21.3	2
14	23.5	21.7	1.8
15	23.5	21.6	1.9
16	23.4	20.9	2.5
17	23.2	19.5	3.7
18	23	17.9	5.1
19	22	16.8	5.2
20	21.8	15.7	6.1
21	21.7	14.6	7.1
22	21.6	13.5	8.1
23	21.4	12.4	9
AVERAGE	**22.17**	**15.92**	**6.25**

Table 4.3 Coldest Day Average without shading elements
Source; Ecotect 2011

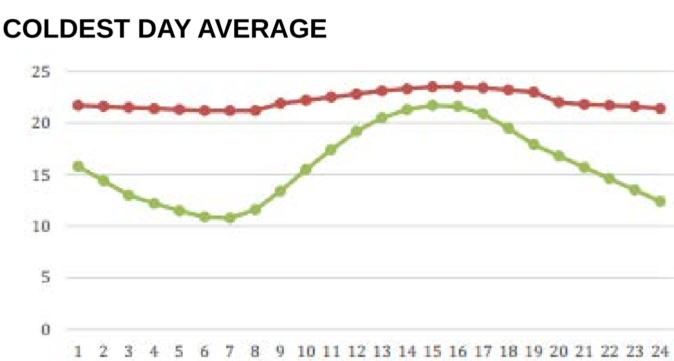


Figure 4.3 Graph showing the average coldest day temperature variance on the model without shading elements
Source; Ecotect 2011

4.3.2 HOTTEST DAY AVERAGE; 11TH APRIL

The result of simulation for both internal and external temperature (degree Celsius) was illustrated in table 4.4 for the date of 11th April (hottest day average) without shading elements. 39.6°C represent the maximum temperature and 36.7°C is the minimum temperature for the inside. 37.93°C is the average temperature for the inside. 40.1°C is the maximum temperature for the outside and 28.2°C is the minimum temperature for the outside, 33.82°C is the average temperature for the outside. The average temperature difference between the outside and the inside is 4.11°C.

HOUR	INSIDE	OUTSIDE	TEMPERATURE DIFFERENCE
	(C)	(C)	(C)
0	37	30.1	6.9
1	36.9	29.8	7.1
2	36.8	29.2	7.6
3	36.8	28.8	8
4	36.7	28.4	8.3
5	36.7	28.2	8.5
6	36.7	28.3	8.4
7	36.8	30	6.8
8	37.9	31.9	6
9	38.2	34.1	4.1
10	38.5	36.2	2.3
11	38.8	37.8	1
12	39.2	39	0.2
13	39.4	39.8	-0.4
14	39.6	40.2	-0.6
15	39.6	40.1	-0.5
16	39.4	39.4	0
17	39.3	38.2	1.1
18	39.1	36.7	2.4
19	37.8	35.5	2.3
20	37.6	34.3	3.3
21	37.3	33.1	4.2
22	37.2	31.9	5.3
23	37.1	30.7	6.4
AVERAGE	**22.17**	**33.82**	**4.11**

Table 4.4 Hottest Day Average without shading elements
Source: Ecotect 2011

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HOTTEST DAY AVERAGE

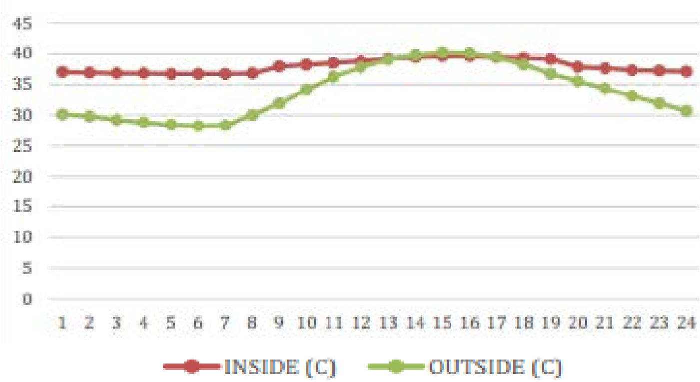


Figure 4.4 Graph showing the average hottest day temperature variance on the model without shading elements

Source; Ecotect 2011

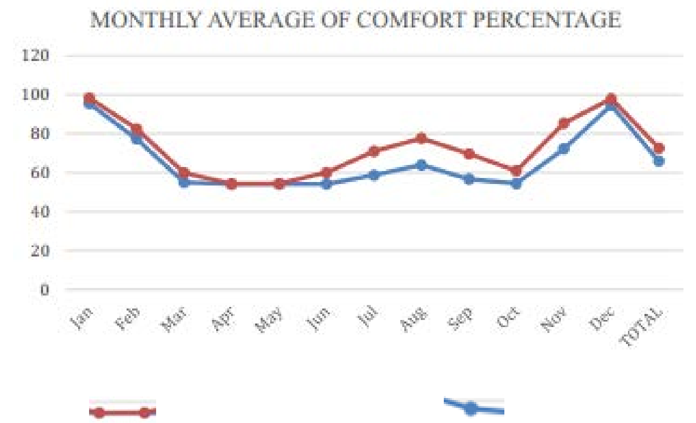
4.5 MONTHLY AVERAGE OF COMFORT PERCENTAGE ON MODELS WITH AND WITHOUT SHADING DEVICE

The table below illustrate the average percentage of comfort of inside air temperature in degree Celsius on a monthly basis, with and without shading devices, 65.91% is the comfort percentage for of the model without shading device for indoor situation while 72.63% is the average indoor comfort percentage with shading device. The average comfort percentage difference between the model with trees and the model without trees is 6.72%.

MONTHS	INDOOR THERMAL COMFORT % WITHOUT SHADING DEVICE	INDOOR THERMAL COMFORT % WITH SHADING DEVICE (50 CM)
JANUARY	95.56	98.31
FEBRUARY	77.23	82.38
MARCH	54.97	59.84
APRIL	54.17	54.22
MAY	58.17	54.35
JUNE	58.74	60.06
JULY	63.98	70.99
AUGUST	63.98	77.58
SEPTEMBER	56.67	69.69
OCTOBER	54.44	60.94
NOVEMBER	72.22	85.36
DECEMBER	94.63	97.88
AVERAGE	65.91	72.63

Table 4.5 Monthly Average of Comfort percentage on models with and shading elements

Source; Ecotect 2011.



WITH SHADING DEVICE WITHOUT SHADING DEVICE

Figure 4.5 Graph showing the monthly average of comfort percentage on both models.

Source; Ecotect 2011

4.6 DISCUSSION

The result for the simulation for both set of models indicate a positive difference with the integration of shading device, with comfort level increasing by 6.72% with shading device and temperature difference of 2.6^{oC} for 50 cm and a comfort level 5.83% for 30 cm and a temperature difference of 2.4^{oC} in cold season and up to 3.2^{oC} in the hot season.

Based on the information gathered from the research carried out, the level of satisfaction in the selected residential building can be said to be average. With that in consideration, here are some recommendations to improve thermal comfort in buildings;

- Deep knowledge of the construction site and its surrounding area should be considered very important.
- High importance should be given to design preliminaries such as investigation and visitation of the site, its micro-climate, solar path and position over the site, and any relevant information on thermal comfort. This Information will have a significant effect on the thermal comfort of the site.
- Choices of materials also have importance on the thermal comfort level of the building.
- Designers should make effort and explore a wide choice of building materials, locating and making good use of their yet undiscovered potential as well as researching different methods by which their limits can be hurdled over and utilities maximized.
- Building codes should be created that enforces the use of sun shading devices like the "1990 Project of Thermal Insulation in Portugal" which encourages designers to incorporate the use of shading devices.
- Institution of Architecture should make the integration of sun shading element in buildings designed by students as obligatory part of the design scheme. This

will raise the awareness level of students to the importance of thermal comfort of their occupant during the design stage.

5.1 CONCLUSION

In conclusion, this research highlighted the importance of thermal comfort to the satisfaction of the occupants of the building and how shading devices can influence that satisfaction level. Factors responsible for thermal comfort in a building must be implemented in the initial stages of the design process. From the results obtained from the simulation, it is clear to see that the integration of these sun shading devices have more advantages than disadvantages on the thermal comfort level of the building. However to achieve optimum effectiveness with regard to the shading devices, consideration such as building orientation, type of material used should be done as early as possible. In order to produce a sustainable design then the architects or designer should put this into consideration.

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