Journal of Fundamental and Applied Sciences

ISSN 1112-9867

Available online at http://www.jfas.info

Research Article

APPRAISAL OF THE CLIMATIC RESPONSIVENESS OF THE HEALTH CENTRE BUILDING – OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE

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Received: 18 December 2018 / Accepted: 31 August 2019 / Published online: 01 September 2019

ABSTRACT

The design of a comfortable indoor climate is of great influence on occupant's health and well-being. This study is focused on appraising the Health Centre Building of Obafemi Awolowo University`s efficiency in producing the required thermal comfort through responsiveness to the local climate or identify its deviations from this issue of climate responsiveness. The climate was analyzed using the Mahoney tables, not excluding the descriptive survey method of gathering data and the critical observation of the building envelopes. Results from the findings showed the lighting within the building needs to be improved upon, the building space should be made to be quite cool and shading devices needs to be incorporated on the required windows. Climate responsive architecture is essential because it makes the building become an intermediary on its own energy housekeeping by opening up to the energy potential of the built environment.

Keywords: Climatic, Responsiveness, Architecture, Thermal Comfort, Health Centre Building.

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doi: http://dx.doi.org/10.4314/jfas.v11i3.26

1. INTRODUCTION

Buildings are necessary to provide shelter from the harsh elements of climate. Climatic elements which are made of sunshine, cloud, temperature, relative humidity and precipitation create an outdoor environment which is unsuitable for human beings to survive. Since time immemorial, man has always sought shelter from the harsh elements of climate. Hence, the building acts as a filter to sieve out unwanted conditions, a shield for protection, and a container that presents a more suitable survival conditions to man. In man's bid to provide this basic need, housing has evolved over the years through many basic forms, design and characteristics (Rybczynski, W 1986). Among the several goals the architect sets out to achieve when designing a building, the creation of a comfortable living space is perhaps the most important (Saberi O *et al*, 2002). Design concepts and parameters are often essential at the pre-design stage to ensure this goal is achieved. A further task is employed on the choice of materials of the building fabric, orientation et cetera and the basic understanding of the local climate. Local builders have used great ingenuity in providing the most comfortable climate conditions possible with the constraints of the local climate (David, L. J 1998). With the advancement in technology, multiplicity of typologies and more sophisticated regulated indoor conditions, designers thought mechanical devices could provide better indoor conditions that could be controlled by the user. This later proved wrong in many instances since the indoor environment lost its pleasantness and coherence with nature resulting in health issues such as 'the sick building syndrome' which is usually associated with indoor air quality resulting from emissions from devices and construction materials. 1984 World Health Organization Committee report suggested that up to 30 percent of new and remodeled buildings worldwide may be the subject of excessive complaints related to indoor air quality (IAQ). Also, the high reliance on mechanical devices to regulate the indoor environment resulted in increased consumption of energy produced mainly from the burning of fossil fuels. In most developing countries where non-renewable energy is still greatly utilized, issues related to greenhouse gas emissions are major concerns with the effect of these being severe climate change due to global warming (IPCC, 1997).

Environmental comfort and energy saving procedures constitute the indicators that can be applied in the conception, construction and use of buildings. Thus light, air, space, health and efficiency constitute structuring elements in the concept of sustainable construction (Amado, M. P *et al* 2007). Even in developed parts of the world, where alternate energy from renewable sources are being used, issues of climate change are still very pertinent. In more recent times, architecture has taken a new turn. With the whole world concerned about the impact of the built environment on the natural environment as well as on man, there has been a shift to designing buildings with nature and not against it giving rise to sustainability. Thus, a building will pose more threats to humans if it fails the major test of providing a stable, friendly and comfortable living space.

One of the key issues in sustainability is climate responsive architecture which according to Kabiru, S. D (2011) refers to an architecture that reduces the negative impact on the environment and sustains the ecosystem of which it is a part. In designing buildings with the elements of climate in mind, buildings are made to respond to the climate and in responding, provide a comfortable thermal environment.

A comfortable thermal environment becomes very necessary especially when dealing with hospitals. This is an important factor. As opined by Azizpour F *et al* (2011) creating a thermally comfortable environment can be helpful in stabilizing moods of patients and can also assist in the healing process. This goes a long way to show how critical the factor of a comfortable thermal environment can be especially in hospitals with respect to developing countries. Patients may be more vulnerable to fluctuations in thermal conditions than the general population because of their already weakened state of health. Babies, for example, have more limited thermoregulatory control than adults (Parsons, 2003, 237) and definitely any temperature fluctuations can affect the overall well-being of a child. Key factors like the temperature of a place must be looked into carefully. Unfavorable temperatures have also been found to affect patients in terms of recovery rates (Kurz et al., 1996) and increase their stress levels (Wagner et al., 2006).

With the rising increase in the cost of fossil fuels, and the overall unpleasantness of over-dependence on active design techniques, as well as the world wide call to sustainable architecture that is climate responsive, there is a need to evaluate the design concerns in the Health Center building of the Obafemi Awolowo University which serves as a health clinic for ailing students and staff in order to appraise its efficiency in producing the required thermal comfort through responsiveness to the local climate, or identify its deviations from this germane issue of climate responsiveness. It is to this end that this study appraises the climate responsiveness of the Health Centre of the OAU Campus. The study will focus on the following objectives

- To analyze the climatic data of the location.
- To identify and examine climate responsive techniques/strategies used in the building.
- To evaluate the thermal comfort level of users in the building.

- To identify strategies that could be effective in providing adequate thermal comfort in the building.

1.1 Scope of the Study

The Study is restricted to the Health Centre Building of the Obafemi Awolowo University Ile-Ife, Osun State, Nigeria located at 7°28′N and 4°34′E. Ile-Ife is an ancient Yoruba city in south-western Nigeria, at 218 kilometres (135 mi) northeast of Lagos. The climate is tropical lying within the equatorial and sub-equatorial rain forests and has the warm-humid climate of the tropics. The climate is classified as Aw by the Köppen-Geiger system being characterized by heavy rainfall and high temperature. In winter, there is much less rainfall in Ife than in summer. The average annual temperature in Ife is 26.2 °C with a mean relative humidity of 75% to 100% while precipitation averages 1340 mm.

Fig.1. Map of Nigeria showing Osun state

Source: http://article.sapub.org/image/10.5923.s.arch.201401.06_001.gif

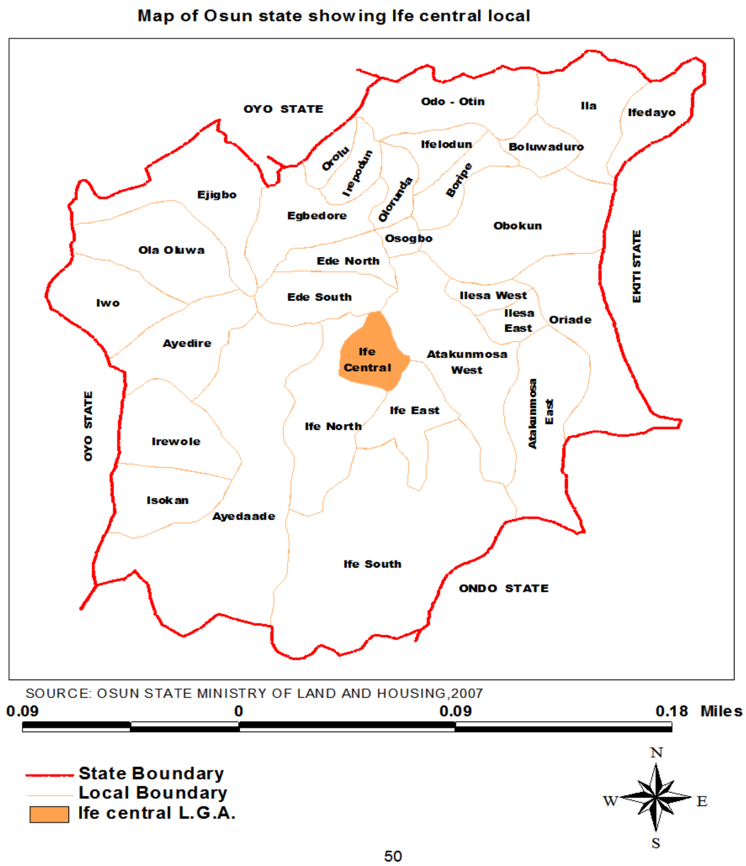

Fig.2. Map of Osun State Showing Ife Central

Source: http://article.sapub.org/image/10.5923.s.tourism.201401.04_002.gif

1.2 Climatic Responsive Architecture

The main important factor is the 'climate' even though it is broadly classified and categorized in different regions of the world in terms of its seasonal and thermal characteristics, that is hot-dry, warm- humid, composite, moderate and cold. It can still differ within the same climate zone or within a few kilometres apart. Hence, the proper understanding of the climatic conditions is vital and often forms the bases of understanding and designing climate responsive buildings. The goal of such design is to reduce uncomfortable conditions created by extreme heat and dryness. Buildings must be adapted to extreme summer/ winter and day / night conditions to achieve a well-balanced indoor climate.

Often times, professionals differ in certain terminology, take for example the term 'architecture' with diver's definition, though such definitions often may reflect a person's cultural, educational, professional or historical background. However, as long as one is understood, that matters a lot.

Like other terminologies too, ‘Responsive architecture’ may be viewed in different light by different professionals and this study is not in any case going to dive into the analysis of such views but will concern itself with the rationale that responsive architecture is the discipline and practice with a distinct type of building design with inherent capacities to alter its form or adapt, to continually reflect the environmental conditions that surround it. Yannas, S. (2003) defined it as, architecture aimed at achieving occupant thermal and visual comfort with little or no recourse to nonrenewable energy sources by incorporating the elements of the local climate effectively This discipline aims to improve the energy performance of buildings with effective and efficient technologies which may include sensors, control systems and actuators within the context of buildings that reflect technological and cultural conditions of its time. The primary ideology of this design is to consider the concepts that reduce environmental impacts with an appropriate response to the dominant climate conditions. This type of architecture as identified by Udyavar (2006) should possess the following paradigms: (a) Energy Efficient Design (b) Preservation of Natural Ecosystems (c) Use of Renewable Energy (d) Water Resource Management (e) Use of Eco-friendly materials (f) Ecological Landscape Design (g) Solid Waste Management and Healthy Indoor Environment.

Several strategies exist for various seasons. The strategies are adopted to meet the needs of those who use the building with focus on the various climatic conditions. According to Abdeen, M. O (2008), these strategies include the following steps;

- **Heating Strategy:** strategies include solar collection, heat storage, heat distribution and heat conservation
- **Cooling Strategy:** strategies include solar control, minimization of external gains, minimization of internal gains, ventilation and natural cooling.

Climate responsive architecture takes advantage of the natural energy sources which includes the sun and wind which are major factors that affect the built environment. Climate ought to determine the form of the building and enable individuals to carry out their activities while the building respond to changes in the climate and provide a conducive environment for occupants and users.

2. RESULTS AND DISCUSSION

2.1 Climatic Analysis Using Mahoney tables

The Mahoney tables are a set of reference tables used in architecture, used as a guide to climate-appropriate design. The five (5) table uses available climatic data that cuts across temperature, humidity, wind and rainfall and simple calculations to give design guidelines as to what form of a building that should be designed. The tables appear to look like a spreadsheet and used to enter specific climatic data used to give design guidelines for thermal comfort. They are named after architect Carl Mahoney who developed the concept alongside Koenigsberger, Mahoney and Evans (1970)

Table 1. Average Monthly Climatic data of Ife Central, Osun State

ILE-IFE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Tmax	32	34	34	32	31	29	28	27	29	30	32	33
Tmin	20	22	23	23	22	22	21	21	21	21	22	21
PPTN	9.1	18.1	101.2	156.4	184.1	203.3	200.3	158.2	205.4	210.8	89.2	12.1
PPTN Day	3	6	12	15	17	18	17	14	21	22	8	2
RH (am)	66	66	82	82	85	88	90	92	84	81	81	72
RH (pm)	36	36	65	67	68	60	81	78	73	62	48	36
W.SPD	2.8	3.4	2.8	2.2	2.5	3.2	3.5	4.6	3.5	3.3	3.5	2.8
W.DRN	NW	SW	SW	SW	SW	S	S	SW	SW	SW	SW	NW

(Tmax: Maximum Monthly outdoor Temperature, Tmin: Minimum monthly outdoor Temperature, PPTN Day: Monthly amount of precipitation (mm), RH(am) Relative humidity in the morning, RH(pm) Relative humidity in the evening, W.SPD: Wind Speed, W.DRN: Wind Direction)

Table 2. Air Temperature (C); (Ebere Donatus OKONTA, 2018)

	J	F	M	A	M	J	J	A	S	O	N	D	Highest	AMT
Monthly mean Max.	32	34	34	32	31	29	28	27	29	30	32	33	34	27
Monthly mean min.	20	22	23	23	22	22	21	21	21	21	22	21	20	14
Monthly mean range	12	12	11	09	09	07	07	06	08	09	10	12	Lowest	AMR

Table 3. Humidity, Rain and Wind (Ebere Donatus OKONTA, 2018)

RH (Percentage)		J	F	M	A	M	J	J	A	S	O	N	D	
Monthly mean max. a.m		66	66	82	82	85	88	90	92	84	81	81	72	
Monthly mean min. p.m		36	36	65	67	68	60	81	78	73	62	48	36	
Average		51	51	73.5	74.5	76.5	74	85.5	85	78.5	71.5	64.5	54	
Humidity Group		3	3	4	4	4	4	4	4	4	4	3	3	Total
Rainfall (mm)		2.1	18.1	101.2	156.4	184.1	203.3	200.3	158.2	205.4	210.8	89.2	12.1	1548.2
Wind	Prevailing	NW	SW	SW	SW	SW	S	S	SW	SW	SW	SW	NW	
	Secondary													

Table 4. Diagnosis

	J	F	M	A	M	J	J	A	S	O	N	D
Humidity Group	3	3	4	4	4	4	4	4	4	4	3	3
Temperature (C)												
Monthly mean max	32	34	34	32	31	29	28	27	29	30	32	33
Day Comfort: Max	29	29	27	27	27	27	27	27	27	27	29	29
Min	23	23	22	22	22	22	22	22	22	22	23	23
Monthly mean min.	20	22	23	23	22	22	21	21	21	21	22	21
Night comfort Max	23	23	21	21	21	21	21	21	21	21	23	23
Min	17	17	17	17	17	17	17	17	17	17	17	17
Thermal Stress												
Day	H	H	H	H	H	H	H	-	H	H	H	H
Night	-	-	H	H	H	H	-	-	-	-	-	-

Table 5. Indicators

	J	F	M	A	M	J	J	A	S	O	N	D	Totals
Humid													
H1 Air Movement (essential)			✓	✓	✓	✓			✓	✓			6
H2 Air Movement (desirable)								✓					1
H3 rain protection						✓	✓		✓	✓			4
Arid													
A1 Thermal Storage	✓	✓									✓	✓	4
A2 Outdoor Sleeping													
A3 Cold-Season problems													

Table 6. Sketch Design and Recommendations

Indicators Totals from Table 5						**Recommendations**
Humid			**Arid**			
H_1	**H_2**	**H_3**	**A_1**	**A_2**	**A_3**	
6	1	4	4	0	0	
						Layout
			0-10		✓ 5-12	1. Buildings oriented on east-west axis to reduce exposure to sun
			11or12		0-4	2.Compact courtyard planning
						Spacing
11 or 12						3. Open spacing for breeze penetration
2-10					✓	4. As3, but protect from cold hot wind
0 or 1						5.Compact planning
						Air Movement
3-12			0-5		✓	6. Rooms single banked. Permanent provision for air movement
1or2	2-12		6-12			7. Double-banked rooms with temporary provision for air-movement
0	0 or 1					8.No air movement requirement
						Openings
			0 to 1		0	9. Large openings, 40-80% of N and S walls
			11 or 12		Or 1	10. very small openings, 10-20%
			Any other conditions		✓	11. Medium openings, 20-40%
						Walls
			0-2			12. light walls; short time lag
			3-12		✓	13.Heavy external and internal walls
						Roofs
			0-5		✓	14.Light insulated roofs
			6-12			15.Heavy roofs; over 8 hours' time lag
						Outdoor sleeping
				2-12		16. Space for outdoor sleeping required
					X	**Rain Protection**
		3-12			✓	17.Protection from heavy rain needed

RECOMMENDATIONS

Layout

Buildings should be oriented on an east-west axis with the long elevations facing north and south to reduce exposure to the sun, if thermal storage (A_1) is required for up to ten months of it thermal storage is required for eleven or twelve months including more than four winter months (A_2)

Spacing

If air movement (H_1) is needed between two and ten months of the year, spacing for breeze penetrations is still needed, but buildings and planting should also be planned to give protection against dusty hot or cold winds (see Table 5 for conditions and Table 3 for wind directions)

Air movement

Rooms should be single baked with windows in the north and south wall if air movement (H_1) is essential for more than two months. Single baking is desirable if air movement is needed for one or two months and thermal storage (A_1) for zero to five months

Openings

In all other conditions, medium-sized openings should be used (from 25 percent to 40 per cent of the area of the north and south walls). Openings in the east walls are desirable only if there is a long cold season (A_3). Openings in west walls are desirable in cold and temperate climates, but must be avoided in the tropics

Walls

External and internal walls should be heavy with high heat capacity if thermal storage (A_1) is needed for three to twelve months

Roofs

A light but well-insulated roof should be used if thermal storage (A_1) is needed for less than six months

Rain Protection

Special Protective measures are needed if rain is frequent and heavy (H_3) e.g. deep verandahs, wide overhangs and covered passages

2.2 Building Analysis

The Health Center is a complex of eight (8) blocks connected together by covered walkways.

The building consists of ground floor blocks in linear form arranged around courtyards and accessed from shaded corridors. Some of the major features of the building include;

- Courtyard planning to permit more airflow and create a pleasant environment through planting, the planting help serve as wind breakers and provide necessary shading.
- Shading devices for windows to prevent the inlet of solar radiation and prevent glare.
- Shaded verandas/corridors to protect the interior from solar radiation
- Large openings of louvre windows to permit good ventilation
- High level windows to enhance ventilation
- Cross ventilation in the spaces.
- Long overhangs
- Covered walkways

See the figures below;

Fig.3. The Approach view the Health Centre Building (Partial view)

Fig.4. Covered walkways and shaded verandas

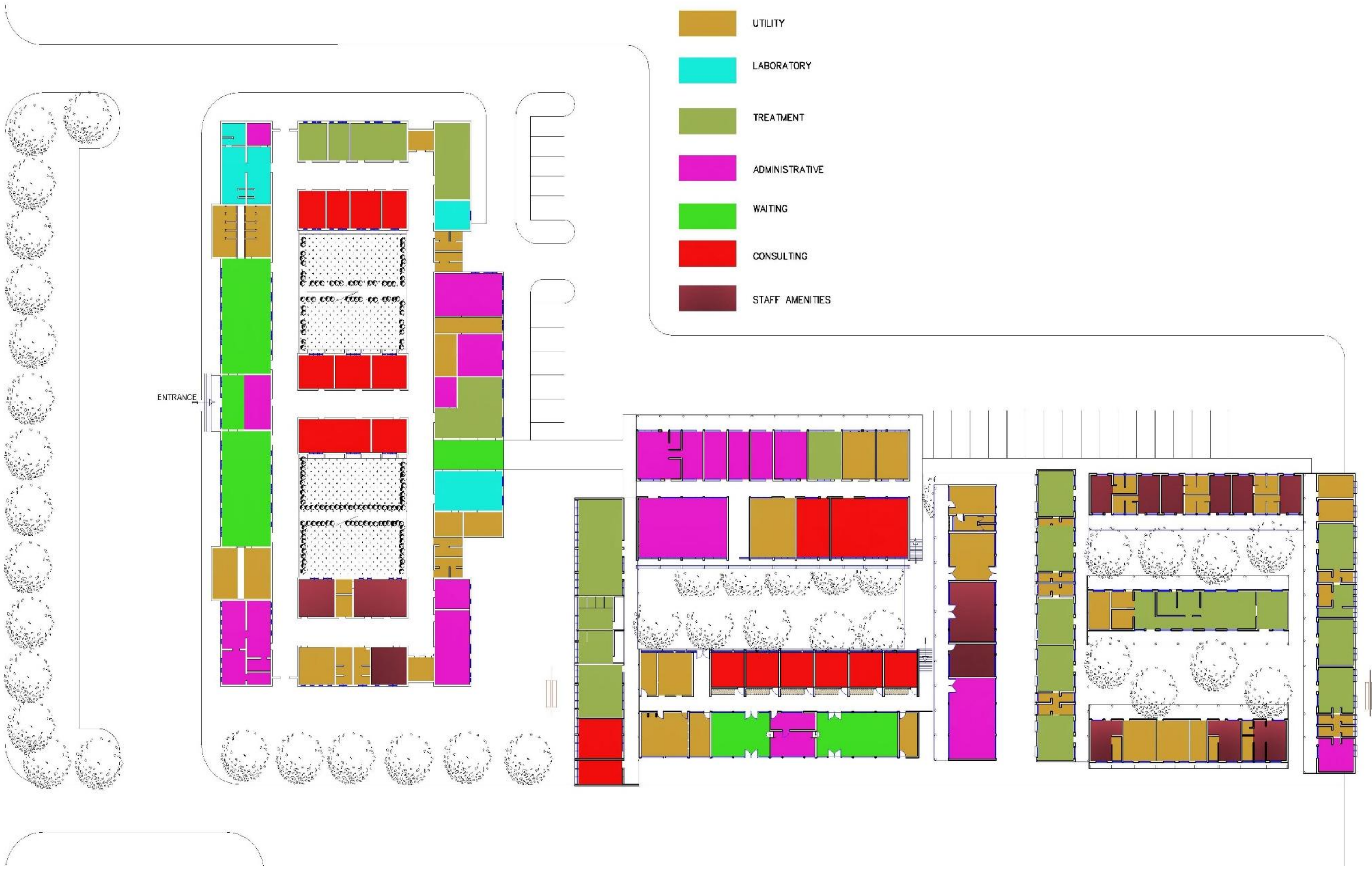

Fig.5. Ground Floor Plan of the Health Care Centre

Fig.6. Shading devices on East window

2.3 Questionnaire Analysis

2.3.1 Demographic Information

From the questionnaire distributed, the personal characteristics of the respondents, out of 40 respondents. 16 were male and 24 females. The result indicates that the female respondents accounted for the majority (60.0%) of the total respondents surveyed, while the male respondents accounted for approximately (40.0%) of the total respondents surveyed. The distribution of the respondents age between 0-30yrs accounted for the majority (57.5%), followed by respondents who are between 31-60yrs constituting (38.5%) of the total respondents surveyed, while respondents who are 61yrs and above, accounted for (2.6%) of the total respondents. Furthermore, the survey data on the status of respondents surveyed revealed that simple majority (50%) are students, followed by respondents who are staff accounting for (42.5%) and others 7.5% who fall in the category of visitors or janitors.

Table 7. Thermal (Heat or Cold) Comfort Information in Space

Features		Frequency	Percent
Do you have control of the AC or fan?			
	Yes	24	60
	No	16	40
Are the windows opened?			
	Yes	15	37.5
	No	25	62.5
Would you accept this environment			
	No	13	32.5
	Yes	25	62.5
How are you feeling at this precise moment?			
	Very Uncomfortable	16	40
	Uncomfortable	3	7.5
	Slightly uncomfortable	15	37.5
	Not uncomfortable	5	12.5
Temperature in the space			
	Cold	3	7.5
	Cool	12	30
	Slightly Cool	2	5
	Neutral	10	25
	Slightly Warm	7	17.5
	Warm	2	5
	Hot	4	10
How would you prefer to be now?			

	Much Warmer	2	5
	Warmer	2	5
	Slightly Warmer	1	2.5
	Neither warmer nor cooler	10	25
	Slightly cooler	4	10
	Cooler	12	30
	Much cooler	8	20
Overall description of the state of the space			
	Perfectly Tolerable	20	50
	Slightly Difficult to Tolerate	11	27.5
	Fairly Difficult to Tolerate	6	15
	Very Difficult to Tolerate	3	7.5

The result shows that a majority of the respondents have control over the Air conditioner (AC) or fan, accounting for 60%. And 62.5% of the respondents within a particular space could attest the windows were opened which also helped to regulate the thermal condition in the space against 37.5% who said the windows were closed. 62.5% of the respondents accepted the environment and 32.5 % of them did not accept the environment to be conducive. However, 40% of the respondents were very uncomfortable with the way they felt at a particular moment within the space and 37.5% were slightly uncomfortable, this could have been affected by a number of factors for example, the kind of clothes they wore, the activities they are engaged in at the moment or their health condition or the temperature within the space for which, 7.5% of the respondents felt cold, 30% felt cool and 10% of the respondents felt hot within the space. Even though 25% of the respondents would have preferred to neither feel warm nor cooler and 30% would have preferred they felt cooler.

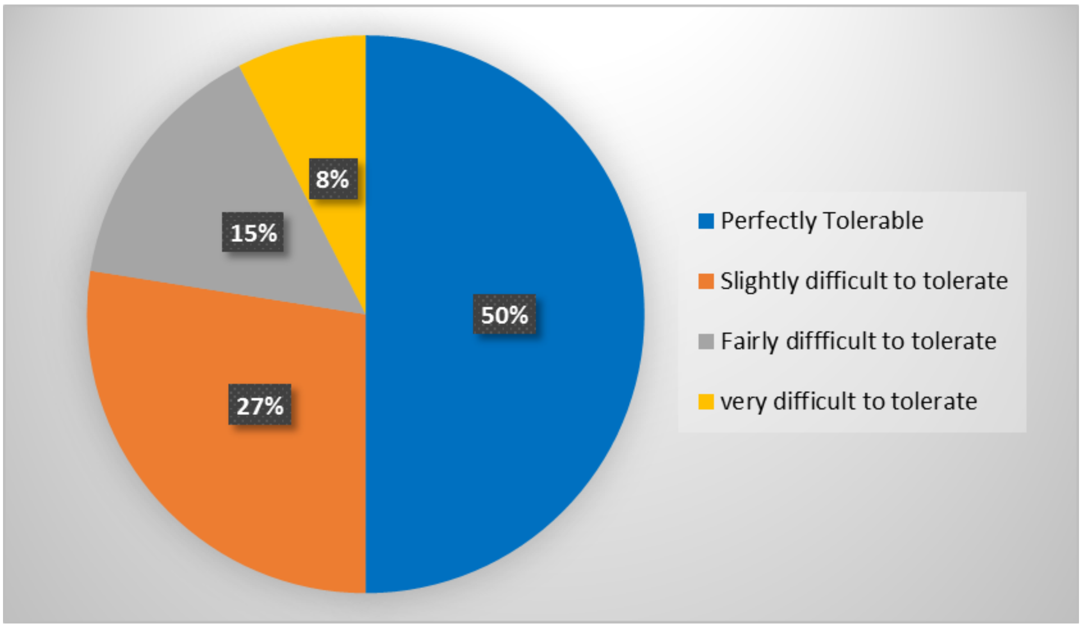

Fig.7. Respondents view on the overall description of the Space

From the above table, the overall description of the state of the space suggested that 50% felt the space was perfectly tolerable and 27.5 felt the space was slightly difficult to tolerate, 15% felt the space was fairly difficult to tolerate and only 7.5% felt the space was very difficult to tolerate.

Table 8. Lighting Information in Space

Features	**Frequency**	**Percent**
Reading and writing with the light condition		
Very Comfortable	9	22.5
Uncomfortable	3	7.5
Slightly Uncomfortable	5	12.5
Comfortable	23	57.5
Level of Adequacy of lighting in Space		
Very Adequate	14	35
Adequate	15	37.5
Slightly Adequate	10	25
Not Adequate	1	2.5

Preferred Lighting Level			
	Much Brighter	6	15
	Brighter	17	42.5
	A little Brighter	8	20
	Neither bright nor darker	8	20
Available light source			
	Daylight	18	45
	Electric lighting	10	25
	Both	11	27.5
Is the daylight only Adequate in this Space?			
	Very Adequate	10	25
	Adequate	17	42.5
	Slightly Adequate	5	12.5
	Not Adequate	7	17.5
Will the combination of daylight and electric lighting be adequate in this space			
	Very Adequate	19	47.5
	Adequate	12	30
	Slightly Adequate	2	5
	Not Adequate	3	7.5

With respect to reading and writing, 22.5 of the respondents felt very comfortable with the light condition, 57.5% were comfortable with the lighting while 20% of the respondents were uncomfortable with the lighting condition within the space. Thus, 15% of the respondents would have preferred that the lighting level be much brighter and 42.5% preferred that the lighting be brighter and 8% felt the lighting condition was neither bright nor darker as seen in figure 8 below

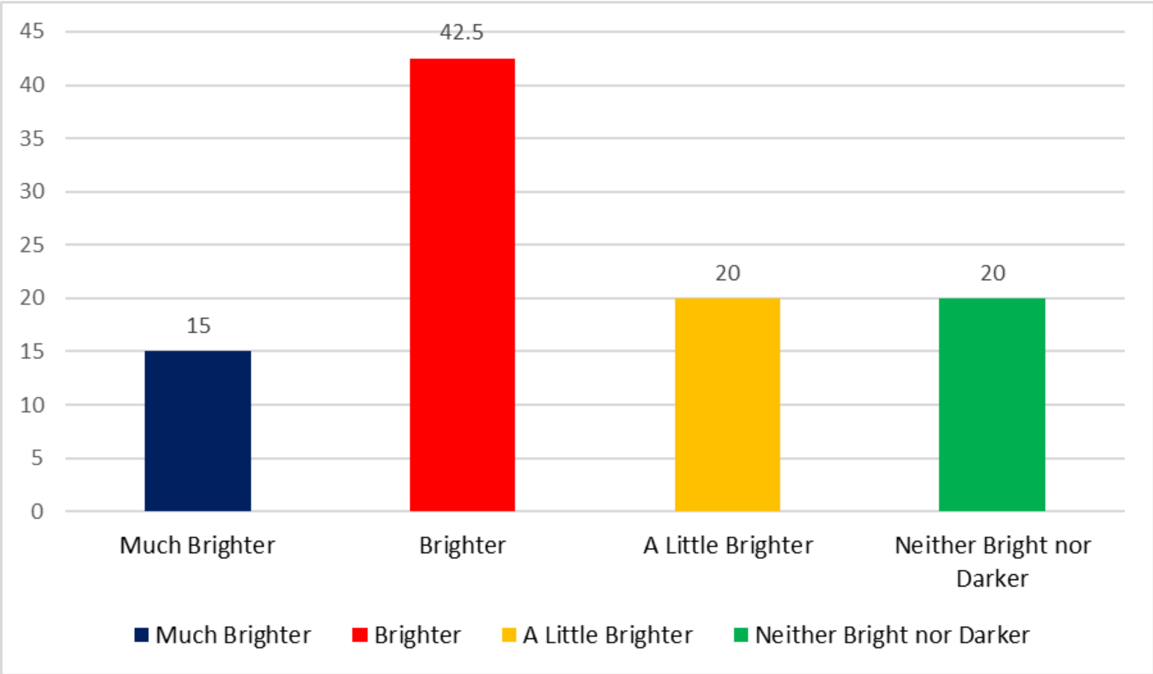

Fig.8. Preferred Lighting Levels

However, 25% of the respondents considered the daylighting in the space very adequate, 42.5% adequate and 12.5% considered it slightly adequate and only 17.5% considered the daylighting not to be adequate, the respondents felt that the combination of the daylight and electric lighting will be very adequate were 42.5% and 30% adequate with 5% slightly adequate and only7.5% felt it will not be adequate.

3. METHODOLOGY

The collection of data focused on the various objectives of this study.

1. To analyze the climate data of the area, the data was sourced from the weather station nearest to Ile-Ife, Osun state which included the following:
    - Maximum and Minimum monthly outdoor temperature
    - Relative humidity for morning (am) and afternoon (pm) in percentage
    - Monthly amount of precipitation (mm)
    - Prevailing wind

This data was subjected to analysis using Mahoney Tables

2. To identify and examine climate responsive techniques/strategies used in the building the data was sourced by observing the building envelopes
3. Descriptive survey method was adopted for gathering data to help in analyzing the thermal comfort levels of users in the building in an accurate way. The use of primary data in this research is to give firsthand information and allow for the results that gives the current satisfaction levels of the respondents. Forty (40) questionnaires was distributed to respondents consisting of both patients and staff.
4. To identify strategies that could be effective in providing adequate thermal comfort in the building, recommendations will be drawn from the Mahoney tables

4. RECOMMENDATIONS AND CONCLUSION

The design recommendations are made on the basis of the remedial actions needed to be taken to alleviate thermal distress which included, shading devices should be provided for windows without shading and facing East or West, exterior walls should be painted with a more reflective colour. Issues related to air movement and shading from solar radiation and rain protection has been properly addressed in the building. Also, the findings of this study reveal that the Health centre building is quite Climate responsive. However, with regards to the adequacy of lighting in the space, the respondents preferred the lighting condition is quite brighter to enhance internal activities in the space. Thus, it is recommended that LED light bulbs are used besides the simple techniques of trimmings trees that obstruct windows and changing the colour of the ceiling to open up the room. The study further showed that the health centre building is also thermally comfortable although most respondents would have preferred that the space was quite cooler, hence the opening of the opening of clerestory windows more frequently can provide effective air movement in the spaces.

Climate responsive architecture is very essential because it makes the building becomes an intermediary in its own energy housekeeping by opening up to the energy potential of the built environment. Consequently, existing buildings need to be assessed for energy integration and optimization measures in their design and construction to minimize renewable energy utilization using the passive techniques with a view to informing designs of future buildings

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How to cite this article:
E. D. Okonta. Appraisal of the climatic responsiveness of the health centre building – obafemi Awolowo University, ile-ife. J. Fundam. Appl. Sci., 2019, *11(3), 1418-1439.*