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The Recital Impact of Climate Variation on Thermal Energy Buildings in Central Nigeria

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Abstract

It is scientifically proven that climate variations directly affect buildings. In other words, whenever there is an increase in temperature, buildings marginally expand and reduce when the temperature level drops; which is a valid explanation for why buildings crack or collapse at times. This research explored the recital influence of climate variation on thermal energy buildings in tropical climate regions such as central Nigeria where three states were considered and examined: Abuja, Plateau and Nasarawa State. The case study method was adopted for the research. To obtain a standard and valid result for this research, thermal energy buildings under the same climatic conditions (cold and hot) in the central region of Nigeria were tested. The study is quantitative research ergo figures, charts, and tables are used in reporting the observed and calculated values. Primary sources such as meteorological observation and data, temporal data, and GIS were useful in gauging the temperature variation and thermal energy effects on buildings. Secondary sources such as published journal articles were also relevant to the research. The outcome of the research reveals that for clay brick buildings, there is no significant difference between the temperature inside the building and outside the building. Whereas, in concrete buildings, it was observed that during the hot season, the temperature inside the building is increasingly high though it all depends on the type of building material that was used in erecting the building. The building enlarges when the temperature goes up and reduces when the temperature goes down. During the cold season, the room temperature in concrete buildings tends to be higher than outside. The thermal air during the cold season is conducive for its inhabitants. Whereas, the temperature during hot climatic conditions has a different inner thermal air and outdoor thermal air. Unlike residents in Jos Plateau State, inhabitants in the tropical climate region suffer a lot from warm air discomfort also known as thermal discomfort. The inhabitants in Abuja and Nasarawa suffer a lot during the hot season because of the temperature rise. Most of the inhabitants in Abuja and its environs use building materials that will regulate the temperature during hot and cold seasons.

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Introduction

Climatic and meteorological fluctuations over time are caused by greenhouse gas emissions and other pollutants that pose adverse paraphernalia on the well-being of the inhabitants, resources, and also buildings. The variation in climate has a significant impact on the thermal energy radiation of a building according to Camilleri *et al.* (2001) ^[11]. As the temperature goes up, the building enlarges because of the high temperature absorbed from the atmosphere. In contrast, the building reduces in size when the temperature level drops. To put it more elaborately, when the building absorbs less amount of temperature from its surroundings, the building contracts. The increase and decrease in the size of the building can lead to the building's fissure (Maddlener and Sunnak, 2011) ^[18]. Lindsay (2020) ^[17] reported that the worldwide air temperature and lunar radioactivity have magnified the issues of human beings regarding the variation in climate in certifying their comfort in thermal buildings even in areas with moderate solstices. According to Bazzadeh *et al.* (2020) ^[6], there exists a functional dependency between the energy

produced and the thermal coziness of its inhabitants. That is, the thermal coziness of inhabitants depends on the amount of energy produced by the world and especially the environment where the building is located. The higher the amount of energy generated, the higher the thermal coziness of its inhabitants, and the lesser the energy released, the lesser the coziness of inhabitants.

Surfeit researchers have carried out research on the thermal effects on buildings across all the continents in the world: Asia, Europe, America, and even some part of Africa. Unlike the extant researches, this current research seeks to harness the recital impact of climate variations on thermal energy buildings. The study is contextualized to the central Nigerian region which includes states such as; Plateau State, Nasarawa State and Abuja. The researcher sought to examine buildings

in the aforementioned states in central Nigeria in order to ascertain the level of comfort or discomfort caused by climatic variations on buildings. The general assumption is that inhabitants in the tropical climate region suffer a lot from warm air discomfort also known as thermal discomfort.

Nigeria is a country situated on the Atlantic coast of West Africa and has three major distinct climate zones. The climatic zone in the south is regarded as a tropical monsoon. The tropical monsoon climate has a long period of wet season. The tropical savannah climate is mostly in the central areas of the country which tends to have longer dry season. The Sahelian hot and semi-arid climate is observable in the northern region of the country. In general, Nigeria is regarded as a tropical climate region because of its high temperature and humidity resulting to thermal.

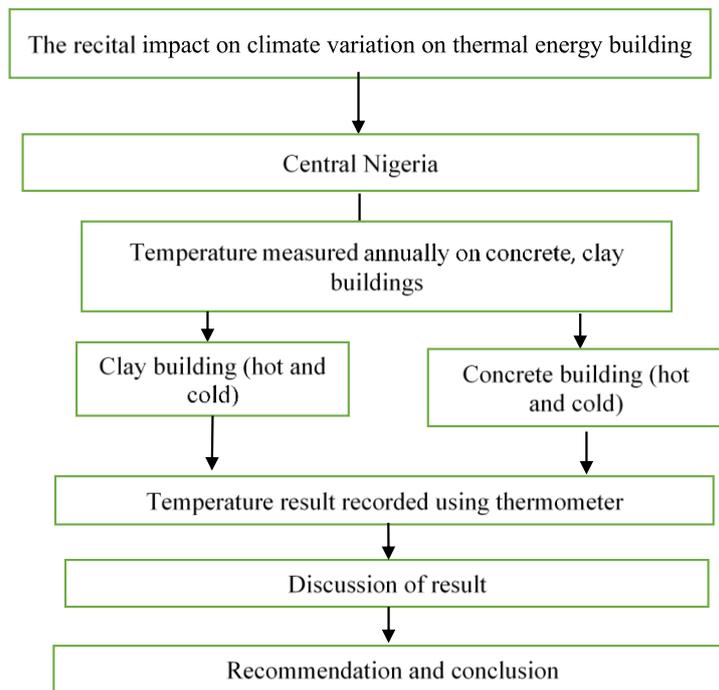


Fig 1: The approach diagram

discomfort. The primary purpose of this investigation is to ascertain the extent of this dynamics on various types of buildings in central Nigeria. The outcome of this

investigation will spike the measures towards ameliorating the thermal energy comfort of buildings in Nigeria particularly in Plateau, Nasarawa and Abuja.

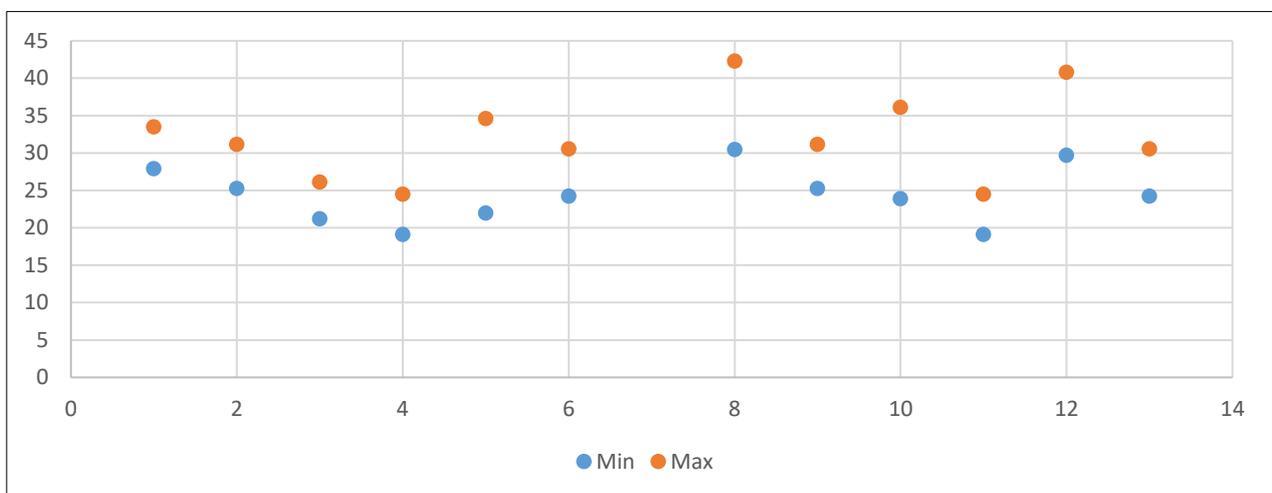


Fig 2: Climate variation in hot and cold (clay and concrete bricks) season.

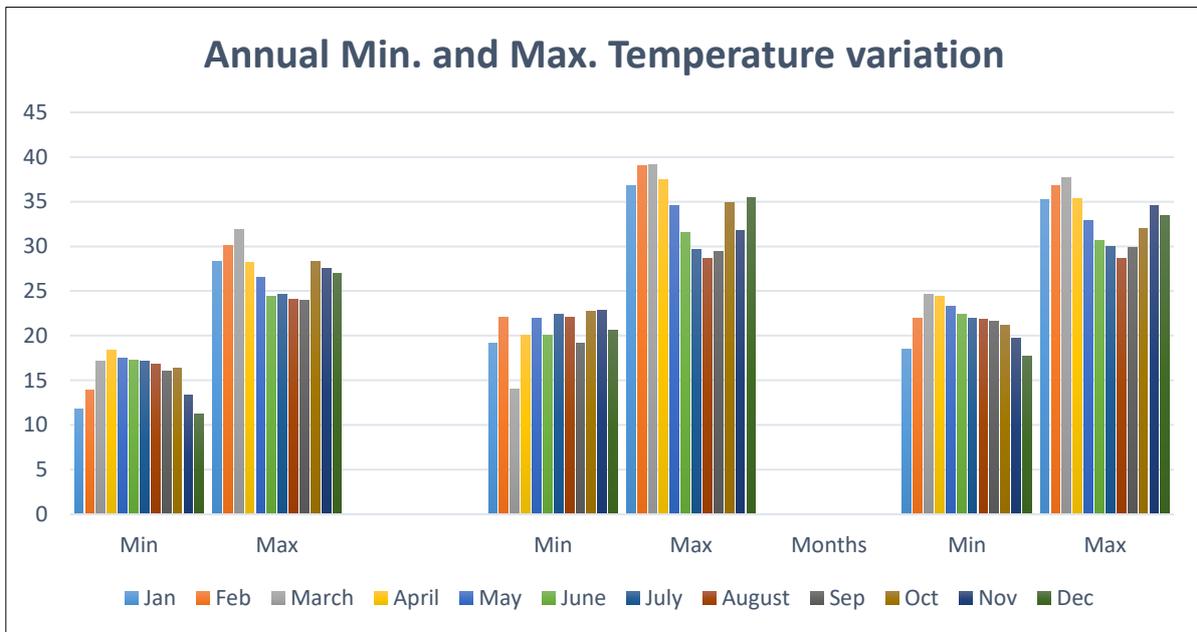


Fig 3: Annual minimum and maximum temperature variation

The figures above represent the annual minimum and maximum temperature variation and also the climate variation of cold and hot season in both clays building and concrete buildings. The figure indicates that the clay building maintain a suitable temperature in both cold and hot season. Meanwhile, concrete buildings are the exact opposite of clay

buildings. Having its temperature fluctuate during cold and hot seasons. Most of the sampled houses used equipments or building materials that enhance the temperature during cold season, such as warmer weather and reduce the temperature during hot season (air conditioner).

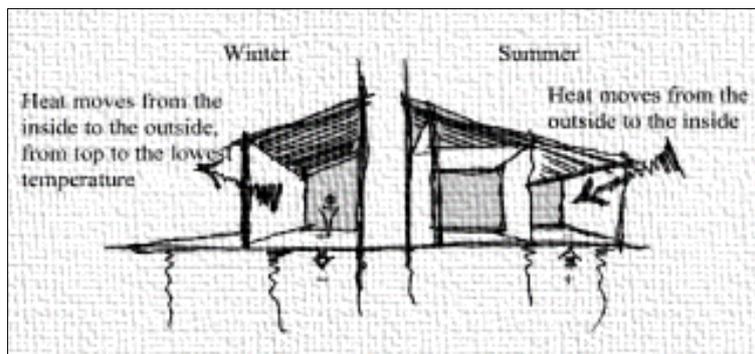


Fig 4: Movement of heat during winter and summer

The above diagram shows the movement of heat during winter and summer and how it affects the room. The diagram shows that, during winter, heat moves from inside to outside and from the top to the lowest and during summer, heat moves from the outside to the inside.

Methodology

This research primarily sets out to gauge the recital impact of climate variation on thermal energy buildings in central Nigeria. The research approach is designed to examine the impact of climate variation on thermal buildings. Important meteorological data obtained through the use of a thermometer and from GIS sources were useful in this study. After a review of pertinent literature from reputable authors to form a better perspective of the recital impact of climate variation on thermal energy building in north central region of Nigeria, the researcher further conducts a case study survey on the buildings from different parts of the region under the same climatic conditions.

Central Nigeria was chosen as the case study; which consists of Abuja, Plateau, and Nasarawa states as the major location of the study with a tropical climate. The buildings in this region consist of ancient parts that are erected with clay bricks of 35cm chunkiness. Other fragments of the buildings were erected with concrete brick of 8cm chunkiness with approximately 1.5cm plaster on the walls. The temperature in the building was examined in both cold weather and hot weather daily using a thermometer to determine the flux in temperature. The temperatures are compared, analyzed, and presented in charts.

Conceptualizing Climate and Climate Change

It is safe to assert that there is no unanimous definition of climate or climate change. Scientists, researchers and governments in their attempt to alleviate the influence of climate variation on human beings and the immediate environs have conceived the phenomenon differently. Climate is conceived as the mean weather condition of a

certain place for some time (Lindsay, 2020) [17]. Overtime, climate has been identified as one of the most important elements that affects most building on the planet. With this in mind and since climate changes overtime, it could potentially cause the building to either expand during high temperature or contract during low temperature. As time passes, climate changes can be influenced by natural processes such as volcanic activities, the output sun, and distribution of the earth land mass which can be internal or external (Bazzadeh, 2020) [6].

As posited by IPCC (2007) [16], variation in the state of climate can be identified by the vicissitudes in the average or the erraticism of its properties, and it continues for a long period normally ten years and above. It is the change that occur strenuously as a result of human events or natural erraticism. However, there is a slight difference between the definition given by IPCC (2007) [16] and UNFCCC. The UNFCCC ascribed their definition to the direct or indirect human events that take place and it alters with the universal atmosphere and which is in accumulation to regular climate erraticism perceived over a given time scope.

One type of climate variation is the “global warming” experienced each time the temperature rises. Global warming as a type of climate variation drives other climate changes such as the configuration of rain fall, frequency and distribution of weather events such as drought, storms, flood and heat wave (Frank, 2005) [14]. At times, the term climate variation is alternatively used in place of global warming although climate variation is a broader term that incorporates global warming. A lot of scholars have debated on the threat posed by climate variation to human beings and its activities. Anthony Gidden (2011) asked a question to the sociologist as to why the societies pay no attention to the magnitude of threat posed by climate variation. Gidden’s response to his question is called the “Gidden Paradox”, in which he states that at first, climate changes do not appear to be very dangerous and it is not considered as a threat, therefore, human beings tend to neglect the later repercussion. The moment the threat become so glaring and uncontrollable, they delay that exist between the emission of greenhouse gases and their full warming impact makes it too late for human beings to act and proffer long lasting solution that will help avert the coming hazard. By the time the threat becomes boundless to overcome,

supplementary warming will be locked in by the radiation already in the atmosphere.

Thermal Energy Building

Thermal energy is the warm air exerted from within a system. Thermal energy is functionally dependent on temperature. In other words, thermal energy is directly proportional to temperature. Whenever a particular region observes a slight variation in climate or temperature, the thermal energy emission of that region changes. If one considers the type of building erected in the study area, thermal energy emission can be at its maximum or minimum in the day time and also at night. This study will investigate the thermal comfort in both traditional and contemporary buildings in Plateau, Nasarawa and Abuja respectively.

Traditional Building

Emusa (2024) [12] defined traditional buildings as all buildings that were erected before the 20th Century. The buildings can be erected with bricks, mud, stones etc. Traditional building in this context, refers to the building erected with the natural resources that surrounds man and his physical environment; such as mud and straw. The mud is used in erecting the walls of the building and the straws are used for thatched roofing. Traditional buildings in central Nigeria were usually erected in two shapes: circular and rectangular (Auwalu, 2019) [5]. The circular buildings often came as single rooms and could also be used as storehouses where farm produces were stored. The rectangular buildings were in form of room and sitting room. The roofing took the shape of a pyramid. After erecting the building with mud; sticks were arranged at the top of the building and straws were thatched on the sticks as roofing. The mud building had features which moderated the heat during the day time and also during the night time. During the day time, the dense mud walls it delays the warmth from the outer to the inside thereby making inside cozy and comfortable for inhabitant to live in. The dense mud walls store warmth during the day time and during the cool nighttime ergo, the inside maintained some certain level of warmth (Auwalu, 2019) [5]. Therefore, the mud building is known for regulating temperature during the day and night time. It is evident that there is no need for any external sources of temperature control, buildings achieve thermal comfort by reflexive means.



Fig 5: Example of a traditional clay house

Contemporary Building

Contemporary buildings are the latest designs of buildings from the 20th Century till date (Adeniran and Eze, 2022) [1]. Unlike the traditional building, the contemporary buildings can assume diverse shapes and structures, it also includes elements such as nonlinear or eccentric form, innovative resources and justifiable building practices may be denoted to as structural design.

According to Adeniran and Eze (2022) [1], the usage of modern materials that conduct heat in building leads to the absorption from the outside wall of during summer, thereby making the inner temperature high and not accommodating for inhabitants to live in freely except with the usage of external materials that will moderate the high temperature. Likewise, during winters, the inner temperature is still not within human comfort zone. The contemporary building is mostly found in the urban areas whereas the traditional buildings are mostly found in the rural areas.

Thermal Conductivity

Warm air conductivity is a designated measure used in

portraying the capabilities deploy in attracting warmth. Warm air conductivity is referred to as the amount of warmth transferred in a single chunkiness of quantifiable resources in a bearing normal to the exterior part of single area based on the unit of hotness incline in stable state environments. The unit of measurement for warmth air conductivity is [W/(m K)] (Newell & Tiesinga, 2019).

Building materials form part of the determining factors that allows warmth to move freely within a system. The movement of heat from the outside environs into the building is done during summer, likewise, the movement of warmth from inside the system to the outside environs is done during winter. The chunkiness of the walls is influential in terms of movement of warm air conductivity coefficient known as k. (Iyengar, 2015). Warm air moves faster in a less chunky wall with approximately 10mm thickness than a wall that is 35mm thick. Materials that contain a relatively large value of k, is regarded as a decent conductor of heat while those materials that have low value of k are decent insulators. (Newell & Tiesinga, 2019).

Table 1: Values of thermal conductivity and density for construction materials

Material	Heat Transfer Coefficient kW/(mk)	Density (kg/m3)
Clay Bricks	0.510	700.00
Concrete Bricks	1.130	2000.00
Wood	0.130	600.00

Source: (Iyengar, 2015)

Using Fourier’s law to determine the amount of heat that is transferred within a system.

$$q = \frac{k}{s} * A * dT$$

q= heat transfer

k = Thermal Conductivity of material

s = material thickness

A = heat transfer area

dT= difference in temperature (Temp1 – Temp2)

To determine the heat transfer in a clay wall of 35mm, through 1m² of wall, with a temperature of 36^o on one side 28^oC on the other side. Take k =0.510 (From table 2)

$$q = 1.457 * 8$$

$$q = 11.656 \text{ W Btu/h}$$

Convert 35mm to m = $\frac{35}{100} = 0.35\text{m}$

$$q = \frac{0.510}{0.350} * 1 [(36^o - 28^o) \text{ C}]$$

The value of q gotten from the above calculations, shows the amount of heat that is transferred from one side of the wall to another within a system per hour.

Table 2: Contrast concerning cold temperatures morning and afternoon (September and December 2024)

Hours	Open-air Temperature	Clay brick building	Concrete brick building	T1 - T2
8am	22.1 ^o C	22.1 ^o C – 16.2 ^o C=5.9 ^o C	22.1 ^o C – 19.4=2.7 ^o C	5.9-2.7=3.2
1pm	29.7 ^o C	29.7 ^o C – 25.4 ^o C=4.3 ^o	29.7 ^o C – 27.6=2.1 ^o C	4.3-2.1=2.2

Source: Field Survey 2024

Table 3: Contrast concerning hot temperatures morning and afternoon (February and March 2025)

Hours	External Temperature	Clay brick building (T1)	Concrete brick building(T2)	T1- T2
8am	29.8 ^o C	29.8 ^o C – 30.4=0.6 ^o C	29.8 ^o C – 30.1=-0.3 ^o C	0.3
1pm	37.6 ^o C	37.6 ^o C - 39.5=-1.9 ^o C	37.6 ^o C – 36.9=0.7 ^o C	-1.2

Source: Field Survey 2025

Impact of Climate Variation on Thermal Energy Building

Climate variation has influenced diverse areas of mankind including his environment, the weather, and most importantly, his comfort zone which can be attributed to the type of building and the location of the building (Bologna and Aquino, 2020) [10]. The researcher sought to examine the impact of climate variation on thermal energy building in Nigeria. The research is narrowed down to three states that

are found in the North central region of the country. They include Plateau state, Nasarawa state and Benue state.

The impact of climate on buildings when it comes to climate variation, particularly in terms of increase in thermal air is dual (Rong and Smith, 2021). First and foremost, hot temperatures affect indoor temperature. Furthermore, a particular specific warming vitality needed for each section of area is dropped, therefore prepared, particular chilling

energy supplies amplified. The factors have influence on the collective vitality request of the structures s, whichever circuitously by sophisticated request of chilled unswervingly based on altered precise vitality necessities.

Location of the Study

Nigeria as a West Africa country is the general study area. The study focuses particularly on the central Nigerian region of the country (Plateau State, Nasarawa State and Abuja). Nigeria's climate is generally considered as a tropical climate although in some far north states, it is semi-arid. As one travels towards the south, it is increasingly rainier (Adeniran and Eze, 2022) ^[1]. In Africa, based on its monsoon, experiences an increasingly elongated and powerful rainy time as one travels from the northern part of the continent down to the south. Starting from the far north, the rainy season last for at least four months beginning from June to September, in the north central, the rainy season begins from April to October which is seven months, from the south, the rainy season last for eight months beginning from March to October and from the south east, the rainy season last for about nine months beginning from March to November (Bergman *et al.* 2019) ^[9].

Nigeria has an annual precipitation of less than 500 millimeters which is 20 inches in the farther north eastern states, on the coasts of Lake Chad, in the north central region of the country, the precipitation ranges from 1,000 to

1,500mm which is like (40 to 60inches), it surpasses 2,000mm (80 inch) in the south and over 3,000mm (120 inch) in the far south east (Ezezue and Diogu, 2016) ^[13]. The temperature in Nigeria also differs according to climate zones. Winter in the North is warm and dry and inhabitants can be uncomfortable because the temperature is high during the day time, up to 40C 104F, but usually cool at night in the hilly northern areas, the cold can be more intense, up to 00C or 32F. From around February to April in north central, heat becomes more intense, reaching 40C or 104F (Adetokun, 2020) ^[2]. The early rain in the southern part of the country and the closeness to the ocean, minimizes the temperature in such areas. The country as a whole observe the same temperature from around June to September because the air is humid and most times, the sky is cloudy as it is the season of rain in the entire country. The temperature ranges from either 28/30C or 82/86F, in the day time throughout winter, temperatures are lesser and relative humidity is greater (Adeniran and Eze, 2022) ^[1].

Abuja

Abuja is the capital of Nigeria and it is located in the center of the country, at 500 meters which is approximately 1,600 feet above sea level, March is the warmest month in Abuja with a mean temperature of approximately 31.150C whereas the coldest month is August with a mean temperature of 25.250C (Adeniran and Eze, 2022) ^[1].

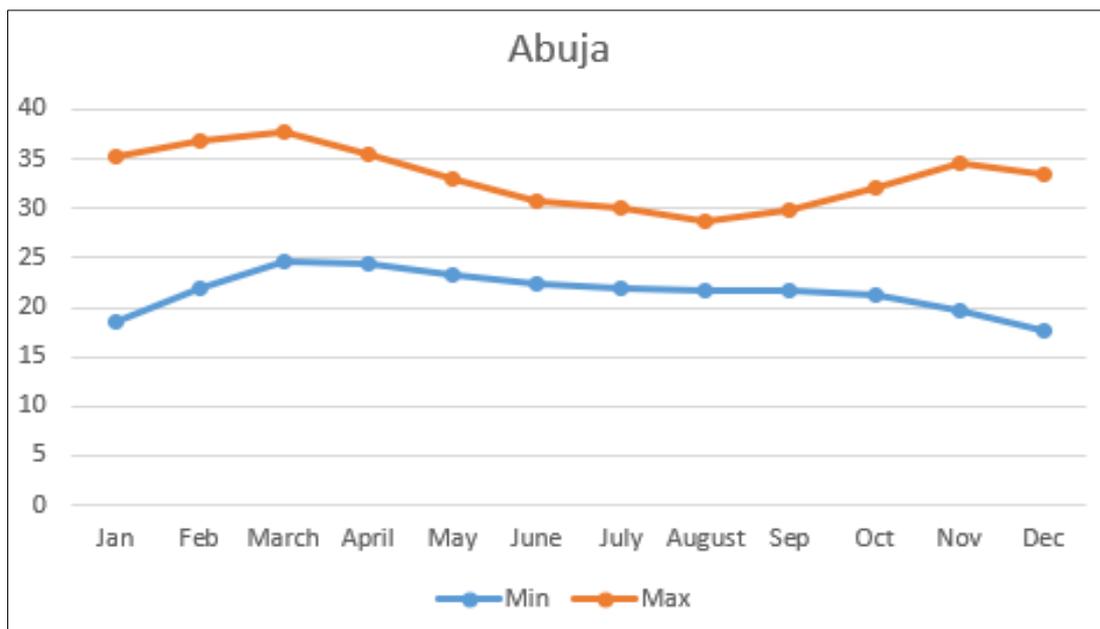


Fig 6: Climate chart of Abuja

Plateau State

Plateau State climate is allayed by its altitude and it is located approximately 1,200 (3,900feet), meters above sea level. It is observed that the annual temperature in Jos (the capital of Plateau State) lies between 21.010C to 27.10C approximately. Plateau State has it mean lowest temperature

in December which is 19.10C and the highest temperature recorded is in March with a total mean temperature of 24.50C (Adeniran and Eze, 2022) ^[1]. The flux of temperature during rainy season is caused by the altitude of the state. The flux in temperature causes the state to have abundant rain than its surrounding.

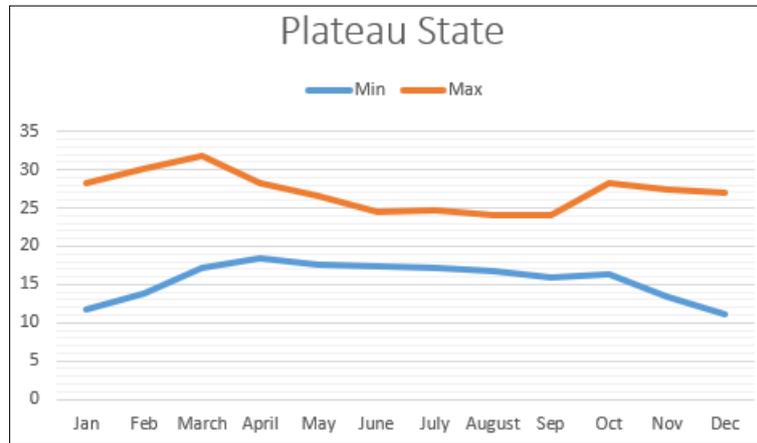


Fig 7: Climate chart of Plateau state

Nasarawa State

Nasarawa state is situated at approximately 133. 63 meters (438.46 feet) above sea level. The climate in Nasarawa state can be categorized as dry and tropical wet climate. The annual temperature of Nasarawa state roughly 29.40°C. The mean temperature of Nassarawa State is slightly below that

of Nigeria with -0.07%. The state has roughly 155 days of rain annually. Nasarawa state has its average lowest temperature in September with a temperature of approximately 24.24°C and obtain its highest temperature in February with an average temperature of 30.54°C estimated. The chart below the climate change of Nasarawa state.

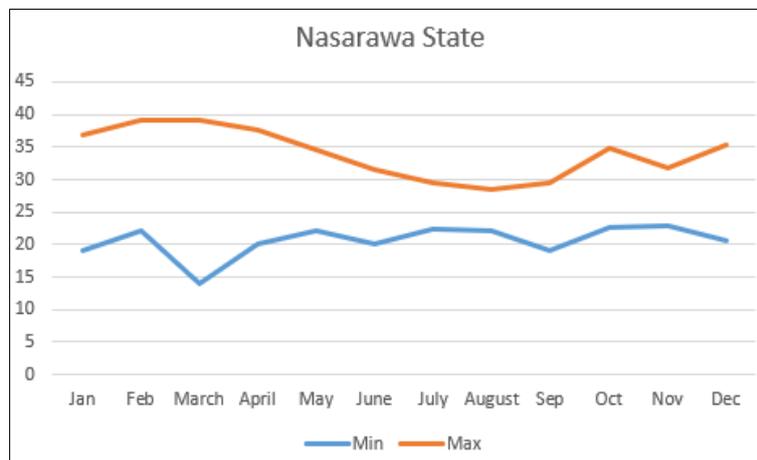


Fig 8: Climate chart of Nasarawa state

Table 4: The Number of Houses, type of Thermal Building and the Climatic variation in Central Nigeria (Abuja, Plateau State and Nasarawa State).

	Abuja	Plateau State	Nasarawa State
Number of Houses Surveyed	39	40	40
Clay Bricks	9	20	20
Concrete Bricks	30	20	20
Date of survey	March, 2025 (Hottest Month)	March, 2025 (Hottest month)	February, 2025 (Hottest Month)
	August, 2024 (Coldest Month)	December, 2024 (Coldest Moth)	September, 2024 (Coldest Month)

Discussion of Findings

The research was carried out in the morning and afternoon during the hottest and coldest months of the year. The research was carried out in the early hours of the day from around 7am – 9am and in the afternoon from 1pm – 3pm. Both concrete brick and clay bricks were examined in order to ascertain the recital impact of climate variation on thermal energy building. During the hottest and the coldest season in Nasarawa and Abuja, buildings were sampled and the result indicate that most of the concrete building are affected by rise in temperature. During cold season, thermal air remains a little bit comfortable for inhabitants. The outcome of the

research reveals that for clay brick buildings, there is no significant difference between the temperature inside the building and outside the building. Whereas, in concrete buildings, it was observed that during hot season, the temperature inside the building is increasingly high though it all depends on the type of building material that was used in erecting the building. The building enlarges when the temperature goes up and reduces when the temperature goes down. During cold season, the room temperature in concrete building tend to be higher than the temperature outside. The thermal air during cold season is conducive for its inhabitants. Whereas, the temperature during hot climatic

condition has a difference between inner thermal air and outdoor thermal air. Unlike residents in Jos Plateau State, inhabitants in the tropical climate region suffer a lot from warm air discomfort also known as thermal discomfort. The

inhabitants in Abuja and Nasarawa suffer a lot during hot season because of the rise in temperature. Most of the inhabitants in Abuja and its environs use building materials that will regulate the temperature during hot and cold season.

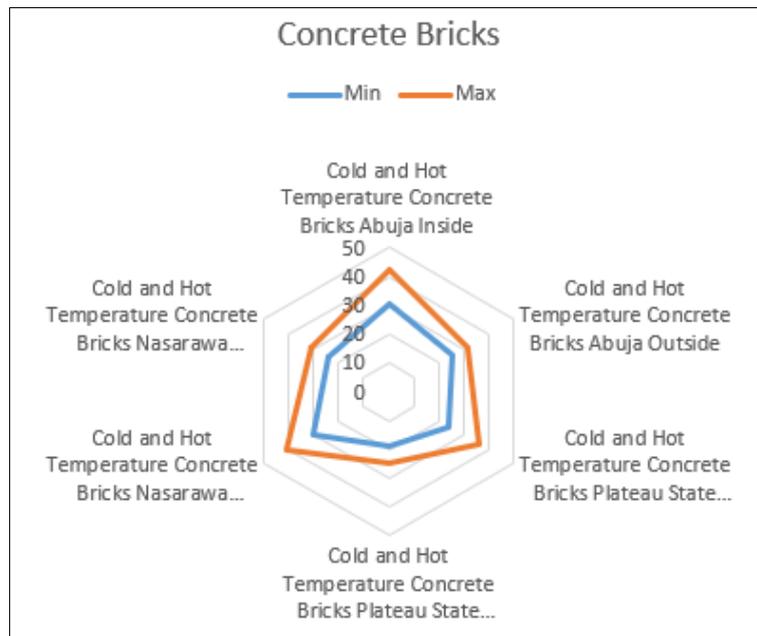


Fig 9: Cold and Hot Temperature of Concrete Bricks

The above chart represents the cold and hot temperature of concrete bricks in central Nigeria. Certain factors were considered at the cause of this research. The size of windows for ventilation, the inches of the block which must 8cm thick and at least 1.5cm plaster and the material that was used in erecting the building. Buildings with air conditioned, fan and other devices that will reduce the temperature of the building were not included on the research. From the above chart, it is

evident that rise in temperature has significant on the inside room temperature. The inside temperature in Abuja is observed to be the highest; with a maximum and minimum mean temperature of 42.3°C and 30.45°C respectively, followed by Nasarawa State with a maximum and minimum mean temperature of 40.8°C and 29.7°C accordingly, and the least is Plateau State with a maximum and minimum mean temperature of 36.1°C and 23.9°C respectively.

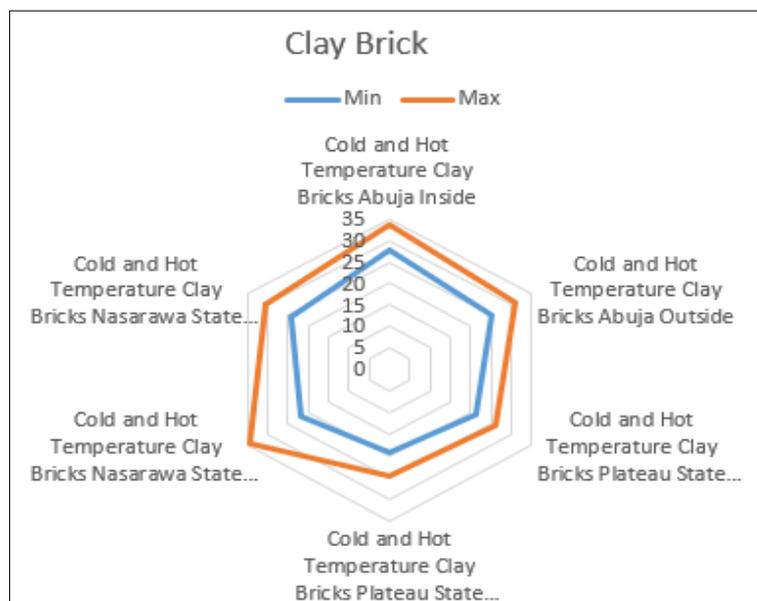


Fig 10: Cold and hot temperature of clay bricks

The above chart represents the cold and hot temperature of clay bricks in central Nigeria. Certain factors were considered at the cause of this research. The factors considered basically are the size of the window and the thickness of the bricks. The investigation showed that there is a slight difference

between the inside temperature and the outside temperature. Abuja has a minimum and maximum inside temperature of 27.9°C and 33.5°C respectively, Plateau state has Minimum and maximum inside temperature of 21.2°C and 26.09°C accordingly and finally Nasarawa state has a minimum and

maximum room temperature of 21.98°C and 34.6°C respectively.

Conclusion

This research is an evidence that climate variation has immense impact on some buildings in the central region of Nigeria. The research, categorically shows how thermal air in clay buildings are always at room temperature during hot and cold season as a result of the thatch used in roofing the building. Conversely, it was observed that concrete building on the other side, tend to have high room temperature most especially in Abuja and Nasarawa state during hot season. Jos Plateau state is regarded as the Europe of the country as its temperature is always on the low side during hot and cold season. Thatched houses in Plateau state are relatively colder than that of Nasarawa and Abuja. The thermal comfort of contemporary buildings is highly dependent on the building materials used in raising the structure. The change in climate can either leads to either expansion of the building throughout high temperature or contraction of the building in terms of low temperature. The study recommends the use of standard building materials that will help the building stand strong in high and low temperature and also to maintain thermal air comfort within the room and avoid cracking and expansion; most importantly, the concrete building.

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