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Evaluation of Double Skin Facade as Heat Modulators for Office Buildings in Kano State

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Abstract
The hot dry climate of Nigeria is characterized by a period of high temperature and low relative humidity in which daily mean maximum indoor temperature for most buildings reaches about 37°C with low indoor air velocity. As such, some buildings tend to fulfil thermal requirements through dependence on mechanical means of cooling to solve overheating. This results in exorbitant cost which is disadvantageous specifically in profit oriented buildings like office buildings where user comfort dictates the level of performance. This study investigates the effectiveness of double-skin facades (DSFs) as heat modulators in the context of office buildings in Kano State. Through a comprehensive analysis of climatic conditions, building energy performance, and occupant comfort, the study assesses the practicality and benefits of integrating DSFs in the region. The research design employs explanatory and experimental approach whereby, simulation tools, and empirical data are used to evaluate the thermal performance, energy efficiency, and environmental impact of DSFs, providing valuable insights for architects, designers, and policymakers involved in sustainable building practices within Kano State. Double skin facade can increase indoor thermal comfort in a building, with wider air gaps improving the overall performance of office buildings and workers productivity. Simulation results show the behaviours of a single skin façade of a selected case study to obtain the hourly temperature of hottest day of the year in Kano and the result were obtained given the discomfort hours for ground floor as 822 hours, first floor 795hours and second floor 770 hours respectively. Similarly, it was observed that a base case setup of 15 storey

of varying cavity depths of 450mm, 600mm and 750mm were simulated. The predicted results stated that the 750mm walling setup double skin façade perform best in the hot dry climate of Kano given a great reduction in discomfort of 505hours. Conclusively, the ability of designers to harness and use the building envelope is crucial for achieving thermal comfort in hot and dry climates. Meanwhile, passive strategies such as natural ventilation, daylighting, and solar heat gain can also be incorporated into the fabric of the building. Based on these findings, the study recommends the adoption of double skin facade designs for office buildings in Kano State, as they can provide efficient thermal comfort and energy savings.

Keywords: Evaluation, Double Skin Façade, Heat Modulators, Office Buildings, Kano State

Introduction

In recent times, man is globally faced with the threat of global warming which is rapidly changing the climate. Human activities are the major contributors to this change one of which is the emission of Green House Gas (GHG). Amongst the emissions, buildings account for approximately a quarter of the global emission (Amed *et al.*, 2016). Considering that amount GHG produced in developing countries is higher than that of developed countries, it is of great importance to consider environmental approach in the field of architecture (Zarghami & Abad, 2015). According to Hotel Energy Solutions (2011), approximately half of the total consumption in office is dedicated to provision of comfort conditions to occupants. Office building is the big energy users and is likely to gain the greatest benefits from improved energy efficiency (Bin, 2012). The hot dry climate of Nigeria is characterized by a period of high temperature and low relative humidity in which daily mean maximum indoor temperature for most buildings reaches about 37°C with low indoor air velocity (Hernandez & Berbbia, 2010). In hot dry climate of Nigeria, some buildings tend to fulfil thermal requirements through dependence on mechanical means of cooling to solve for overheating (Malgwi & Sagada, 2014). This tends to be expensive and disadvantageous especially in most profit oriented buildings like office buildings where user comfort dictates the level of performance. Iyati *et al.* (2014) opined that, the growing demand for indoor environmental comfort is leading to a substantial evolution of the building envelope especially in the tropics where buildings receive excessive solar radiation. Consequently, the building skin is required to be responsive and dynamic by regulating the flow of heat, light, and air from outdoor to indoor to effectively respond to climatic conditions and occupant comfort (Fabio, 2015). As such, it can be leveraged for minimizing heat gains. Moreso, the amount of heat gain through the building's envelope can be reduced by designing a ventilated Double Skin Facade (DSF). According to Amed *et al.* (2016), DSF is optimally one of the best options in managing the interactions between the outdoor and the indoor spaces.

STATEMENT OF THE RESEARCH PROBLEM

According to research conducted by the American Society of Interior Designers in 2016, workers priorities workplace comfort as the second most important factor after salary when considering the advantages of their job. The office staffs has been encountering thermal discomfort as a consequence of a defective air-conditioning system and/or insufficient electricity to cool the working environment. As a result, the workplace experiences elevated temperatures and humidity levels throughout the latter part of the day. Consequently, this has led to a decline in employee productivity and the emergence of unfavourable sentiments within the workforce, specifically manifested as a tendency to engage in unproductive behaviour. Adverse temperature conditions have a detrimental impact on the productivity and performance of those occupying such environments. The available literature and statistics about the performance of double-skin façades, specifically in relation to thermal comfort, occupant control, and energy efficiency, are mostly focused on colder and temperate climates found in Europe and North America (Poirazis, 2014). Within these particular situations, there are instances of effective implementation. Nevertheless, the knowledge or documentation about the efficiency or usefulness of using double-skin facades in hot regions remains uncertain. The objective of this work is to replicate the operational characteristics of double-skin facades inside regions characterised by high temperatures using Kano economic city as a study area. The data acquired would result in a collection of recommendations for the development of energy-efficient double-skin facades in regions characterized by high temperatures.

AIM

This study aims to evaluate the effectiveness of using double-skin facades as a means of regulating heat in the architectural design of office buildings inside Kano Economic City, located in Kano State with a view to improve occupants' comfort.

LITERATURE REVIEW

Energy Consumption in Office Buildings

In Nigeria, there is a challenge of power supply therefore, quite a number of people depend heavily on costly alternative sources (Enscope, 2014). Oyedepo (2012) asserts that, approximately 60% to 70% of the Nigerian population has no access to electricity which renders the use of active systems expensive. The shortage of energy sources and escalating energy demand resulted to the re-evaluation of design practices and the development of new passive techniques to achieve comfort conditions in buildings (Geetha & Velraj, 2012). In Nigeria, there has been insufficient attention to developing sustainable ideas and materials to combat the issue of global warming which has resulted into extreme temperature rise within the country (Akinwolemiwa & Gwilliam, 2015). Adelaja (2008) emphasizes that, given the massive growth in new construction and inefficiencies of existing building stock in developing countries such as Nigeria, greenhouse gas emissions (GHG) from buildings will be more than doubled in the coming years if nothing is done. This stresses the need for Architects and designers to devices means and measures to adopt passive cooling techniques in buildings.

In addition, Milan *et al.* (2014) claim that, most of the energy consumed by buildings is for provision of lighting, heating, cooling and air-conditioning. As such, there is permanent effort to use energy saving measures to reduce building energy consumption while maintaining or improving internal thermal condition. In hot dry climates, it is estimated that about half of the urban peak load of energy consumption is used to address space cooling demands. The rate in urbanization in developing countries is rapidly rising and the pressure placed on energy resources to satisfy indoor comfort is also increasing (Dabaieh *et al.*, 2015). According to Fabio (2015), the building envelope is required to be responsive and dynamic by regulating the flow of heat, light, and air from outdoor to indoor to effectively respond to climatic conditions and occupant comfort. Therefore, providing high thermal performance office buildings in hot dry climates can be achieved by implementing proper building envelope design. Consequently, proper design of the building skin is one of the practical solutions to internal heating.

Heat Modulation and thermal mass

According to Farrou *et al.* (2014), heat modulation is concerned with the thermal storage capacity of the building structure which controls solar heat gain in order to achieve a balance between heat gain and admitting sufficient daylight without compromising the architectural and structural requirement of the building envelop. It is therefore the process by which heat is controlled from gaining access into the building through the building mass, maintaining indoor temperature and removing any heat gain by natural means. Heat modulation is one of the three widely accepted frameworks for passive cooling which are heat prevention, heat modulation and heat dissipation (Mumovic & Santamouris, 2009). While, thermal mass in reference to a building refers to mean materials capable of absorbing, holding, and gradually releasing heat otherwise known as thermal energy to its surrounding space when there is a difference in temperature between the mass and the surrounding space. Researchers have found that homes with high-mass exterior walls (such as adobe, brick, masonry (stone), concrete) in the hot climate require less energy for air conditioning than low-mass wood-framed homes with similar levels of wall insulation. The effectiveness of thermal mass is in its energy storage capacity contained in materials used for walls, floor, windows, ceiling and roofing.

Contribution of Building Envelope to Heat Reduction

Present-day façade technologies are results of a long process developed over time but a radicalchange in the building envelope technologies occurred in the past century. In the past, people especially in the west preferred massive wall construction however, towards the 1950s, building enclosures were modified and glazed facades and curtain walls were introduced(Goia, *et al.,* 2010). According to Mumovic and Santamouris (2009), heat modulation in buildings consists of methods adopted to reduce and regulate heat gains.As one of the critical steps in developing sustainable cooling designs, heat modulation can be achieved through effective solar control and control of internal heat gains. Parameters such as building envelope's insulation, solar shading of facade and air infiltration needs to be taken into consideration. The delay strategy can provide reduction of cooling load and modulation of internal temperature through heat discharge. The cycle of heat storage and discharge should be coupled with heat dissipation techniques to prevent overheating (Fariborz & Jong, 2009). Heat modulation is achieved through thermal mass and night ventilation. The modern style of transparent facades became very popular which was adopted globally as an international style paying less attention to its energy performance and effects of climatic conditions (Goia *et al*., 2010). Presently, the most pleasant of Architecture are known as systems that maintain great correlation with nature by adopting natural potentials to maintain comfort for building occupants (Behzad *et al*., 2012). The first phase is by managing the effect of external environment on the building envelope. The building envelope has been traditionally considered as a barrier between the interior and exterior variable weather conditions and the performance is evaluated in terms of its ability to segregate interior and exterior spaces (Zarghami & Abad, 2015).

Building skin is considered a selective pathway for buildings to work with the climate, responding to heating, cooling, ventilation, and natural lighting which determines the physical processes and plays a dominant role on the overall energy performance of the building (Haggag, 2007). According to Odunfa *et al.* (2015), the building envelope is one of the mostimportant components with respect to heat gain and overall heat transfer coefficient taking cognisance of orientation as it plays a crucial role. Furthermore, the impact of building envelope design can reduce thermal performance to a great extent especially when insulation is integrated in roof and walls of the envelope. The process will help the reduction of cooling energy consumption extensively. According to Mostafa (2016), the building envelope is the tool for achieving the heat modulation strategy as it absorbs heat during the day, regulates the magnitude of indoor temperature and reduces peak cooling load in which a portion is transferred to the night hours.

Double Skin Facades

Passive cooling refers to techniques which can be used to prevent and modulate heat gains (Asimakopoulos, 2013). Passive cooling can be achieved through techniques for solar and heat control, heat modulation and heat dissipation. Modulation of heat gain deals with the thermal storage capacity of the building structure (Kharchi & Imessad, 2015). DSF revolve on the idea of a building system consisting of two skins (internal and external) with an airflow cavity with ventilated openings to prevent overheating. Regazzoli (2014) and Saelens (2002), defined DSF as a combination of a Single Skin Facade (SSF) which is doubled on the outside by a second layer having a naturally sealed or self- regulating cavity. Parra *et al.* (2015), also defined DSF as two skins (a glazed outer layer and either a glazed or mixed inner layer) placed such that air flows in the intermediate cavity

Iyati *et al.*, (2014), also revealed that DSF application on building envelopes especially on high-rise buildings enhance thermal performance. DSF design involves decisions on geometric parameters, glass selection, ventilation and control strategies. Conversely, DSF design strategy that works in one climate may not be directly applicable to other climates (Ray *et al.*, 2009). As a result, the design of DSF for each particular geographical location should be unique due to differences in external conditions as configurations are dependent on these factors. Materials have great impact on heat modulation in buildings with DSF, as different materials have different thermal properties. Different materials are used depending on design and specifications however; the use of glass is majorly used to achieve a feel of transparency and innovativeness. Control of solar gains in buildings can be achieved through use of external shading and energy efficient glazing. The energy efficient glazing summarizes the “switch off” and “reflect” energy efficient strategy by reflecting excess heat gains, increasing the reflectance of the external surfaces and relieving indoor spaces from excessive peak temperatures (Farrou *et al.*, 2014). In this time where fully glazed façades are the norm, specialized glazing is adopted in defence against solar heat gain. Specialist coatings have been developed to control heat gain while maximizing the transparency of the system. In addition, increase in DSF cavity depth combined with a higher opening glazing ratio does not only increase airflow but also contributes to increased room temperature (Yoon *et al.,* 2022).

Gratia *et al.* (2013), investigated various DSF cavity depths (300mm, 600mm, 1200mm and 1500mm) and concluded that the larger temperature difference that occurred was 5.8°C between the shallowest and the deepest depths. DSF is considered one of the architect's solutions to overheating in buildings especially in the hot dry region characterized by high rising air temperature. As such the right application of DSF in buildings will greatly influence and enhance heat modulation.

RESEARCH METHODOLOGY

The study is a quantitative research adopted an explanatory and experimental approach to frame the answers to the research questions. The experimental research approach was adopted which involved dynamic thermal computational simulations and employs the parametric analysis to answer research questions.

Dependent and Independent Variables

The dependent variable is thermal comfort, thermal comfort is measured in terms of indoor dry bulb air temperature, indoor relative humidity, solar radiation, and air velocity. However, operative indoor air temperature combines the effect of surface temperature of the wall surface as well as air temperature and is considered more accurate. The independent variables that were examined are classified into two groups. The groups are planning design variables and double skin façade variables. Planning design variables to be examined are orientation and shading. Double skin façade variables to be examined are ventilation mode, partition type and ventilation of the cavity mode. These variables were examined as part of the process of creating a suitable base-case on which to test the performance of Dependent variables.

A study by Rezazadeh and Medi (2017), determined the appropriate cavity width based on the number of comfort hours for DSF using design builder through which desired results were obtained. For the purpose of this study, Design Builder was be used. Design Builder combines building modeling and ease of use with 'state of the art' dynamic energy simulation. It is a unique software tool for creating and assessing building designs. It had been specially developed so it can be used effectively at any stage of the design process. From the concept stages where just a few parameters are needed to capture the building design to much more detailed building models for established designs. It is a user-friendly modeling environment where you can work (and play) with virtual building models. It provides an environmental performance data such as: annual energy consumption, HVAC component sizes and maximum summertime temperatures. Design Builder allows importing 3D architectural models created in Revit, ArchiCAD or other 3D CAD systems supporting .gbXML, and dxf data exchange. The simulation was conducted using design builder in different stages. A base case model produced in Revit 2021 was imported and simulated using weather boundary conditions of Kano for the hottest day. Hourly indoor temperature was obtained for the hottest day (April, 13) measured in ºC. The independent variables were modified and integrated with base case through which simulations where performed for the various DSF models.

RESULTS AND FINDINGS

For the purposed of smooth simulation operation, the simulation of single skin facade (SSF) model that was used as case studies was simulated first, after which the base case which is a double skin façade (DSF) with a varying cavities was simulated to compare the degree of thermal modulation between the two materials.

Parameters were generated from design builder version 6.1.0.6 2019 that would be used for the simulations which include:

- **U-value**: is the rate of heat transfer per unit area per degree of temperature difference, and is the inverse of the R-value. That is, U= 1/R and R=1/U. the U-value is measure W/m2K, where W, stand for watts, M2, for meter square and K for kelvin.

The lower the U-value, the better the thermal performance and the lower the energy loss. The U-value of the various building components such as floors, walls and windows were determined from value generated from the design builder interface as shown in Table 1.

Table 1: External design conditions and U-value of the building components

Simulation Input Data			
Working schedule	8am to 5 pm	Ground floors U-value	**0.27W/m^2 K**
Artificial lighting thermal load	15 W/m^2	Exterior walls U-value	**0.5W/m^{2}K**
occupancy latent gain	4.2W/m^2	Exterior walls solar absorption	**0.51 W/m^2**
Air leakage	0.05 – 0.1ACH	Exterior walls reflectivity	**0.55 W/m^2**
Floor height	3.3m	Roof u-value	**0.25W/m^2 K**
Exterior glazing width	3.9mm	Roof solar absorption	**1 W/m^2**
Exterior glazing U-value	5.73 W/m^{2}K	Roof solar reflectivity	**0.57 W/m^2**
Exterior glazing solar absorption	0.56W/m^2	Cavity partition elements U-value	**6W/m^{2}K**
Exterior glazing reflectivity	**0.73 W/m^2**	**Windows frame conductivity**	**0.14W/m^{2}K**

Source: Design Builder Simulation Software (2023)

Human comfort is a subjective concept which varies from person to person and changes overtime. For office operation in a dry climate Kano a light business wears of (clo) factor of 1.0 is considered desirable. The indoor office humidity is given as minimum of 35% and maximum at 55% with air speed velocity of 0.5m/s and various indoor desirable condition as shown in Table 2 below.

Table 2: Internal design conditions, occupancy, operations and comfort band

Clothing (clo)	1.0 (light business wears)
Humidity (%)	35-55
Airspeed (m/s)	0.5
Lighting level (lux)	400 (office block standard requirement)
Number of occupants	2 (per office)
Activity Carried out	Basically typing
Sensible gain (w/m2)	5
Latent gain (w/m2)	2
Air change rate (air-change/hr)	1.0 (average)
Wind Sensitivity (air-change/hr)	0.50 (somewhat sensitive)
Lower Comfort Band (°c)	19
Upper Comfort Band (°c)	33
Ventilation System	Natural ventilation
Operational hours	3240 per year

Source: Design Builder Simulation Software (2023)

Base Case Model of 450mm air cavity gap

A base case which is a 4.5m by 4.5m office space of 10 floors including the Ground floor with a floor to ceiling height of 3.3m and 150mm monolithic concrete floors and a decked roof. The double skin wall DSF is applied in this study to help improve thermal comfort. The external double glass walling material setup is alternated for each case and all other parameters are kept constant. The total hours of discomfort are predicted from the simulations as shown in Figure 1 below.

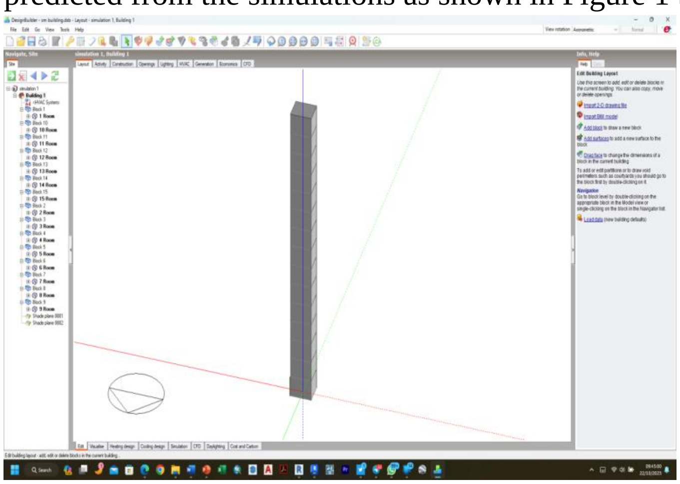

Figure 1: Design Builder Simulation Tool Interface

Source: Author's field work (2023)

Ground Floor simulation result of base case 450mm cavity gap

Figure 2: Shows the results from Design Builder simulation. It predicts that the 450mm air gap walling setup

will have total discomfort hours of 754 hours out of the total 3240 operational hours in a year. The highest number of discomfort hours is predicted to be in May and no discomfort in January, February, august, September, November and December. It is predicted that there will be no discomfort in these months as the months have relatively low average temperature and thus the predicted temperature will fall within the comfort bands.

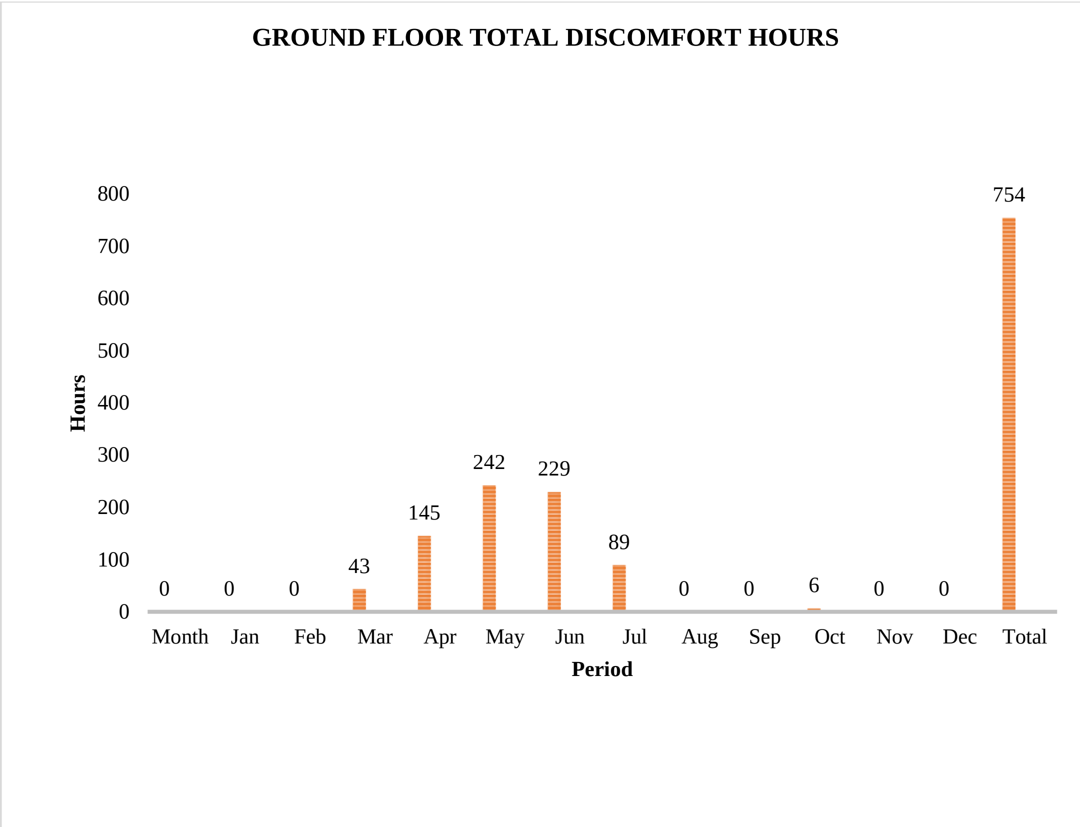

Figure 2: Discomfort hours for the 450mm air gap wall setup for ground floor office
Source: Author's field work (2023)

First Floor to fourth Floor simulation result of base case 450mm cavity gap

Figure 3 shows the results from Design Builder simulation. It predicts that the 450mm air gap walling setup will have total discomfort hours of 736 hours out of the total 3240 operational hours in a year on the first floor offices. The highest number of discomfort hours is predicted to be in May and it has been predicted that there will be no discomfort in January, February, august, September, November and December. It is predicted that there will be no discomfort in these months as the months have relatively low average temperature during working hours and thus the predicted temperature will fall within the comfort bands.

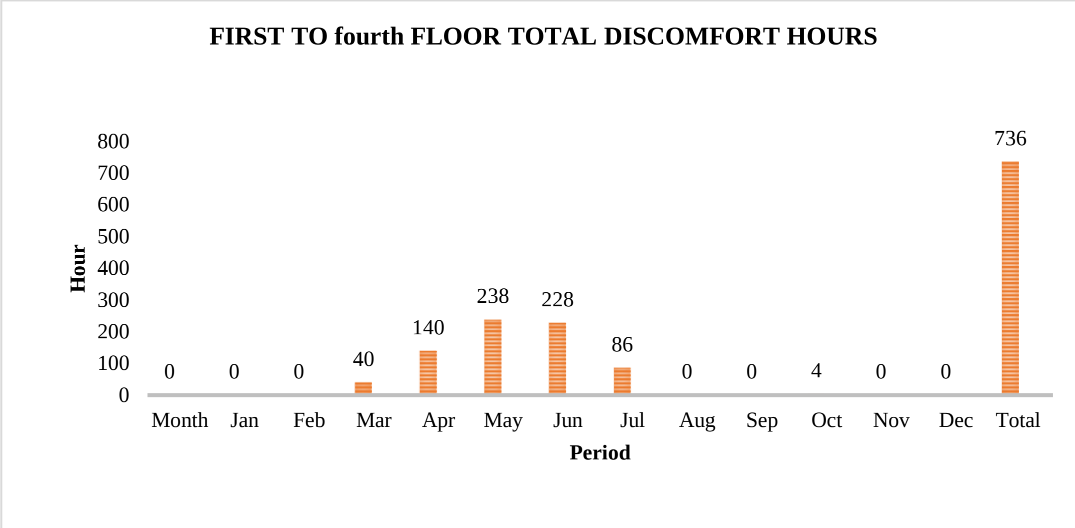

Figure 3: Discomfort hours for the 450mm air gap wall setup for first floor to fourth Floor office
Source: Author's field work (2023)

Fifth Floor to ninth floor simulation result of base case 450mm cavity gap

Figure 4 shows the results from design builder simulation. It predicts that the 450mm air gap walling setup will have total discomfort hours of 702 hours out of the total 3240 operational hours in a year on the third to seventh floor offices. The results from simulation predict that temperature increases are negligible at heights above 10 meters above ground level as the air temperature at this height remains almost the same. The highest number of discomfort hours is predicted to be in May and it has been predicted that there will be no discomfort in January, February, august, September, November and December. It is predicted that there will be no discomfort in these months as the months have relatively low average temperature during working hours and thus the predicted temperature will fall within the comfort bands.

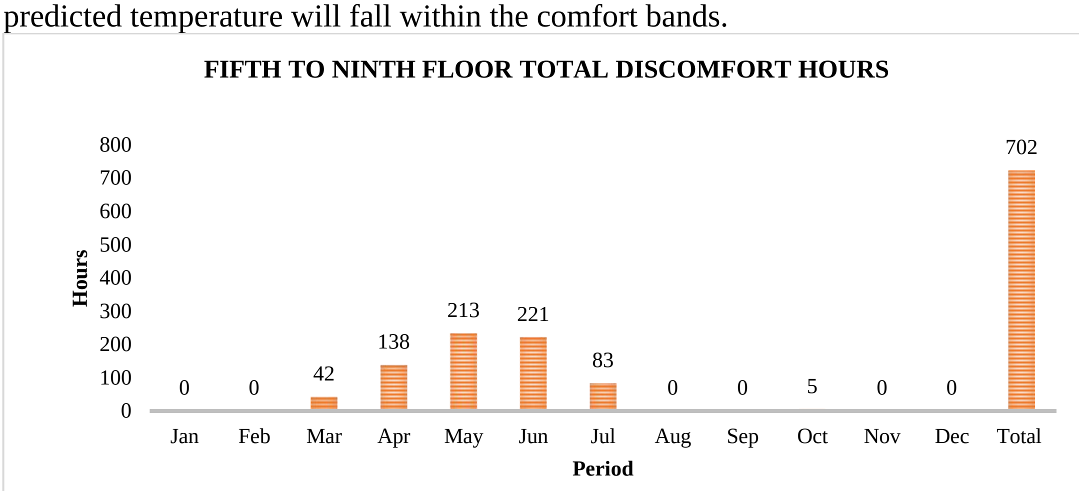

Figure 4: Discomfort hours for the 450mm air gap wall setup for fifth to ninth floor offices

Source: Author's field work (2023)

Ground Floor Simulation result of base case 600mm cavity air gap

Figure 5 shows the results from Design Builder simulation. It predicts that the 600mm air gap walling setup will have total discomfort hours of 690 hours out of the total 3240 operational hours in a year. The highest number of discomfort hours is predicted to be in May and no discomfort in January, February, august, September, November and December. It is predicted that there will be no discomfort in these months as the months have relatively low average temperature and thus the predicted temperature will fall within the comfort bands. It is predicted from simulation that the 600 mm air gap wall setup performs better than the 450mm air gap double wall.

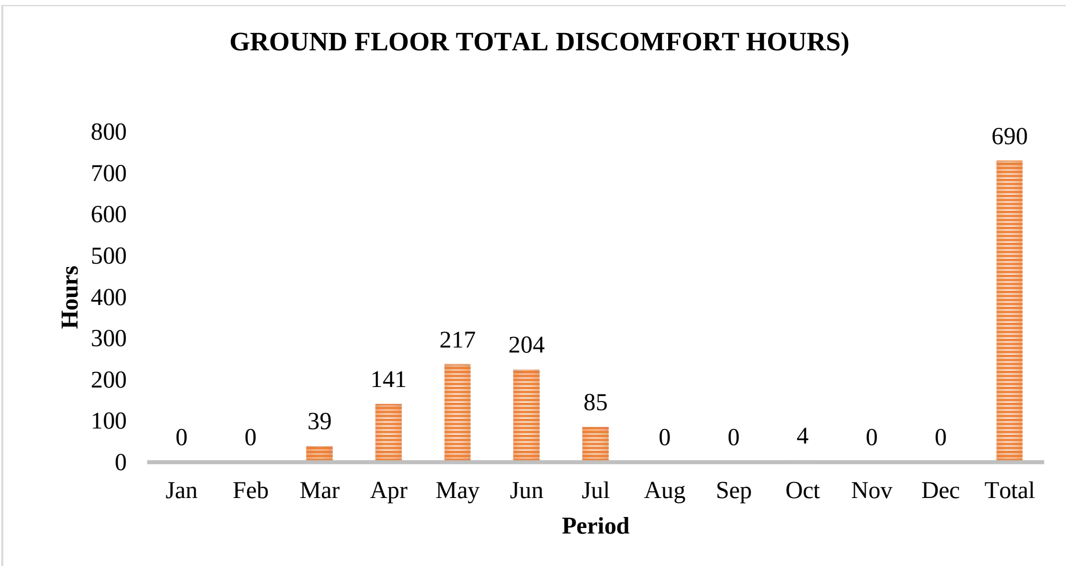

Figure 5: Discomfort hours for the 600mm air gap wall setup for ground floor office
Source: Author's field work (2023)

First Floor to fourth floor Simulation result of base case 600mm cavity air gap

Figure 6 shows the results from Design Builder. It predicts that the 600mm air gap walling setup will have total discomfort hours of 653 hours out of the total 3240 operational hours in a year on the first floor offices. The results from simulation predicts that thermal discomfort is slightly more on upper floors as warm air rises to the higher floors thereby increasing the temperature which will in turn raise the level of thermal discomfort. The highest number of discomfort hours is predicted to be in May and it has been predicted that there will be no discomfort in January, February, august, September, November and December. It is predicted that there will be no discomfort in these months as the months have relatively low average temperature during working hours and thus the predicted temperature will fall within the comfort bands. It is predicted from simulation that the 600 mm air gap wall setup performs better than 450mm air gap double wall.

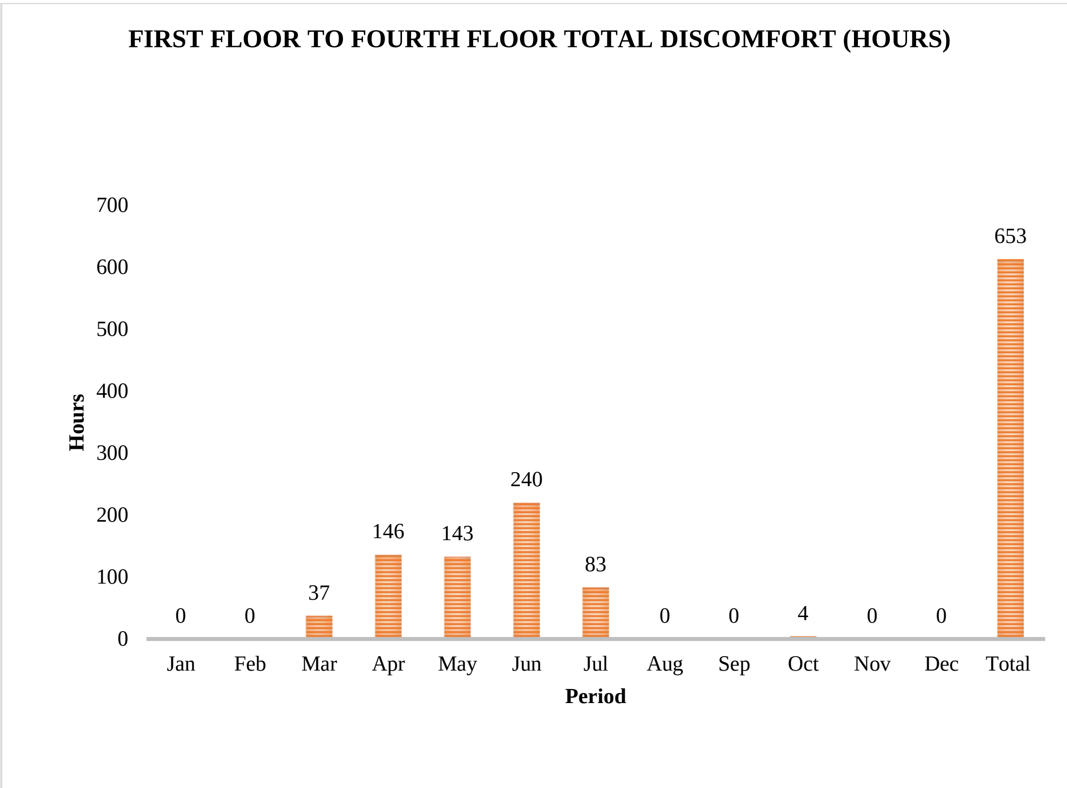

Figure 6: Discomfort hours for the 600mm air gap wall setup for fourth floor office
Source: Author’s field work (2023)

Fifth to ninth floor Simulation result of base case 600mm cavity air gap

Figure 7 shows the results from design builder simulation. It predicts that the 150mm air gap walling setup will have total discomfort hours of 591 hours out of the total 3240 operational hours in a year on the fifth to ninth floor offices. The results from simulation predict that temperature increases are negligible at heights above 10 meters above ground level as the air temperature at this height remains almost the same. The highest number of discomfort hours is predicted to be in May and it has been predicted that there will be no discomfort in January, February, august, September, November and December. It is predicted that there will be no discomfort in these months as the months have relatively low average temperature during working hours and thus the predicted temperature will fall within the comfort bands. It is predicted from simulation that the 600 mm air gap wall setup performs better than the 450mm air gap double wall.

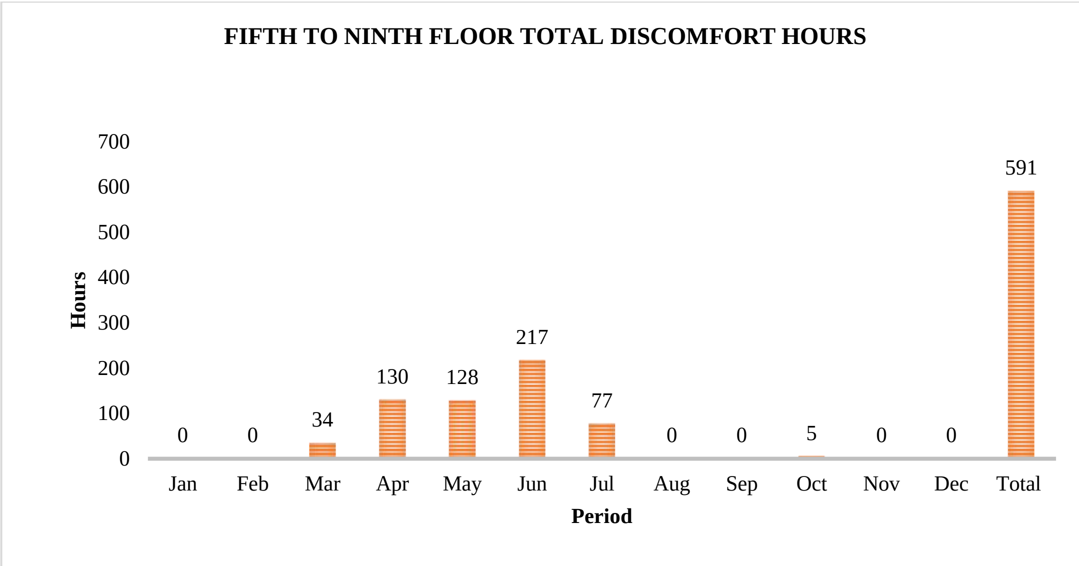

Figure 7: Discomfort hours for the 600mm air gap wall setup for fifth to ninth floor offices

Source: Author's field work (2023)

Ground Floor simulation result of Base case model 750mm cavity air gap

Figure 8 shows the results from Design Builder simulation. It predicts that the 750mm air gap walling setup will have total discomfort hours of 581 hours out of the total 3240 operational hours in a year. The highest number of discomfort hours is predicted to be in May and no discomfort in January, February, august, September, November and December. It is predicted that there will be no discomfort in these months as the months have relatively low average temperature and thus the predicted temperature will fall within the comfort bands. It is predicted from simulation that the 750 mm air gap wall setup performs better than the 450mm and 600mm air gap double wall.

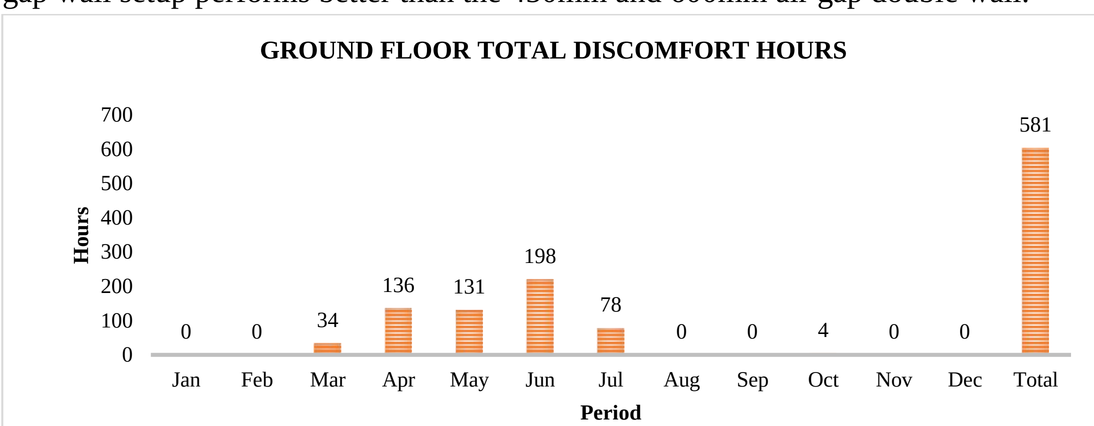

Figure 8: Discomfort hours for the 750mm air gap wall setup for ground floor office

Source: Author's field work (2023)

First Floor to fourth floor simulation result of Base case model 750mm cavity gap
Figure 9 shows the results from Design Builder simulation. It predicts that the 750mm air gap walling setup will have total discomfort hours of 556 hours out of the total 3244 operational hours in a year on the first floor offices. The results from simulation predicts that thermal discomfort is slightly more on upper floors as warm air rises to the higher floors thereby increasing the temperature which will in turn raise the level of thermal discomfort. The highest number of discomfort hours is predicted to be in May and it has been predicted that there will be no discomfort in January, February, august, September, November and December. It is predicted that there will be no discomfort in these months as the months have relatively low average temperature during working hours and thus the predicted temperature will fall within the comfort bands. It is predicted from simulation that the 750 mm air gap wall setup performs better than the 600mm and 450mm air gap double wall.

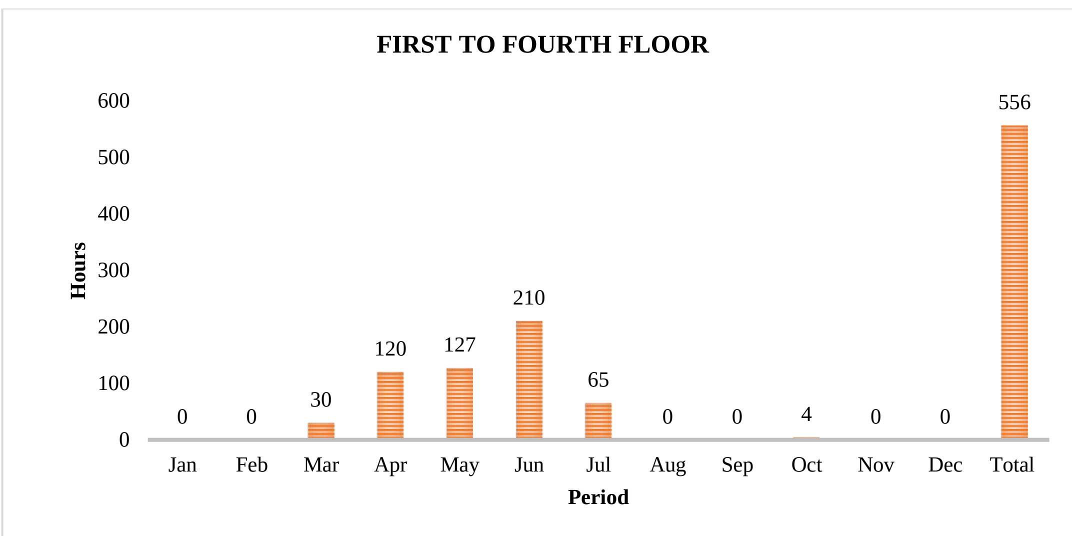

Figure 9: Discomfort hours for the 750mm air gap wall setup for first floor office
Source: Author's field work (2023)

Fifth Floor to ninth floor simulation result of Base case model 750mm cavity gap
Figure 10 shows the results from design builder simulation. It predicts that the 750mm air gap walling setup will have total discomfort hours of 505 hours out of the total 3240 operational hours in a year on the fifth to ninth floor offices. The results from simulation predict that temperature increases are negligible at heights above 10 meters above ground level as the air temperature at this height remains almost the same. The highest number of discomfort hours is predicted to be in May and it has been predicted

that there will be no discomfort in January, February, august, September, November and December. It is predicted that there will be no discomfort in these months as the months have relatively low average temperature during working hours and thus the predicted temperature will fall within the comfort bands. It is predicted from simulation that the 750 mm air gap wall setup performs better than the 600mm and 450mm air gap double wall.

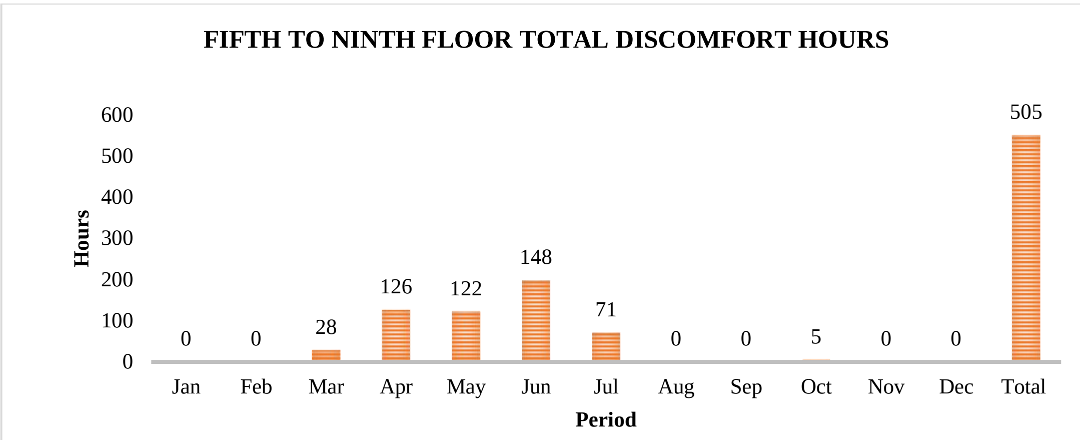

Figure 10: Discomfort hours for the 750mm air gap wall setup for fifth to ninth floor offices

Source: Author's field work (2023)

Summary of findings

Simulation results show the behaviors of a single skin façade of a selected case study to obtain the hourly temperature of hottest day of the year in Kano and the result were obtained given the discomfort hours for ground floor as 822 hours, first floor 795hours and second floor 770 hours respectively. Similarly, it was observed that a base case setup of 15 storey of varying cavity depths of 450mm, 600mm and 750mm were simulated. The predicted results stated that the 750mm walling setup double skin façade perform best in the hot dry climate of Kano which has the best thermal property as a result of its low U-value and solar absorption. Table 3 below shows the reduction in the U-value of the component used.

Table 3: Thermal properties of the walls used

Variables	450mm Air gap	600mm Air gap	750mm Air gap
U-value (w/m2.K)	2.710	1.720	**1.200**
Thermal Admittance (w/m2.K)	0.840	0.880	**0.960**
Solar Absorption (0-1)	0.251	0.237	**0.195**

Visible transmittance (0-1)	0	0	**0**
Thermal Decrement (0-1)	0.06	0.21	**0.47**
Thermal Lag (hrs)	0.42	0.75	**1.16**
Emissivity	**0.9**	**0.9**	**0.9**

The table shows that the 750 mm air gap set up has the best thermal property as a result of its low u-value and admittance and solar absorption. Also given a great reduction in discomfort of 505 hours, it has also been noted that the discomfort levels are high during the working hours as a result of the high solar insulation and other climatic factors recorded in the area. DSF greatly reduces internal heat gains in building therefore enhancing thermal comfort and reducing dependency on mechanical cooling system and consequently reduces greenhouse gas emission thereby qualifying DSF as passive techniques for enhancing heat modulation

CONCLUSION

This research investigates the effectiveness of creating an indoor thermally comfortable office buildings using double skin facade to improve worker's performance, and producing a functional working environment. The result obtained showed that double skin facade if incorporated, enhances thermal comfort in office building design. Therefore, the application of double skin facade strategies if successfully integrated in office design ensures a conducive atmosphere for workers, providing office buildings with efficient thermal comfort and by extension enhances workers productivity and overall wellbeing.

RECOMMENDATION

The study highly recommended that, designers, government, building regulatory agencies and other relevant stake holders should take into consideration the integration of double skin facade for thermal comfort and make it part of the rules and regulations governing office design. Furthermore, architects and other relevant professionals should make use of the findings of this research as it provides guide and will aid in coming up with a better and functional office design that will to a large extent satisfy the need of workers in putting their best during working hours. Finally, employers and allied professionals should recognize the significant roles of thermally comfortable environment in enhancing workers performance of their employees.

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