Future Cities and Environment

Assessing the Effect of Prefabricated Double-Skin Façade on the Thermal Comfort of Office Building to Achieve Sustainbility

CASE STUDIES

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Case Studies of Office Complex, Kuchigoro and Office Complex, Garki, Abuja-Nigeria

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ABSTRACT

The increased interest in energy efficient construction because of environmental issues and rising energy costs has resulted in the adoption of initiatives aimed at rising energy efficiency in the building industry as an energy intensive industry with significant potential to decrease energy needs and ozone pollution. Prefabricated double-skin façade (DSF) has been proposed as a sustainable building technology that can be used to boost energy efficiency and the indoor thermal comfort of buildings in hot climates. The study aims to test double-skin façade as a means to enhance indoor thermal comfort of office buildings in Abuja Nigeria. Three types of DSFs will be thermally tested using an environmental analysis software which is used to simulate building performance by designers known as Autodesk Ecotect analysis 2011. The analysis will be carried out on two office buildings in Abuja. In each DSF type single and double glazing of the outer skin will be tested to find out which is more suitable. The result showed that DSF has potentials of improving indoor thermal comfort of office buildings and reduction of energy usage.

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1. INTRODUCTION

The increased interest in energy efficient construction because of environmental issues and rising energy costs has resulted in the adoption of initiatives aimed at rising energy efficiency in the building industry as an energy intensive industry with significant potential to decrease energy needs and ozone pollution (Silva et al., 2013). Buildings account for 33% of carbon dioxide (CO_2) emission and 40% of material and energy use worldwide and also the energy usage of office buildings is 10–20 times more than energy use of residential buildings (Yang et al., 2008) as a result of higher internal loads generated by personal computers, solar gains and enhanced comfort levels which has made the use of air-conditioning a necessity. Improving efficient use of energy in buildings is one of the fastest and cost effective steps to minimize CO_2 emissions: one of the key triggers of global warming (Saidur, 2009). Nigeria has been afflicted by severe power deficits because of its energy sector's low efficiency (Gatugel Usman et al., 2015). Around 10% of Sub-Saharan African non-electrified population are located in Nigeria and as of 2017 about 40% of Nigerians have no access to electricity (Yetano Roche et al., 2019). The large majority of the country's electricity is supplied by diesel and petroleum back-up generators which is not sustainable. The government has initiated various measures and initiatives to resolve the weak output of the power production, transmission and distribution industries (Gatugel Usman et al., 2015). But there is still poor supply of power within the country and dependency on petroleum products to provide power using backup generators is unsustainable as, it increases the emission of CO_2 into the atmosphere. Governments around the world are setting basic requirements for an energy efficient design and upgrade of existing buildings to reduce the ultimate energy consumption and related CO_2 emissions of the building sector. In order to expand this objective, research efforts are needed to focus on all components of the built environment and, in particular, on the building envelope (Ghaffarianhoseini et al., 2016). Prefabricated construction methods has been identified as a key player in the sustainable development of building construction; popular use of prefabricated structures in the building has been observed due to the introduction of a new guideline to encourage the use of prefabricated façade as a form of sustainable element in building construction (Taware, 2017).

The introduction of light weight building envelopes, different types of curtain wall technology, intelligent facades were made possible all as a result of the use of prefabrication, example is the double skin façade (DSF) which offers environmental benefits such as; energy saving, ventilation, air-flow and thermal-comfort improvement, sunshine and glare protection, sound-insulation, noise reduction and acoustic improvement, visual and aesthetic quality improvement and also economic benefits of reduced long-term costs (Ghaffarianhoseini et al., 2016). Double skin façade (DSF) is "A facade spanning one or more floors with multiple layers of skins. The skin may be airtight or ventilated". The external layer offers ambient and sound insulation safety and the façade is equipped with intermediate ventilation and thermal insulation. Buildings with a double skin facade will achieve greater thermal performance by innovative research and design relative to conventional single skin facades (Chan et al., 2009).

The use of double skin facades (DSF) has recently become more common in the construction sector. Once properly designed, the total usage of HVAC in buildings can be easily minimised by removing part of heating energy in winter and minimising thermal overheat during summer (De Gracia et al., 2013). The DSF device includes important elements of exterior glazing, internal glazing and an air cavity. The external glazing is rigid single layer and the internal skin is a double-glazed insulation unit. The air cavity can be ventilated using natural or mechanical means depending on the concept and can range between 200mm to over 2m in width (Halil & Mesut, 2011). The architectural design of office buildings has a significant influence in ensuring the thermal comfort of occupants as well as reducing energy usage. Different styles of transparent facade are being installed nowadays for new structures, especially for office buildings. The façade plays a vital role as an exterior filter which can be configured as a passive device for energy conservation and the climate barrier. (Kilaire & Stacey, 2017). Double-skin façade (DSF) is recommended as a suitable facade especially for high-rise buildings because of its potential strengths for improved daylighting, minimized heat gain and natural ventilation (Ghaffarianhoseini et al., 2016). ***Figure 1*** shows a typical DSF.

1.1 DSF TYPOLOGY BASE ON THE PARTITION OF THE CAVITY

There are various types of DSF and (***Table 1***) explains the types of double skin façade based on the construction types of the cavity.

To ensure energy efficient buildings, building envelope has to have elements of thermal and air insulation. And according to this study DSF can be proposed as one type of building envelope that can provide the building with the required insulation to help decrease the energy usage of the building by improving the thermal comfort.

To confirm the performance of DSF various DSF experiments in various climate regions were undertaken to evaluate the adequacy of the system to improve the interior of glazed buildings. In a study by (Baldinelli, 2009) in warm climate of Italy, the solar heat was primarily absorbed by the DSF's exterior skin in the summer and the inner skin and internal atmosphere was not influenced by any major impact, thereby

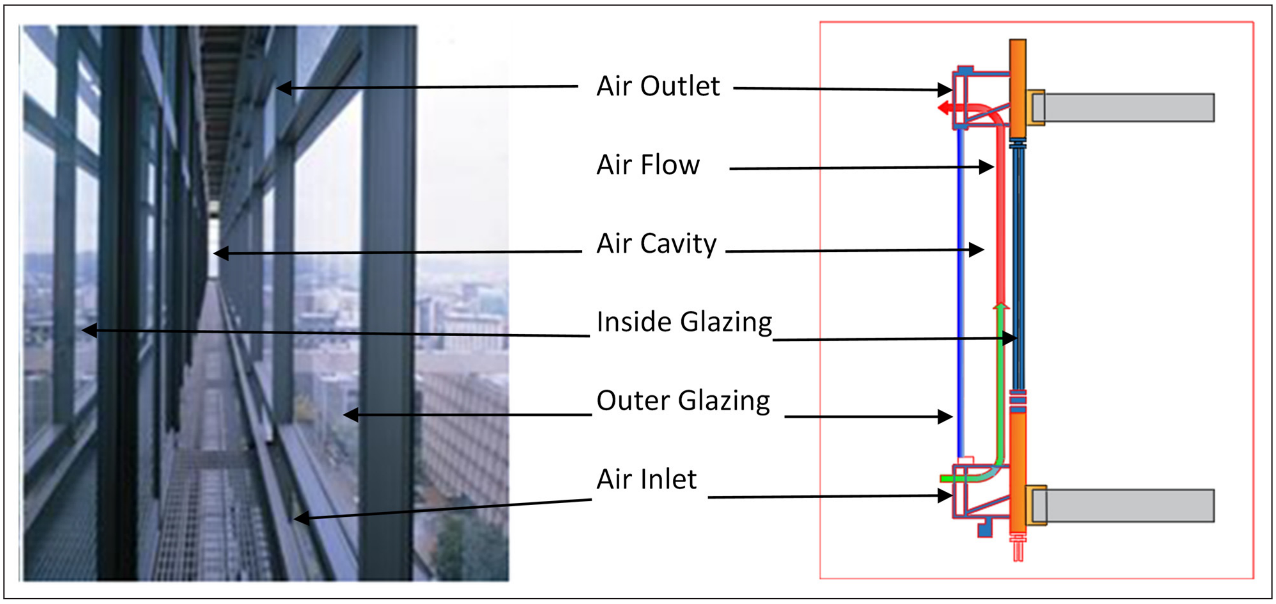


Figure 1 Double-skin façade detail. **(a)** (Daneshkadeh, 2013) and **(b)** author.

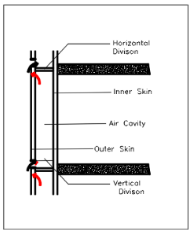
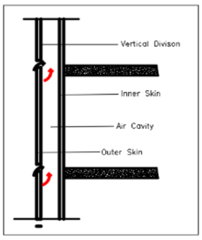
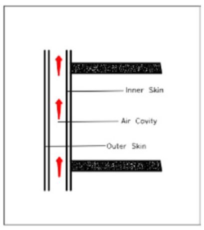
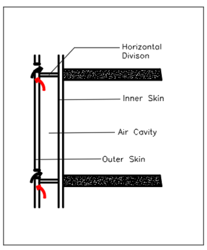
DSF TYPOLOGY	DETAIL SECTION	PROPERTIES
Box window		- The cavity is divided into vertical and horizontal compartments. - There is no shaft in the cavity. - Windows can be opened inside of the ventilation vessel - The outer façade gives intake and exhaust air openings.
Shaft box		- The cavity is subdivided into vertical compartments, along the height of the façade creating a wide ventilating shaft above it. - Separate box windows or other façade elements at different levels expel their exhaust air into the shaft which increases thermal performance.
Multi story		- The cavity is not subdivided. - The ventilation of the cavity is usually through wide gaps on the base and roof of the building. - It is typically used in winter as an air supply facade and in summer as an exhaust façade.
DSF Typology	Detail Section	Properties
Corridor		- The air cavity is usually subdivided at each floor level horizontally. - Sometimes vertical divisors are added to protect against fire and vibration. - The corridor is usually made wide enough to act as a platform for support. - The cavity allows for natural ventilation without allowing hot air move upward to the floors above.

Table 1 Types of DSF.

minimizing building cooling requirements. In short, high glass surface temperatures may lead to uncomfortable indoor conditions, particularly in areas near the DSF. In another study in the hot arid climate of Iran by (Hashemi et al., 2010) In hot and cold environments, DSF activity has been observed and studies have revealed that the variation in temperature of the external layer, the internal layer and the cavity will significantly reduce the energy used for heating in winter, and the study proposed that the elimination of cooling loads in the summer would require more innovations like night ventilation and the implementation of shading of the cavity. However, preventing overheating of the DSF interior is the best and then inside the building space to guard against direct solar radiation. Advanced glazing can prevent the thermal flow through glazing surfaces although is reliant on the type of glass. (Lee et al., 2014).

This research aims to investigate how different types of double skin façade contributes to enhancing the efficiency of office buildings' indoor environmental quality (IEQ) by assessing its effect on thermal comfort (TC) in the climate of Abuja, Nigeria. The method to be used will be simulation analysis using Autodesk Ecotect analysis 2011. The software enables designers to model construction performance from the earliest stages of conceptual design. It is a comprehensive interface for the study of energy, light and sound that can analyse relevant analytics in a completely graphical setting using three-dimensional models built in its own setting or other software applications. The software has been used to check for thermal comfort and energy usage by many researches (Maknun, 2020), (Rezazadeh & Medi, 2017).

2. MATERIALS AND METHODS

The building selected are three story office buildings located in Abuja. Oriented with their longer sides facing the North-South Axis and the shorter sides facing the East-West Axis. Autodesk Ecotect Analysis 2011 will be used to measure the temperature of the building as it is without any form of DSF and with the various types of double-skin façade. After collecting the building information and weather data, each building will be modelled using Autodesk Revit 2015 before exporting to Ecotect Analysis for simulation. Revit will be used for the modelling because modelling with Revit is easier, more flexible and more accurate than the Ecotect environment. Predefined data like; weather parameters as well as equipment performance, occupancy level, building material properties and internal heat gains from machines and occupants are all set for the simulation in ECOTECT. Each of the buildings was simulated as it is without any DSF as base case before simulation with the various types of DSF. And thermal performance of the building within the working hours was calculated.

2.1 MATERIALS

2.1.1 The study area; Abuja, Nigeria.

Nigeria is divided into five climatic zones according to (Mobolade & Pourvahidi, 2020) in their research on bioclimatic zoning of Nigeria considering thermal comfort of buildings. The authors divided Nigeria's climatic zone into; Hot-dry climate, hot humid, Temperate-dry, Temperate Humid and Temperate dry with cool climate. As in (***Figure 2***). And Abuja falls under the Temperate- dry climate.

However, according to (Batagarawa, 2013) Abuja is experiencing a composite of hot and humid climate and hot and dry. The city experiences three annual weather conditions. This includes a warm, humid wet season beginning in April and ending in October; and a dry

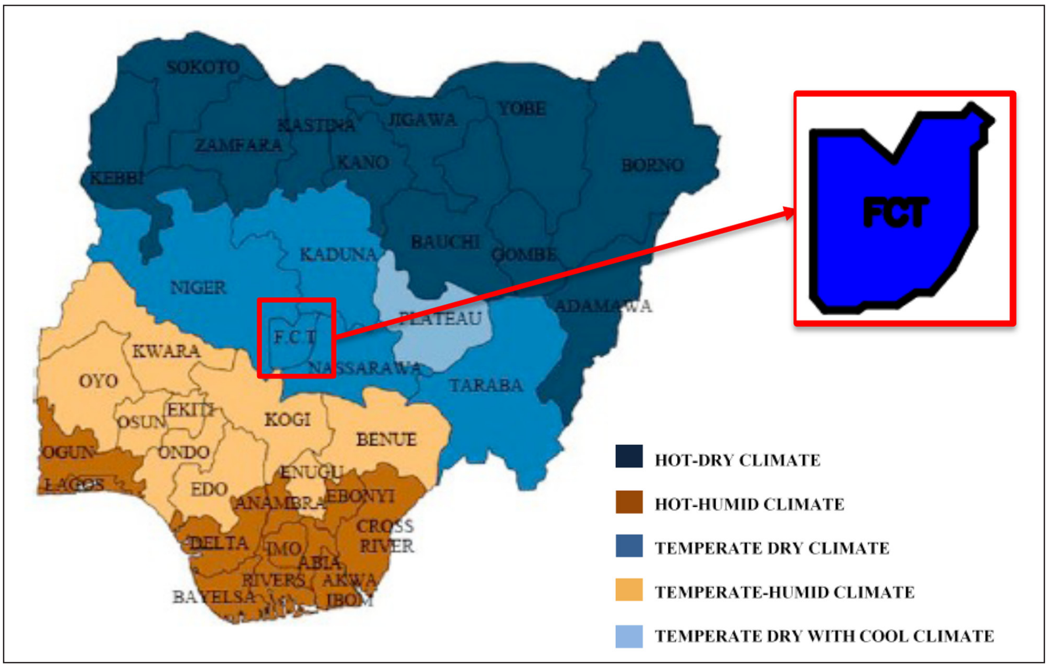


Figure 2 Climate classification of Nigeria (Mobolade & Pourvahidi, 2020).

season lasting from November to March. In between the two, there is a short harmattan interlude and this study adopts the classification of Abuja under this classification because it was a study focused on the Abuja.

Abuja, is Nigeria's capital. Located within the Federal Capital Territory (FCT) in central Nigeria, it was established primarily in the 1980s. Abuja is divided into three phases, from the centre to the suburban areas. Considering that the focus of this study is office buildings, the work is confined to the city's central Phase 1 district (***Figure 3***). The main business zone of the city, where most national and international companies have their offices, is the central Phase 1 neighbourhood. This is the place in Abuja where the buildings under investigation are located.

2.1.2 Case Studies of Office Complex, Kuchigoro and Office Complex, Garki, Abuja-Nigeria

Two buildings (office complex) located in Abuja, phase 1, each of two suspended floors were selected for the study. The characteristics of the buildings will be presented in this section. The buildings are;

- Office Complex, Kuchigoro (Case A)
- Office Complex, Garki, Area 11, Abuja (Case B)

The buildings are three story reinforced concrete frame structure with hollow sandcrete block walls, with single one way glazing panels for windows, oriented with their long sides facing the North-South Axis and the shorter sides facing the East-West Axis thereby reducing solar heat gains. The roof is made of concrete, painted with light colour to reduce indoor heat gains. Ceilings are made with Gypsum board which is a good material for achieving indoor thermal comfort. The offices are cross ventilated, also a factor that enhances indoor thermal comfort conditions. ***Tables 2*** and ***3*** shows typical Floor plans of the buildings and ***Table 4*** shows the thermal properties of the building eements.

2.2 METHOD

Two buildings (office complex) each of two suspended floors were selected for the study and simulation was performed for thermal comfort using the software ECOTEC 2011. The software was fed with climatic data and predefined thermal properties in other to determine the improvement. Each of the buildings was first simulated as it is with single skin as a base case. Then the same buildings were simulated with the three types of double-skin each attached to the North and South façade of the building and the comparison of result was carried out.

Ecotect Analysis provides hourly weather data for all days of the year with precise details of variations in temperature, humidity and radiation. ***Figure 4*** shows a graphical representation of the methodology used and ***Figures 5*** and ***6*** shows the façade of the buildings simulated.

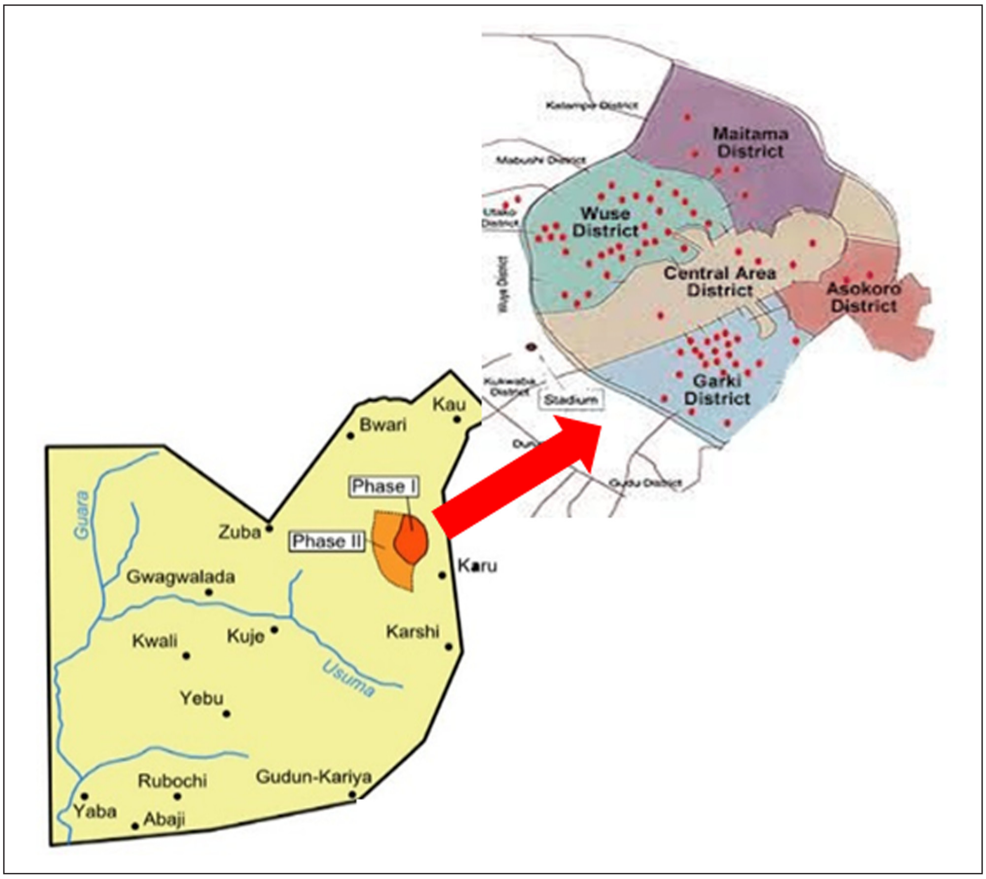


Figure 3 Abuja districts highlight phase 1.

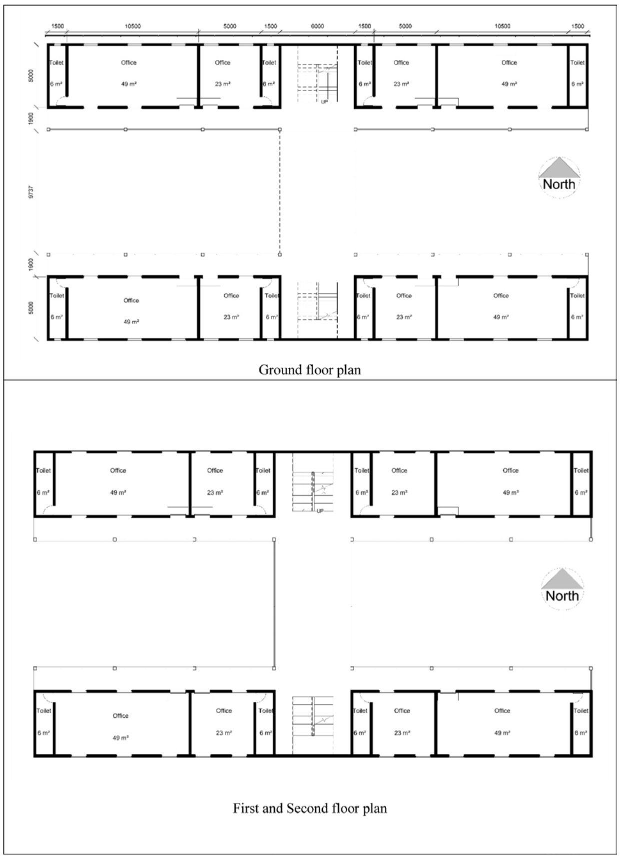
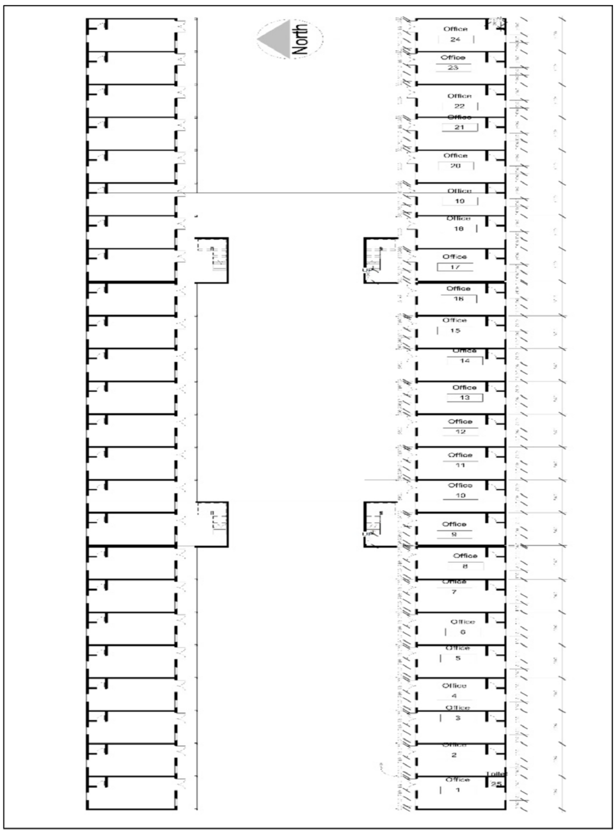


Table 2 Typical floor plans Case A (Office Complex, Kuchigoro Abuja).



Typical ground, first and second floor plan

Table 3 Office Complex, Garki, Area 11, Abuja (Case B).

WALL (HOLLOW SAND CRETE BLOCK UN-INSULATED)	
Thickness (mm)	230
Km – Internal heat capacity (KJ/m2-k)	101.2560
Radiated heat transfer coefficient (W/m2-K)	5.540
R-Value (m2-K/W)	0.523
U-Value (W/m2-K)	1.914
SINGLE CLEAR GLASS (6MM)	
Total solar transmission	0.861
Direct solar transmission	0.837
Light transmission	0.898
U-value (ISO 10292/EN 673) (W/m2-K)	5.894
SLAB (UN-INSULATED CONCRETE FLOOR)	
Thickness (mm)	150
Km – Internal heat capacity (KJ/m2-k)	93.96
Radiated heat transfer coefficient (W/m2-K)	5.130
R-Value (m2-K/W)	0.477
U-Value (W/m2-K)	2.097
CEILING (WOODEN-JOIST INTERNAL CEILING – PLYWOOD/PANEL)	
Thickness (mm)	19.1
Km – Internal heat capacity (KJ/m2-k)	8.0793
Radiated heat transfer coefficient (W/m2-K)	5.130
R-Value (m2-K/W)	0.331
U-Value (W/m2-K)	3.021
ROOF (UN-INSULATED CONCRETE ROOF WITH ASPHALT)	
Thickness (mm)	150
Km – Internal heat capacity (Kj/m2-k)	176.400
Lower resistance limit (m2-K/W)	0.261
R-Value (m2-K/W)	0.261
U-Value (W/m2-K)	3.825

Table 4 Thermal properties of the buildings elements as it is.

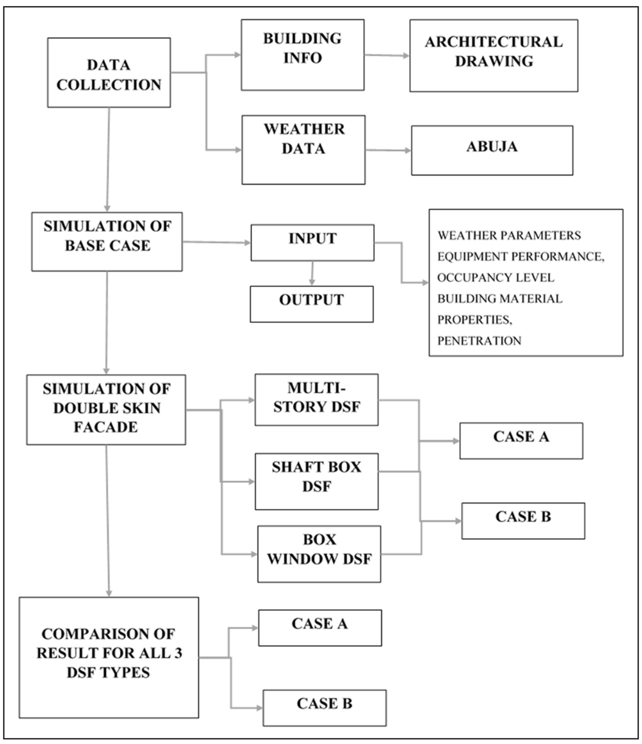


Figure 4 Method.

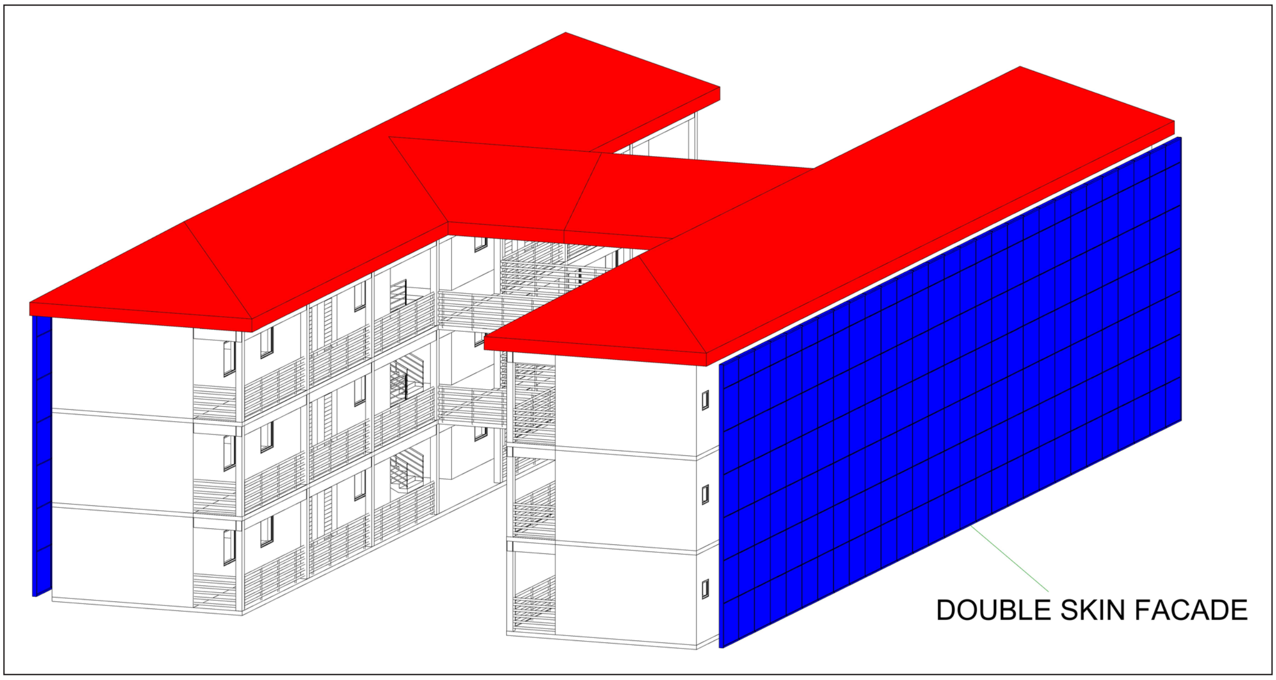


Figure 5 Case A showing the façade of the building with DSF attached.

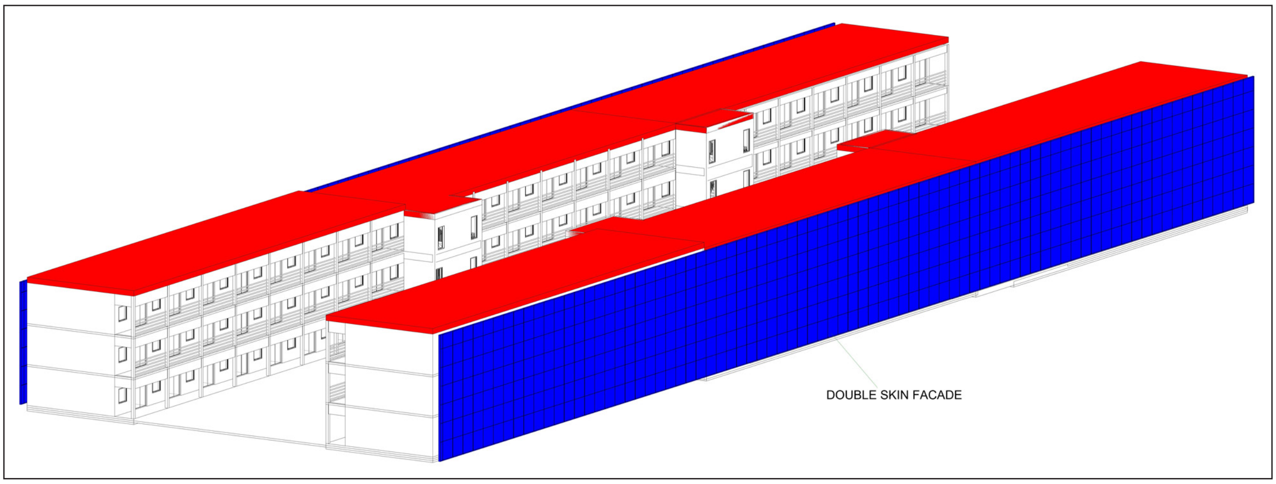


Figure 6 Case A showing the façade of the building with DSF attached.

Simulations of the building was carried out on the 15th January without any form of DSF and then with DSF as this is the latest date on the data file available as at the time of the simulation to see how the building performs and have a basis for comparison with the addition of DSF and know by how much there is an improvement. When modelling the building, weather parameters as well as equipment performance, occupancy level, building material properties, penetration, internal heat gains from machines and occupants are the input data of simulations for ECOTECT.

- Windows operation was scheduled from 8 a.m. to 5 p.m. 7 days a week.
- The model set an air speed of 1.5m/s.
- There were also planned internal gains from the occupants and machines from 8 a.m. to 5 p.m. 7 days a week.
- It had fully enclosed thermal zones i.e. the interior spaces are well enclosed. Therefore, it is possible to measure the thermal efficiency of each region.
- The properties characteristics were then allocated as the model was developed.
- The materials have been chosen from the Ecotect material library. However, some of the chosen materials were changed to ensure that the properties are as similar to the real material properties as possible.
- The weather file was uploaded, containing all the climatic details.
- In the first simulation, each of the buildings was simulated for thermal performance as it is with single-skin to be used as a base case.
- Also mixed mode ventilation was considered.

2.2.1 Office Complex, Kuchigoro Abuja, and Office Complex, Garki as it is without any form of DSF

Figures 7 and ***8*** shows the modelled building exported into Ecotect.

3. RESULTS

3.1 SIMULATION OF THE BASE CASE

The result of the building performance without any form of DSF on Jan 15th, as can be seen in (***Figure 9***) and (***Figure 10***) considering the working hours (8:00–17:00).

The temperature of the building was within the comfort level below 26°C from (8:00–9:00) in Case A and (8:00–11:00) in case B, but increased above 26°C from (10:00–17:00) in Case A and from (12:00–17:00) in case B which means more energy for cooling will be needed, the average temperature on that day was 25.94°C in case A and 26.21°C in case B.

3.2 SIMULATION WITH DOUBLE SKIN FAÇADE

In the simulation with the various DSF types, a second skin was attached at 600mm distance from the wall of the building. All building materials, orientation and construction method were kept constant during the different simulations, mixed mode ventilation was considered in both simulations and also both single and double glazing were tested in each building for all the three types of DSF.

The inlet vents on the DSF's outer surface were designed to be open 24 hours during the year.

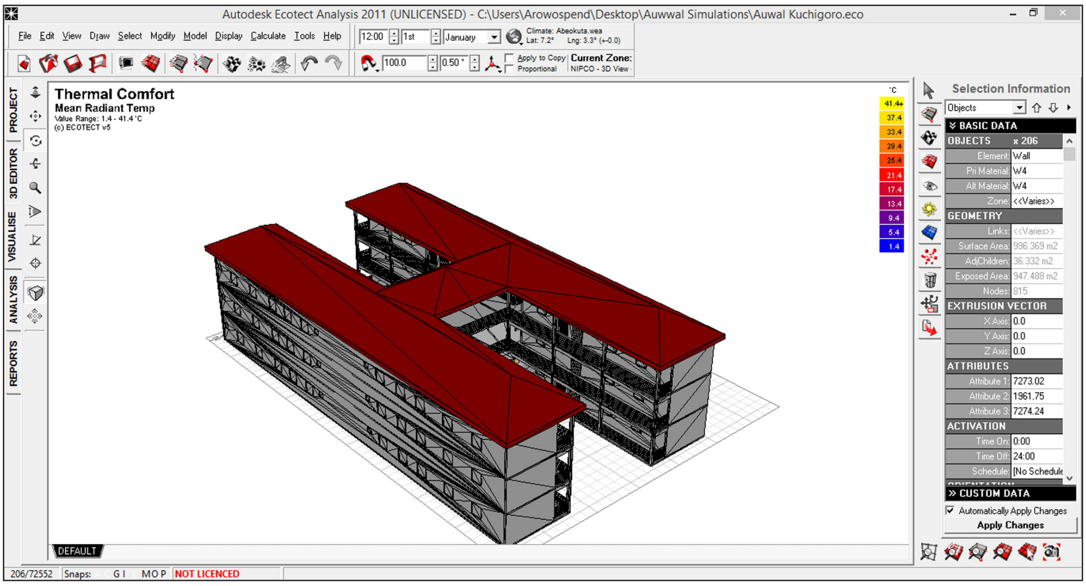


Figure 7 Exported building in Ecotect analysis 2011.

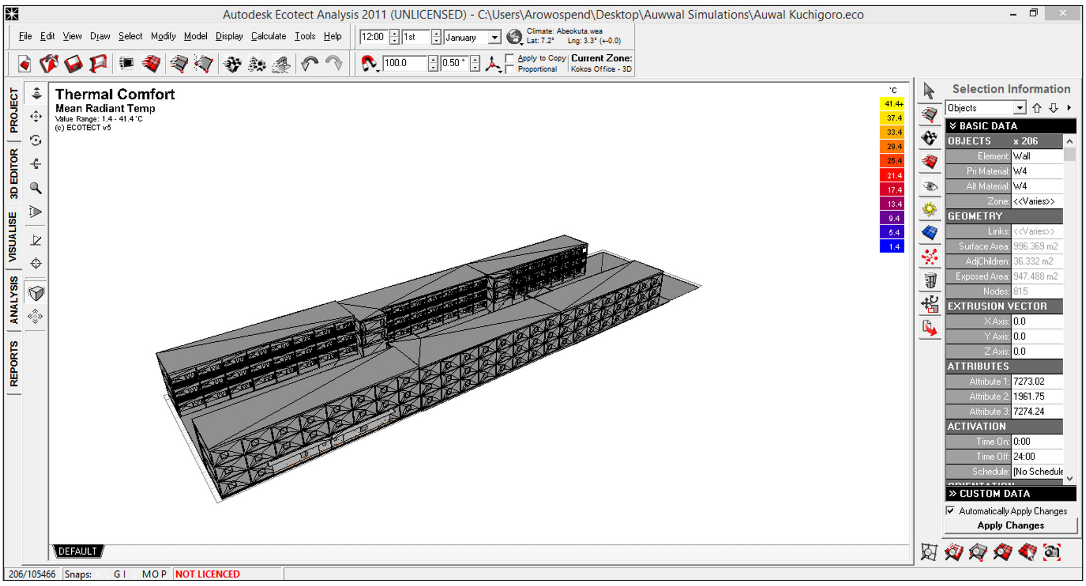


Figure 8 Exported building in Ecotect analysis 2011.

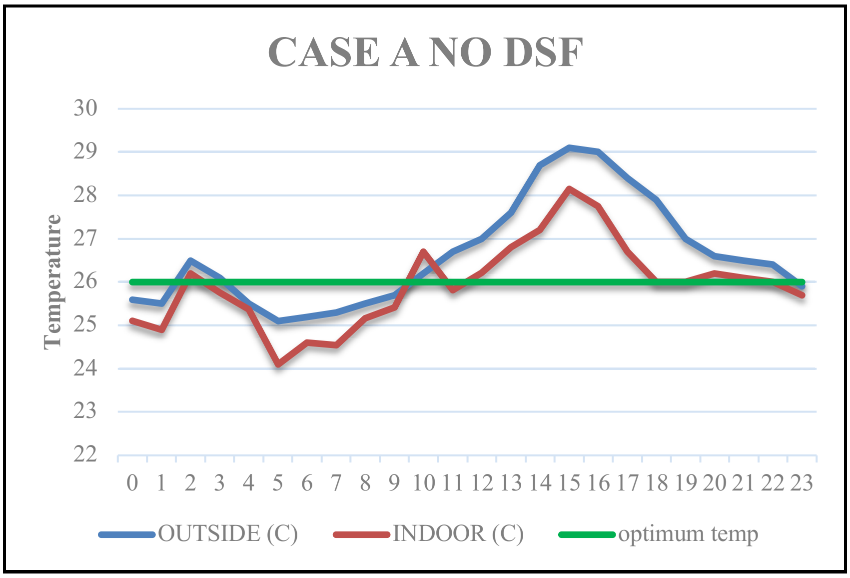


Figure 9 Hourly temp conditions without DSF.

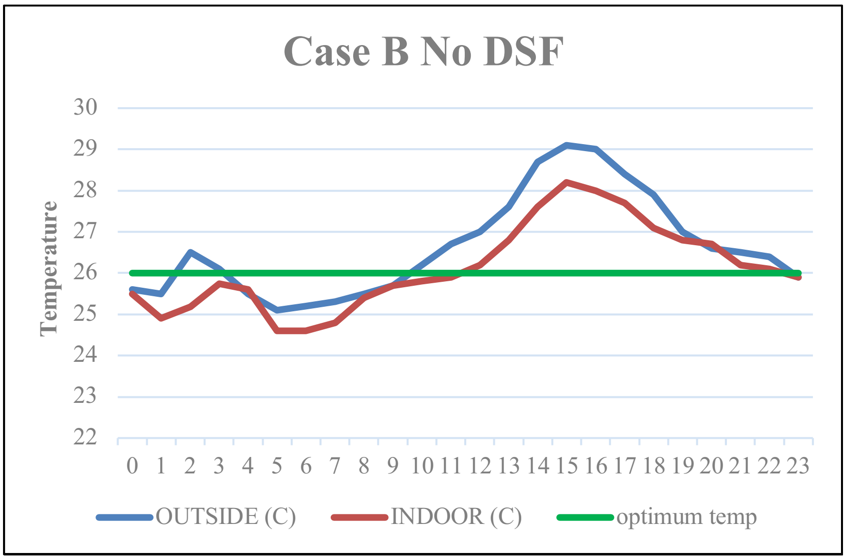


Figure 10 Hourly temp conditions without DSF.

3.2.1 Multi story DSF installed in Case A (Office Complex, Kuchigoro Abuja) and Case B (Office Complex, Garki, Area 11, Abuja)

In the second simulation multi-storey DSF was installed with 600mm distance from the wall of the building as in ***Figure 11***.

At first single glazed multi-story DSF was used and the temperature was below 26°C from (8:00–12:00) in both case A and case B and increased above 26 degrees from (13:00–17:00) in both cases. The temperature performance further slightly improved when double glazing was used as the temperature was below 26°C from (8:00–12:00) and slightly above 26°C from (13:00–16:00) in case A while from (13:00–17:00) in case B and started to fall below 26°C from (17:00). ***Figure 12*** and ***Figure 13*** shows the performance of both single and double glazed multi story DSF as compared with the base case and outdoor temperature. It can be observed that the graph of the outside temperature appears on top, then the graph of the performance of the building as it is (base case) under that then followed by the single glazed multi story DSF and the double glazing appeared at the bottom of all indicating that double glazed performed better than the single glazing.

3.2.2 Shaft box DSF installed in Case A (Office Complex, Kuchigoro Abuja) and Case B (Office Complex, Garki, Area 11, Abuja)

In the third simulation shaft DSF was installed at 600mm distance in the building as in ***Figure 14***.

Just like the second simulation single glazed shaft box DSF was used first, the temperature was below 26°C from (8:00–12:00) in both cases and increased above 26°C from (13:00–16:00) in case A and (13:00–15:00) in case B and a slight fall from (17:00). The temperature performance further improved when double glazing was used as the

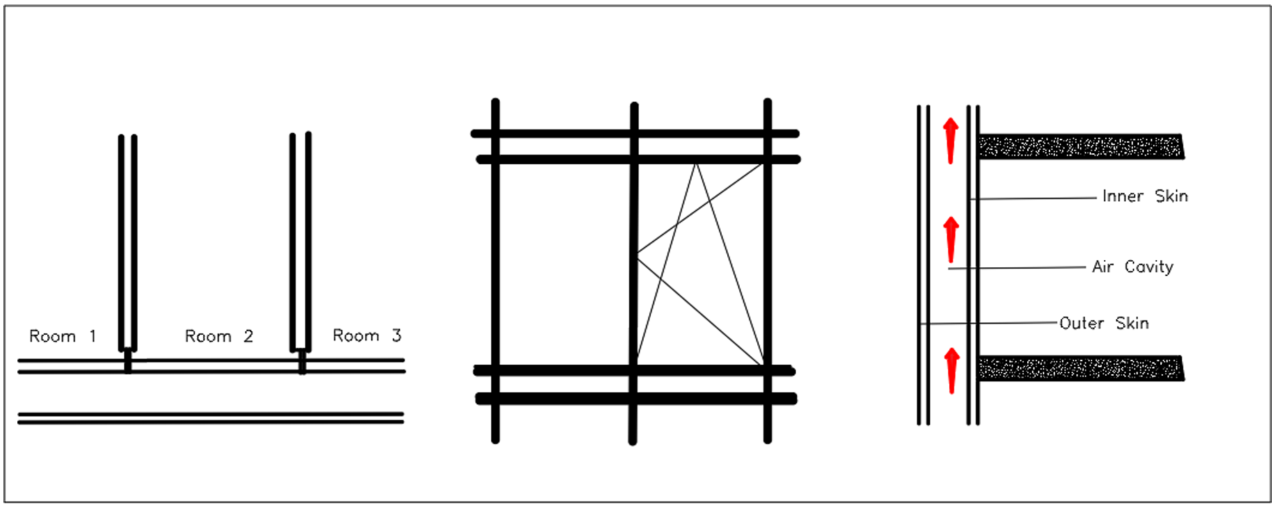


Figure 11 Floor, elevation and section of Multi story (drawn by author).

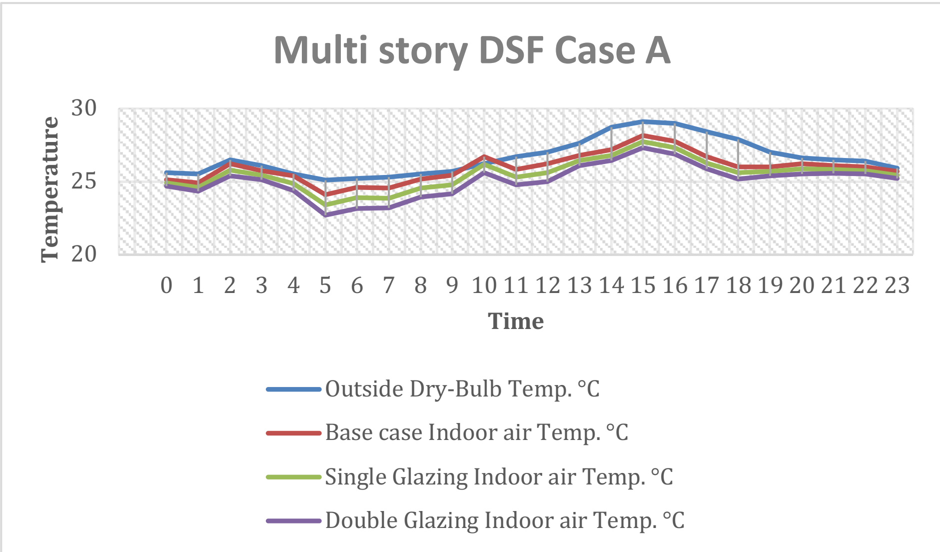


Figure 12 Hourly temp conditions with multi-story DSF.

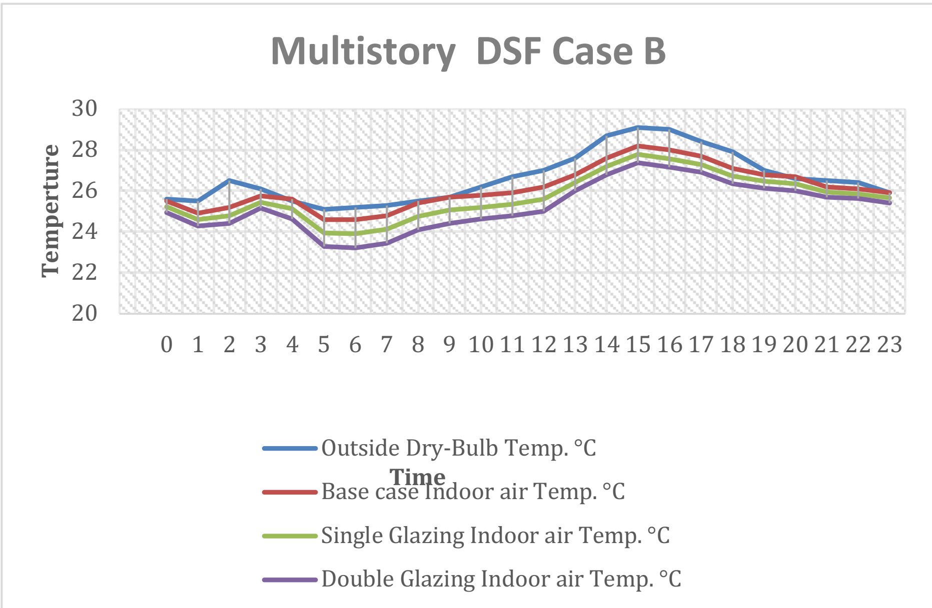


Figure 13 Hourly temp conditions with multi-story DSF.

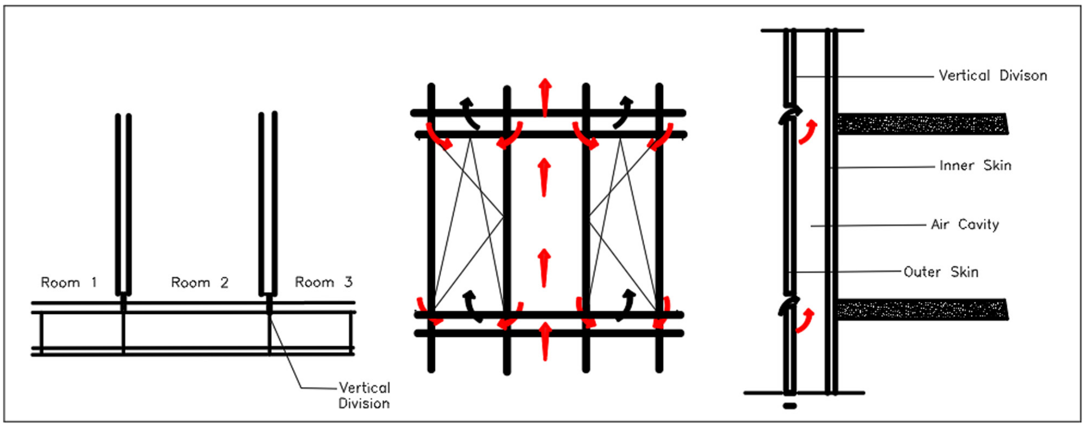


Figure 14 Floor, elevation and section of Shaft box (drawn by author).

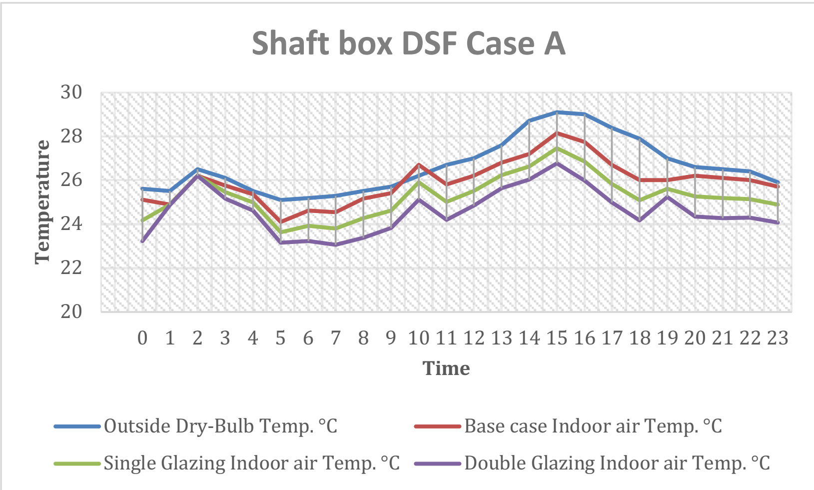


Figure 15 Hourly temperature conditions with Shaft box DSF.

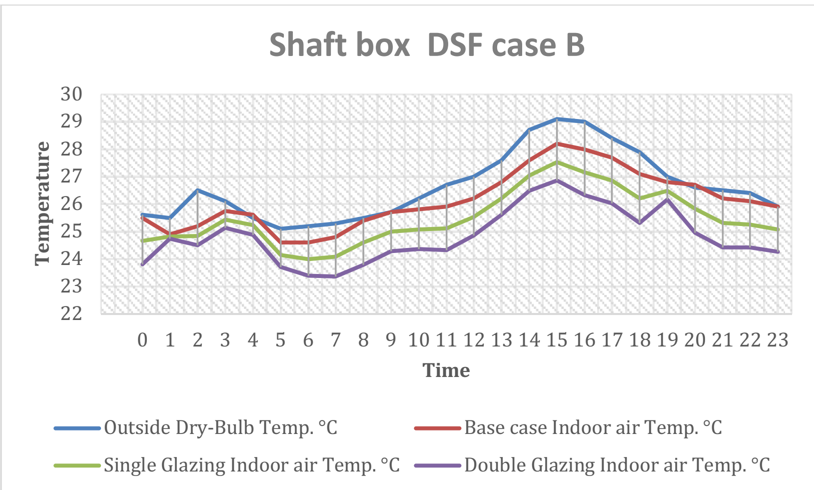


Figure 16 Hourly temperature conditions after integrating with Shaft box DSF.

temperature was below 26°C from (8:00–13:00) in both cases and slightly above 26°C from (14:00–15:00) in case A and (14:00–17:00) in case B. the temperature fall back from (16:00–17:00)in case A. ***Figure 15*** and ***Figure 16*** shows the performance of both single and double glazed shaft box DSF as compared with the base case and outdoor temperature, and it can be observed that the graph of the outside temperature appears on top, then the graph of the performance of the building as it is (base case) under that then followed by the single glazed multi story DSF and the double glazing appeared at the bottom of all indicating that double glazed performed better.

3.2.3 Box window DSF installed in Case A (Office Complex, Kuchigoro Abuja) and Case B (Office Complex, Garki, Area 11, Abuja)

In the fourth simulation a box window DSF was installed in the building as in ***Figure 17***.

All building materials, orientation and construction method were kept constant during the different simulations also mixed mode ventilation was considered in both simulations. Also as in the previous simulations single glazed box window DSF was used first, the highest temperature recorded during working hours was 26.05°C in case A and 26.12°C in case B, at (15:00). And when double glazing was the highest temperature was 25.33°C in case A and 25.38°C in case B, at (15:00). ***Figure 18*** and ***Figure 19*** shows the performance of both single and double glazed Box window DSF as compared with the base case and outdoor temperature, and it can be observed that the graph of the outside temperature appears on top, then the graph of the performance of the building as it is (base case) under that then followed by the single glazed Box window DSF and the double glazing appeared at the bottom of all indicating that double glazed performed better than the single glazing.

4. DISCUSSION

Two different Buildings located in Abuja were simulated to compare the results of the indoor thermal comfort conditions of buildings in the region. The buildings are all existing and were modelled with some level of accuracy. The buildings were then simulated using Ecotect analysis on 15th January, 2020 to check temperature readings using different forms of Double skin façade (DSF) to know the effect of DSF on the buildings.

The results showed a similarity in performance of the three types of double skin façade across the two buildings as follows:

- When multi-story DSF was applied to the buildings the percentage improvement of temperature in case B (1.95%) is higher than the percentage improvement in case A (1.7%) using single glazing. So also using double glazing the percentage improvement in case B (3.85%) is higher than the percentage improvement in case A (3.24%).

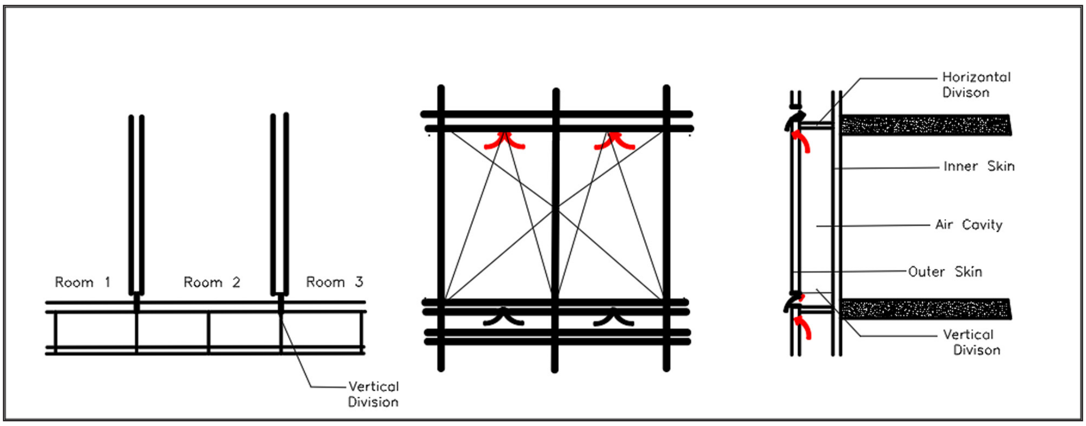


Figure 17 Floor, elevation and section of Box window (drawn by author).

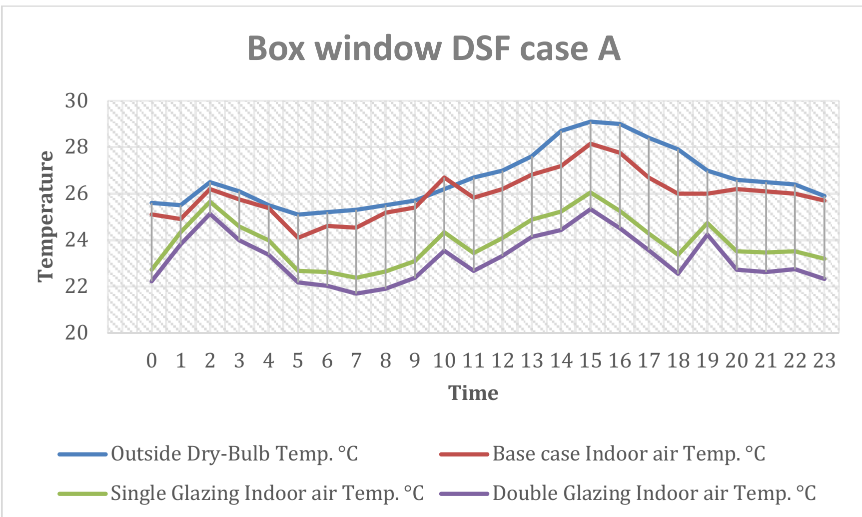


Figure 18 Hourly temp conditions with Box window DSF.

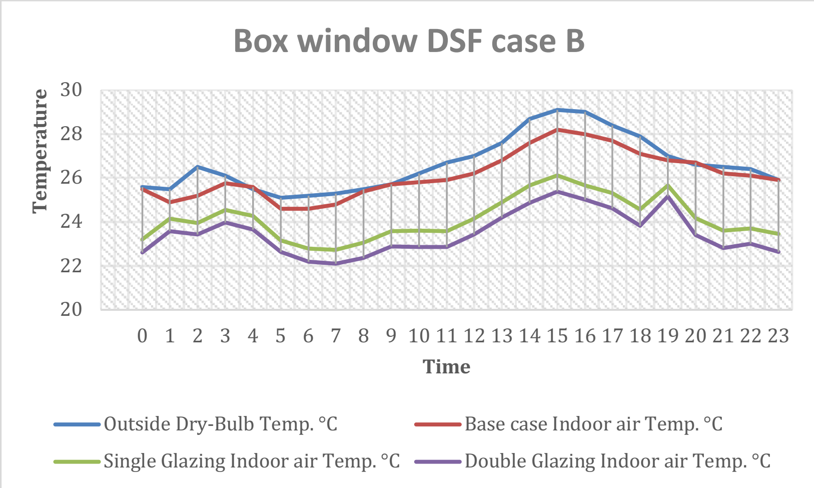


Figure 19 Hourly temp conditions with Box window DSF.

	MULTI STORY DSF	SHAFT BOX DSF	BOX WINDOW DSF
Case A	1.7	2.82	7.79
Single glazing % improvement			
Case B	1.95	2.47	7.86
Single glazing % improvement			

Table 5 Percentage improvement of the DSF using single glazing.

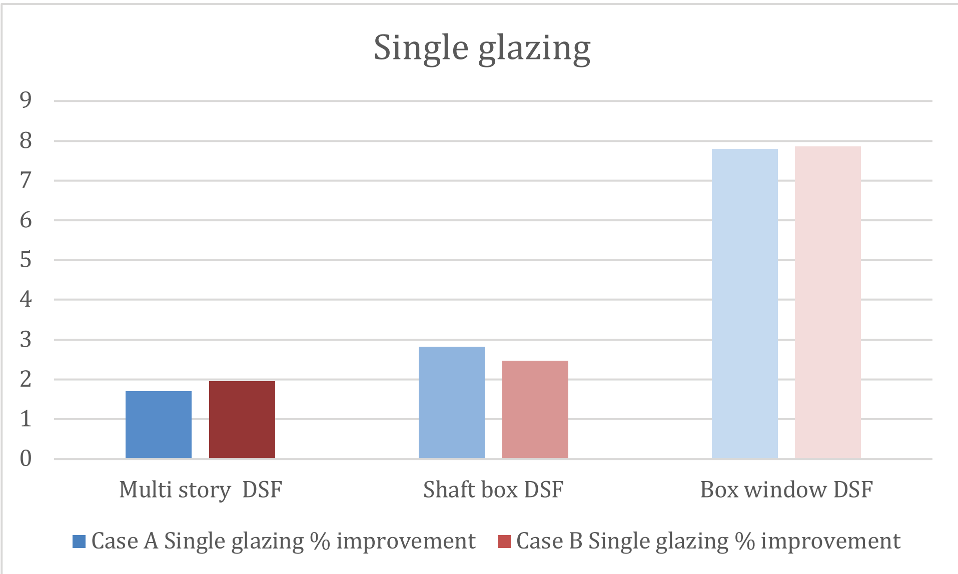


Figure 20 DSF performance in case A and B using single glazing.

- With the application of Shaft box DSF, the percentage improvement of temperature in case B (2.82%) is higher than the percentage improvement in case A (2.47%) using single glazing. So also the percentage improvement in case B (5.38%) is higher than the percentage improvement in case A (4.78%) using double glazing of the DSF.
- Box window DSF was applied also and the percentage improvement in case A using single glazing (7.79%) is lower than the percentage improvement in case B (7.86%) using single glazing while the percentage improvement in case B (10.42%) is lower than the percentage improvement in case A (10.45%) using double glazing of the DSF. But the performance can be said to be similar because in both cases the temperature of the indoor air dropped when the double-skin façade was used.
- ***Table 5*** and ***Figure 20*** Shows comparison of the performance of the 3 DSF typology using single glazing in Office Complex, Kuchigoro (Case A) and

Office Complex, Garki (Case B). The result showed similar performance as there was reduction in indoor temperature across all DSF types.

Likewise, ***Table 6*** and ***Figure 21*** Shows comparison of the performance of the 3 DSF typology using double glazing in Office Complex, Kuchigoro (Case A) and Office complex, Garki (Case B). The result showed similar performance as there was reduction in indoor temperature across all DSF types.

The Box window DSF has shown the most comfortable results of an increase in indoor conditions by about 8% using single glazing and 10% using double glazing as seen in (***Table 7***).

Focus was given to temperature because according to literature the adaptive comfort of occupants is mostly reliant on different factors like the background of occupant, the level of light satisfaction in certain climates and a certain comfort level cannot be generalised for every other climate, the study therefore focused on improving the indoor temperature, since it is the most dominant of all the factors of thermal comfort and an acceptable temperature can make other factors negligible.

5. CONCLUSION

The following conclusion were derived from the study

According to the result of the simulation, natural ventilation offered by double-skin facades is successful in developing conditions that are compliant with comfort requirements and can be used in reducing the solar heat gain to promote natural ventilation and reduce the disadvantages of mechanical ventilation in office buildings in Abuja, Nigeria.

DSF has potentials of improving thermal comfort conditions of office buildings in Abuja and Box window

	MULTI STORY DSF	SHAFT BOX DSF	BOX WINDOW DSF
Case A	3.24	5.38	10.48
Double glazing % improvement			
Case B	3.85	4.78	10.42
Double glazing % improvement			

Table 6 Percentage improvement of the DSF using double glazing.

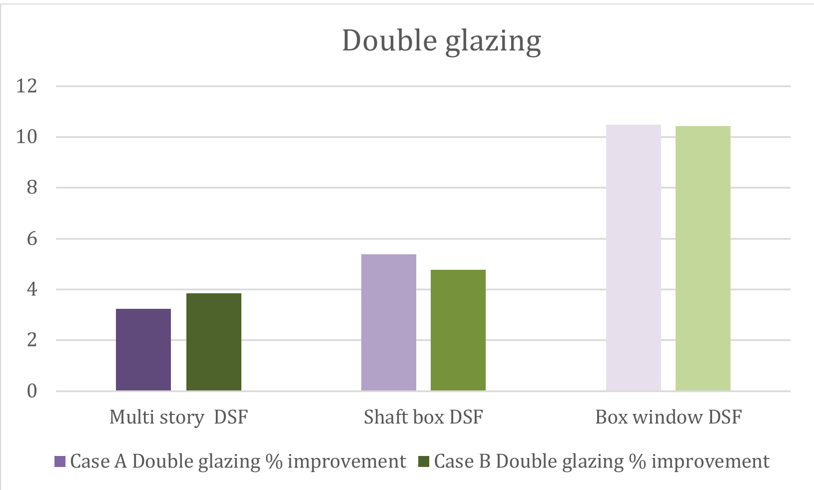


Figure 21 DSF performance in case A and B using double glazing.

DSF TYPE	SINGLE GLAZING % IMPROVEMENT		DOUBLE GLAZING % IMPROVEMENT	
	CASE A	CASE B	CASE A	CASE B
Multi story	1.7	1.95	3.24	3.85
Shaft Box	2.82	2.47	5.38	4.78
Box Window	7.79	7.86	10.48	10.42

Table 7 Percentage improvement of all DSF types using both single and double glazing.

DSF having shown an improvement of about 10% has shown the best performance as compared to shaft box and multi-story DSF.

Use of prefabricated construction can make the rehabilitation of buildings fast, energy efficient and qualitative. The DSF can be applied to existing buildings during rehabilitation in order to improve their thermal comfort conditions and energy efficiency.

Sustainability of the building has been improved through increased Energy efficiency by reducing the use of mechanical ventilation and this will reduce the need for electricity which is scarce in Nigeria.

COMPETING INTERESTS

The authors have no competing interests to declare.

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