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Impact of Building Orientation on Building Performance
(A Case Study of Selected Buildings in Ikotun Area of Lagos)

[1.] Ajoku Judith Ifeoma
Architecture Department
Bells University of Technology
Ota, Ogun state, Nigeria

[2.] Ifeoluwa Akande
Architecture Department
Bells University of Technology
Ota, Ogun state, Nigeria

Abstract:- Building orientation is the positioning of a building in relation to seasonal variation in the sun path as well as prevailing wind pattern. It is no doubt a significant design consideration. Building orientation is also the practice of tilting a building towards maximizing certain aspects of its surroundings, such as a street appeal, scenic view and drainage advantage among others. The impact of orientation on a building ranges from thermal comfort to lighting, ventilation, energy consumption and economy of building. Sustainable building design can be used to save building operating energy and to correctly predict the amount of energy to be consumed. The research aims at assessing the effect of building orientation on thermal comfort, daylighting, ventilation and economy of building on buildings in Ikotun area of Lagos Nigeria. The research sourced for data via the use of literature reviews, case studies of various buildings in Ikotun and the use of questionnaires for Ikotun residents to assess their level of comfort which in turn is used to evaluate the effect of building orientation. Questionnaire was also sent to the built environment professionals to get their professional input on the topic. The research findings show that longitudinally true south orientations, longitudinally north-east and latitudinal north-east maximize building performance to occupants.

Keywords:- *Building; Orientation; Thermal Comfort; Daylighting; Economy; Ventilation; Air Quality.*

I. INTRODUCTION

In Lagos state, Nigeria, it has been observed that, there have been an increase rate of discomfort over the years due to exponential growth in population and development. The by-product of the uprising of buildings and infrastructure on the environment. There are many factors responsible for this. This research would focus on one of the factors which is often neglected and overlooked because of its triviality and time consumption - Building orientation.

Building orientation according to (Habibi S, 2017) is the positioning of a building in relation to seasonal variation in the sun path as well as prevailing wind pattern. Building orientation was also defined by (Olanrewaju, A. L., & Abdul-Aziz, A. R., 2011) as a significant design consideration, to sun path directions and prevailing cool and hot winds. Building orientation according to (Kellert, S. R., Heerwagen, J., & Mador, M., 2011) is the practice of facing a building so as to maximize certain aspects of its surroundings, such as a street appeal, to capture scenic view, for drainage consideration, etc.

The impact of orientation on a building ranges from thermal comfort to lighting, ventilation, energy consumption and economy of building. Sustainable building design can be used to save building operating energy and to correctly predict the amount of energy to be consumed.

Energy consumption is partly dependent on weather for example, during the dry season more energy is consumed to maintain thermal comfort than in the rainy season (Adekunle, T. O., 2015).

Accurate orientation, correct location on a site, and landscaping changes may decrease the energy consumption of a typical building by 20% (Albatayneh, A., Mohaidat, S., Alkhazali, A., Dalalah, Z., & Bdour, M. ., 2018) and provide the building designers with the economical tools to reduce energy consumptions. Most of the times, owning to the ignorance of consumers, people ignore one of the most important questions in the planning and preliminary stages of building design and construction. Questions regarding the orientation of the building are not asked. In the traditional era before the invention of cooling systems such air conditioners and fans, it was one of the most important aspects as natural light and air was of prime importance. However, with the advent of modernization, we have mechanical and electrical support such as LED lights and air conditioners, thereby, we don't feel their need anymore. Nevertheless, if you want the building to function optimally in terms of building performance, building orientation is one thing you must keep in mind.

The purpose of this study is to evaluate the impact of building orientation on building performance.

The following questions drive the aim of the research:

i. What are the various building orientations options, approaches and processes?
ii. Is there a relationship between building orientation options and building comfortability?
iii. What are the benefits of building orientation on building envelope performance?
iv. What is the impact of building orientation on the occupants and their environment?

A. Justifications

This study is important to take into context the adverse effect of building orientation when neglected and present alternative methods, options and processes to help avoid them. It will also help identify the principles and practices that will help future designs to enhance maximum comfort via most effective building orientation, harnessing natural energy and ensuring an optimally functioning design.

B. Study Area

The study focuses on the following five (5) building types in Ikotun area of Lagos state:

i. Institutional Building
ii. Commercial Building
iii. Hospitality Building
iv. Residential Building
v. Religious Building

Their current building orientation and the effects so far on, design, building performance, environment and occupants are to be looked into.

Figure 1: Map of the Ikotun area.
Source: Google map 2021

C. Building Orientation

The word "orientation of the building" is used to describe the setting or fixing of the position of the layout plan of a building in relation to the direction of north (Attia, S., Eleftheriou, P., Xeni, F., Morlot, R., Ménézo, C., Kostopoulos, V., ... & Hidalgo-Betanzos, J. M., 2016). The direction of normal to the long axis is referred to as building orientation. (Pooja Patel, 2017) In her work "Importance of Building Orientation in Architecture" explains that the building orientation is usually used to refer solar orientation while planning of building with respect to sun path. The orientation may apply to a specific space or, more importantly, a specific location. The expression "building orientation" refers to the alignment of a structure in relation to the sun, which is normally achieved to maximize solar gain at the right time of year in cold climates and to minimize solar gain in hot climates. The best house orientation will boost the structure's energy efficiency by making it more convenient to live in and less costly to operate in terms of energy usage. This ultimately highlights the importance of building orientation when designing a construction that must optimize natural capital before incorporating artificial enhancements.

D. Thermal Comfort

Building orientation enhances thermal comfort when done properly, (Perini, K., & Magliocco, A., 2014) in "The Significance of the Orientation on the Overall buildings Thermal Performance-Case Study in Australia" explains that, Correct orientation is a low-cost option to improve occupant's thermal comfort and decrease cooling and heating energy. An appropriate building orientation will allow the desirable rainy season sun to enter the building and allow ventilation in the dry season by facing the warm wind stream. The image below (fig. 2) shows a comprehensive analysis of sun path in relation to building orientation.

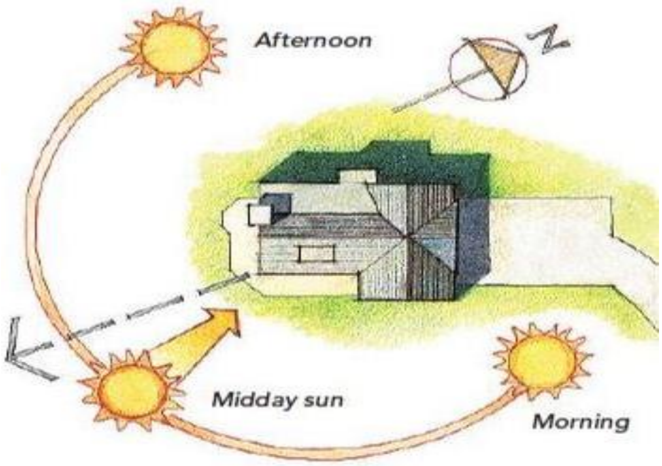

Figure 2: Sun path with respect to the positioning of the building.
Source: The Godfrey Hoffman Hodge Blog, 2016.

E. Shading Against Direct Heat Gain

As the sun moves from east to west, the heat of the day increases and with the building positioned with longer walls facing the north and south positions or placed diagonally, it causes shading on the south and west facing windows and doors.

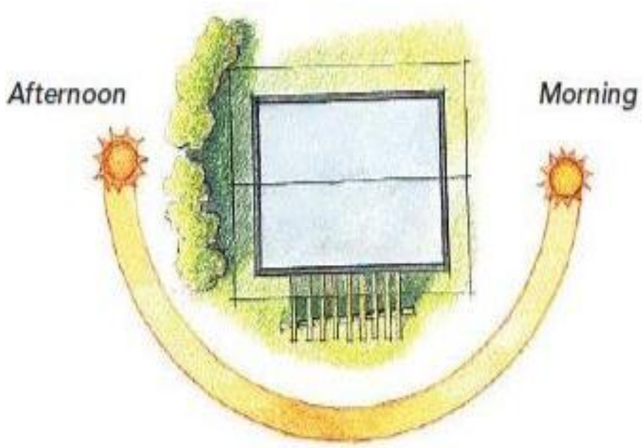

Figure 3: shading against excess heat gain.
Source: The Godfrey Hoffman Hodge Blog, 2016.

F. Thermal Flexibility

In the dry season, the sun is higher in the sky than in the rainy season. This fact allows windows to be protected to a considerable extent from the dry seasons heat gain while still allowing the low rainy seasons sun to enter into the building.

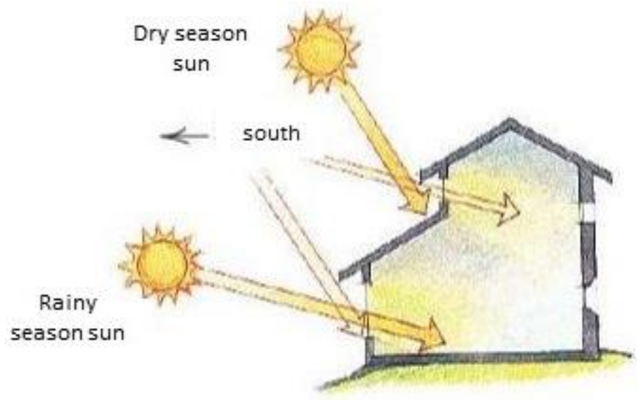

Figure 4: Sun entry during the two seasons of the year.
Source: The Godfrey Hoffman Hodge Blog, 2016.

G. Orientation

The amount of solar radiation received by the building envelope depends on its orientation. An important clue in developing energy efficient facades is knowledge about the distribution of solar radiation due to orientation.

Buildings should be planned in such a way that benefit is obtained from shaded indoor and outdoor living areas when the weather is hot. The high angle of the sun makes it easy to shade the house by a generous roof overhang. This is because the sun is much lower in the sky throughout the day, favoring the vertical surface diagram above shows ‘The incident radiation on the east face in the morning and the west face in the evening is still high, but not as high as that on the north face during the middle of the day. The south face receives no direct component because in hot-humid regions (like Nigeria) close to the equator the diffuse radiation has a predominant share of the overall radiation and the fact that the distribution of the diffuse radiation is almost identical at all orientations, the orientation of the buildings might be more influenced by other external aspects, like the prevailing wind direction.

H. Lighting

Building orientation is also considered as a key principle in achieving optimal lighting in a structure. Since the Earth is positioned on an axis, the direction of the Sun in the sky changes with the seasons. This is most noticeable in the dry season, when the Sun is higher in the sky to the north, than in the winter, when the Sun is lower in the sky to the south. This shift in the Sun's relative direction is a significant heating and cooling element to remember while maximizing or minimizing a building's passive solar benefits throughout various seasons. Houses that are geared toward the sun will save 10-40% on home heating. When planning and constructing a new home, it's critical to understand how your home's location and orientation influence its energy profile.

Houses that are oriented longitudinally use less electricity for heating and cooling, which means lower power costs and more warmth. For example, according to (Planlux lighting designs, 2019) in the planning for solar access and building orientation journal, master planning of a city or region is an excellent opportunity to have solar access. Solar access planning at the largest scale will greatly simplify natural light architecture at the building scale. This means that no matter how large a project is, building orientation that emphasizes preparing for the future is essential for natural lighting. Solar access planning entails more than just direct solar access and shading. Building orientation (typically elongated on the east-west axis) is important in urban planning because it allows for the use of direct sunshine, shading, and sunlight reflecting from surrounding land and buildings. The use of natural light in buildings is made easier by building orientation. The orientation of a building is essential for shading and redirecting Sunlight, but not so much for non-directional daylight.

I. Daylighting

This is where a building's use of daylight is used to monitor both visual convenience and energy consumption. Comfort in terms of temperature Proper daylighting techniques would allow you to make the most of the sun's light. Through using natural resources, you may reduce the usage of an electrical or mechanical device. Illuminating the daylighting massing methods are similar to the approaches used in daylighting. Heating that is provided without the use of electricity. The use of skylights in larger buildings will maximize natural light visibility. Several skylights Single-story buildings of any scale will benefit from skylights. Throughout the day, there is a lot of natural light. Buildings of more than one story can be demolished. Created with thinner profiles. Since the sun would be reflected from the walls of higher buildings, windows can be taller and wider to accommodate for natural lighting. Buildings come in a variety of shapes and sizes, as well as cutouts. Atriums and courtyards allow lighter to enter the building's interior spaces. Buildings with a longer East-West axis are also better for day lighting.

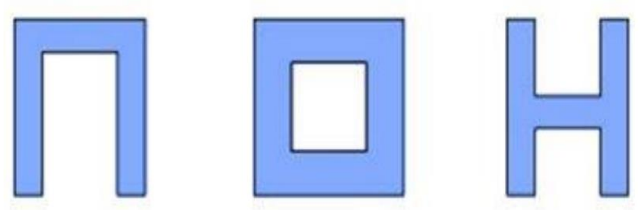

Figure 5: Examples of building layous that can maximize Daylighting.
Source: (Nathan-Mazzuca, 2017).

J. Location and Orientation

It is important that a building be planned in such a way that it blends in with the site's position and orientation. Based on a building's position and orientation in the northern hemisphere, the following properties may be correlated with light quality. For the detail below, replace north with south and vice versa for the northern and southern hemispheres.

Lighting quality: Light on the southern façade is most abundant and relatively uniform.

Design note: This is the most desirable façade for admitting light because excess solar gain in the summer can be controlled with overhangs. Fenestration dimensions on the southern façade should be maximized.

- **Using a North Orientation**

Lighting quality: The light is less abundant on the northern façade, but it is more uniform and diffuse.

Design note: It is the second most sought-after façade, after the southern façade. Adequate fenestration is recommended on the northern façade

- **Using an East Orientation**

Lighting quality: The eastern façade receives only half-day sunshine and has a varying amount of illumination during the day. As a result, designing the best fenestration for the east facade is more complex. Summer heat gain occurs at inconvenient periods on the façade, while passive solar effect is minimal during the cooler seasons of the year.

Design note: The dimensions of the eastern façade, as well as the number of fenestrations on the façade, should be kept to a minimum. Vertical displays can aid in light monitoring

- **Using a West Orientation**

Lighting quality: The lighting on the western façade varies during the day, allowing just half-day exposure to the sun. As a result, designing the best fenestration for the west facade is more complex.

Design note: The size of the western façade, as well as the number of fenestrations on the façade, should be kept to a minimum. Vertical displays can assist with light management.

K. Ventilation

A designer should consider not only orienting a building toward the sun, but also guiding the entire floor plan in alignment with the sunlight. Rooms that are used the most can be located on the southern side of the building. In the winter, inhabitants will benefit from the warmth of the sun's rays due to the position of the sun. As a result, they will be relieved from the heat during the warmer months. Rooms that aren't used too much can be placed at the north end of the building. During the harsh cool dry winds, these rooms can serve as a buffer. Mountainous, scenic, or hilly elevations exaggerate the north-south sun. Major temperature variations can be found in small regions in these areas. If a building is being constructed on a hill, it should be on the south facing slope to prevent the heavy shade caused by the mountain's edge. Building a structure halfway up a hill is suitable because it is protected from high winds, receives enough sunshine, and avoids drainage problems.

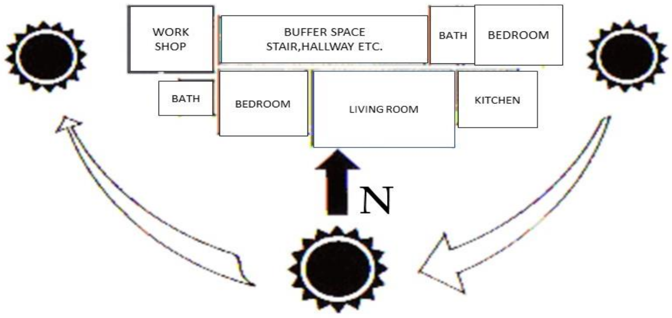

Figure 6: floor plan oriented to south to maximize ventilation around building.
Source: (Nathan-Mazzuca, 2017).

It is critical to plan the building's orientation so that the shorter axis of the structure aligns with the prevailing winds. It will make the most wind ventilation if it is aligned this way. The picture below illustrates this. See how the building receives more wind ventilation as it is angled so that the greater surface faces the wind. The amount of wind ventilation is limited by orienting the building so that the narrowest wall surface faces the wind. Another type of passive architecture that uses natural wind current for building cooling is Cross ventilation.

Wind Ventilation: This is a form of passive ventilation that makes use of the wind's natural force or movement. Push or pull air into a structure. It is also known for being the simplest, most basic, and most widely used. Passive cooling and ventilation are a low-cost option. To get the best out of wind ventilation, the pressure differential between the inside and outside air must be as large as possible. The amount of air going in and out should be maximized. On the other hand, higher pressure is considered to exist on the on the outward side of a building, there is lower pressure than on the windward side.

Cross Ventilation: This is a form of passive ventilation that aids in the flow of air. Multiple windows on a building double as inlets and exits, allowing wind to be drawn in and then sucked out. These windows double as fans, allowing natural breezes to circulate in the building. The diagram below depicts the various window placement options for cross ventilation. When windows are placed opposite each other, the room air mixes, allowing cooling and warming air to enter the building.

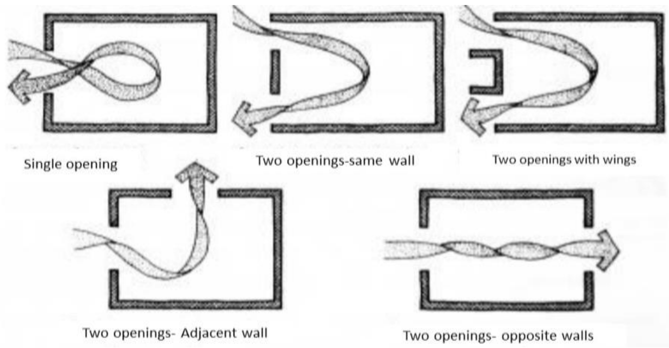

Figure 7: Types of opening to enhance ventilation.
Source: (Nathan-Mazzuca, 2017).

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Passive Ventilation: This is a crucial step in the passive design phase that determines a structure's form and overall orientation. By minimizing energy loads and maximizing free energy from the sun and wind, a building that is effectively positioned would increase the free energy from the sun and wind. Passive heating, ventilation, and daylighting are also critical considerations to remember during the construction process when massing a structure.

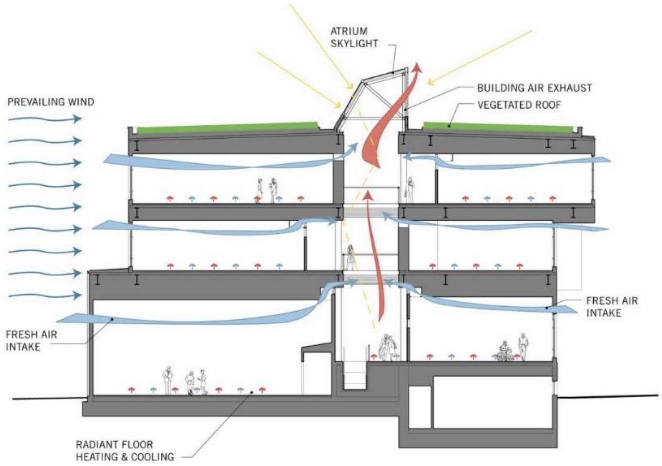

Figure 8: Passive cooling illustration.
Source: (NBI new building institute, 2010).

L. Building Orientation VS. Energy Use

Building orientation is critical in passive solar architecture, according to Morrissey, Moore, and Horne (2011). According to Morrissey et al. (2011), building orientation is a low-cost choice for maximizing passive solar benefits and lowering energy consumption. Building orientation can alter building energy activity in the southern hemisphere, such as:

- Optimizing daylight availability.
- Improve the heating advantages of solar gain during the cold seasons, and
- Decrease summer cooling loads due to solar gain in colder climates (Morrissey et al , 2011). Overheating is the biggest issue in hot humid climates ((Ling, Ahmad, & Ossen, 2007).

Appropriate building orientation allows solar radiation to be minimized. As a consequence, the buildings require less energy to provide active cooling. Building orientation and openings are critical for achieving thermal comfort and lowering energy consumption for ventilation, heating, lighting, and other uses. Many experiments have discovered that the building longitudinal orientation axis can be aligned East-West, so that the southern facade absorbs the most heat in the cool season and the north façade absorbs the least in the very hot season, based on the azimuth and elevation angles of the sun in hot and cold seasons. As a result, this research examines various orientations and their effects on energy consumption in order to best determine the optimal orientation for achieving greater thermal comfort when maximizing illumination and natural ventilation. This is expressed in a decrease in building energy demand. Building orientation is inferred to be a key parameter that affects not only energy consumption but also the value of other parameters including clarity ratio and form factor.

II. RESEARCH METHOD

A qualitative research method was adopted for this study. The research framework employed the use of case studies and two different questionnaires for data collection and analysis. One questionnaire was sent to the built environment professionals in Lagos state and the other was sent to the Ikotun residents exclusively. The research method is appropriate because the impact is directed towards the comfort of the end users which in turn determines the building performance.

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar.

- **Population of the Study**

The population of study focuses on the number of inhabitants of the Ikotun area in Alimosho. Alimosho is a Local Government Area in the Ikeja Division, Lagos State, Nigeria. It is the largest local government in Lagos, with 11,456,783 inhabitants, according to the official 2006 Census. The building population according to the National Population commission data, 2020 is 72,320

- **Sample Size and Sampling Method**

The stratified sampling method was used in dividing the population into subpopulation that may differ in important ways, it allows you draw more precise conclusions by ensuring that every subgroup is properly represented in the sample. The sampling according to CIA world fact book 2020 is as follows:

TABLE1: Population Sample

AGE	MALE	FEMALE	TOTAL	PERCENTAGE
0-14	274608	262786	537394	41.7%
15-24	132701	128521	261222	20.27%
25-54	197567	196779	394346	30.6%
55-64	26026	27197	53223	4.13%
65 and above	20030	22497	42527	3.3%

TABLE 2: Building Sample

BUILDING TYPE	PERCENTAGE	NUMBER OF BUILDINGS
Residential building	60%	43392
Educational building	2%	1446.4
Institutional building	3.5%	2531.2
Commercial building	15%	10848
Industrial building	0.5%	361.6
Storage buildings	1%	723.2

Religious buildings	7.5%	5424
Mixed used buildings	3%	2169.6
Hospitality building	5%	3616
Health care buildings	2.5%	1808

A. Case Studies

a) **Mukandasi Olayemi Aguru Memorial mosque, Ikotun Lagos**

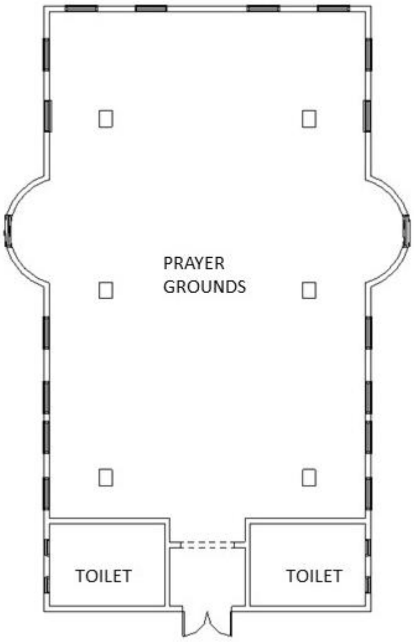

Figure 9: floor plan Mukandasi Olayemi Aguru Memorial Mosque.
Source: Researcher's sketch, 2021.

Plate 1: side view of mosque.
Source: field survey, 2021.

Observation

North direction: In the case study above the north direction is faced upward collected with the use of a digital compass.

The shape of building: The building layout is a rectangle with curves at both sides.

Fenestration: There is a total of eighteen windows on the west elevation, eighteen windows on the east elevation, eight windows on the north elevation and two screen walls and a balcony on the south elevation, double swinging casement window used.

Landscape features: There are no land scape features the site is completely screed.

Shading devices: An extension below and around the roof is the only shading device.

b) **Zenith Bank Ikotun, Lagos**

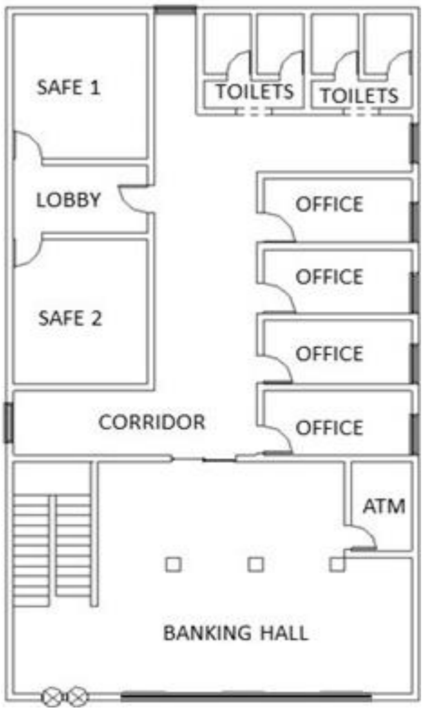

Figure 10: floor plan of zenith.
Source: researchers sketch, 2021.

Plate 2: approach view of zenith bank.
Sourc: field survey, 2021.

Observation

North direction: In the case study above the north direction is faced towards the left collected with the use of a digital compass.

The shape of building: The building layout is a rectangle.

Fenestration: there are fifty curtain panels on the west elevation (approach view), eighteen sliding windows on the south, three at the north elevation and three at the east elevation.

Landscape features: there are no landscape features the site is interlocked with interlocking blocks.

Shading devices: there are no shading devices in this building.

c) **Marble Hill Hotel Ikotun, Lagos**

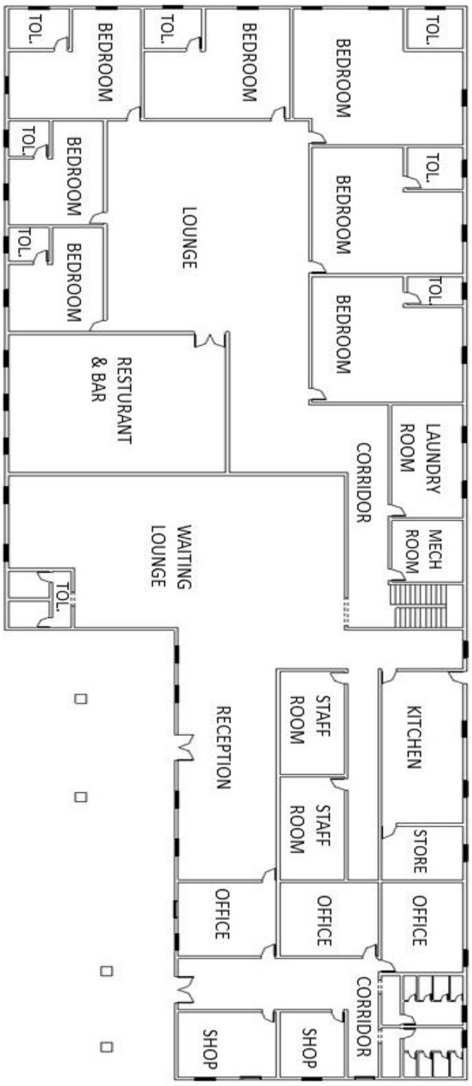

Figure 11: Marble Hill hotel floor plan.
Source: researchers sketch, 2021

Plate 3: Approach view of Marble Hill Hotel.
Source: field survey, 2021.

Observation

North direction: In the case study above the north direction is faced diagonally right by 35 degrees, collected with the use of a digital compass.

The shape of building: The building layout is L shaped.

Fenestration: There are twenty-eight double swinging windows in the north-west elevation, eight in the north-east, thirty-two in the south east elevation and fourteen at the south west elevation.

Landscape features: there are little gardens around and the site is mostly covered by interlocking blocks.

Shading devices: the windows are carved round with window hoods extrusions.

d) **Lagos Land Mark Montessori School Ikotun, Lagos**

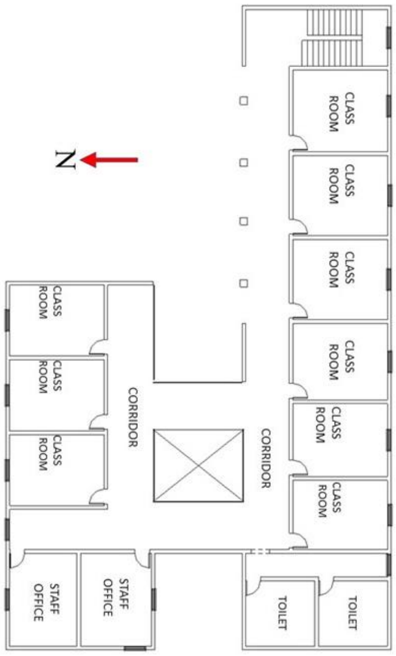

Figure 12: floor plan of land mark montessori school.
Source: researchers sketch, 2021.

Plate 4: rear view of school.
Source: field survey, 2021.

Observation

North direction: In the case study above the north direction is faced downward, collected using a digital compass.

The shape of building: The building layout is regular and takes some sort of H inverted shape.

Fenestration: There are fifteen sliding windows on the north elevation, three on the west elevation, twenty-four at the south elevation and none at the east elevation.
Landscape features: there are little gardens around and the site is mostly covered by interlocking blocks.
Shading devices: the windows are carved half way with window hoods extrusions.

*e) **Omo Salami Apartments, Ikotun***

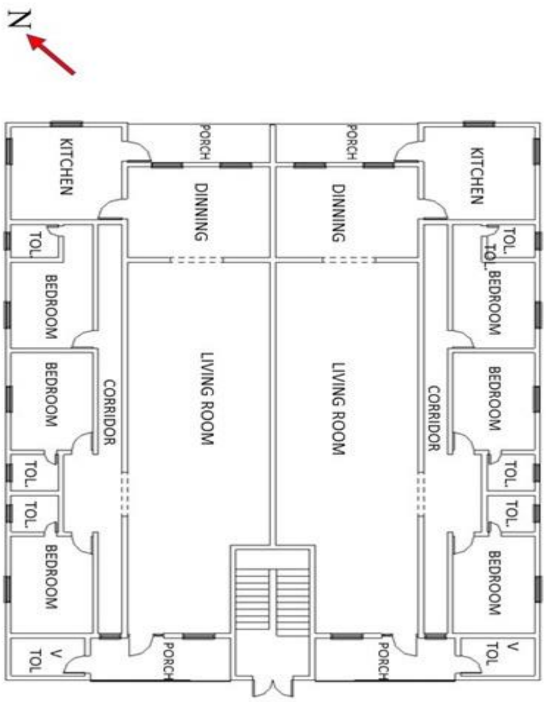

Figure 13: floor plan of omosalami apartment.
Source: researches sketch, 2021.

Plate 5: approach view to the apartment.
Source: field survey, 2021.

Observations
North direction: In the case study above the north direction is faced 215 degrees clockwise, collected using a digital compass.
The shape of building: The building layout is a rectangle.
Fenestration: There are fourteen sliding windows on both the south-east and north-west elevations, twelve at the north-east and eight at the south-west.
Landscape features: the site is completely interlocked with interlocking tiles.
Shading devices: there are no shading deceives.

III. DATA ANALYSIS AND PRESENTATION

a. Response Rate of the Questionnaire

A response rate is the percentage of individuals who respond to a given questionnaire and is used as a tool to understand the degree of success in obtaining completed questionnaire from a sample (Adetola, Aborisade and fasanmi, 2017). Out of the 350 questionnaires sent out at random around Ikotun and various building types both physically and online, 307 fully answered. The response rate is 87.7% (307/350*100 = 87.7%). And for the questionnaires sent at random to the built environment professionals in Lagos, 300 were administered online and 240 returned fully answered. The response rate is 80% (240/300*100 = 80%). Thereby, the analysis will be based on answered and retrieved questionnaire.

b. Personal Data

Based on the survey questionnaires, this section presents the respondents personal data. The classifications are: respondents' gender, age, educational background, and occupation.

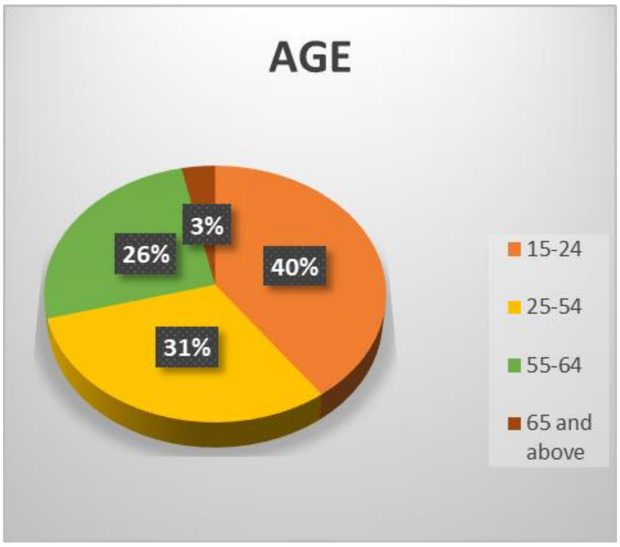

Figure 14: Distribution age of built environment professional respondent
Source: field survey, 2021

Figure 14 shows the distribution by age of the built environment professionals' respondents by age where 40% of the respondents ages range from 15-24, 31% range between 25-54, 26% range between 55-64 and 3% range from 65 and above. By implications, the majority of respondents are in the age range 15-24 not far behind ages 25-54 followed by 55-64 and lastly 65 and above.

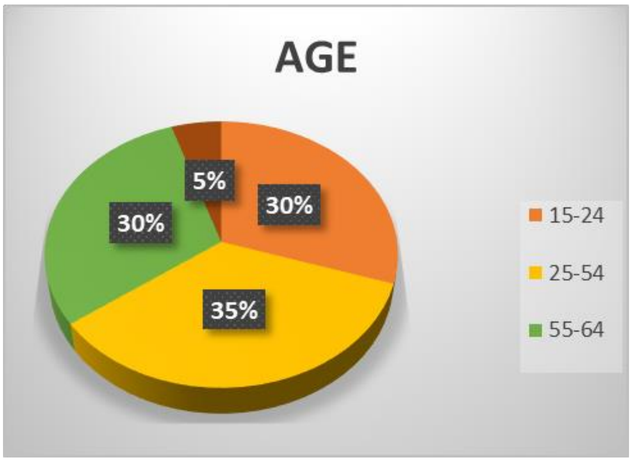

Figure 15: Distribution age of Ikotun residents' respondent
Source: field survey, 2021

Figure 15 shows the distribution by age of the built environment respondents by age where 30% of the respondents ages range from 15-24, 35% range between 25-54, 35% range between 55-64 and 5% range from 65 and above. By implications, the majority of respondents are in the age range 25-54 not far behind ages 15-24 and 55-64 and lastly 65 and above.

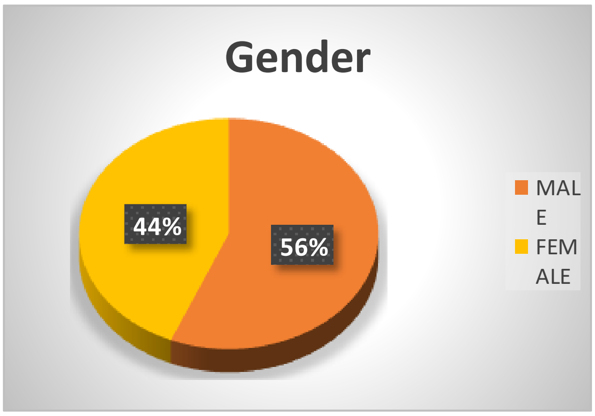

Figure 16: Distribution gender of built environment respondent.
Source: field survey, 2021.

Figure 16, shows the distribution by gender of the built environment professional respondent, by gender 56% of respondents are male and 44% are women. By implication, the male respondents are more than the women by 12%.

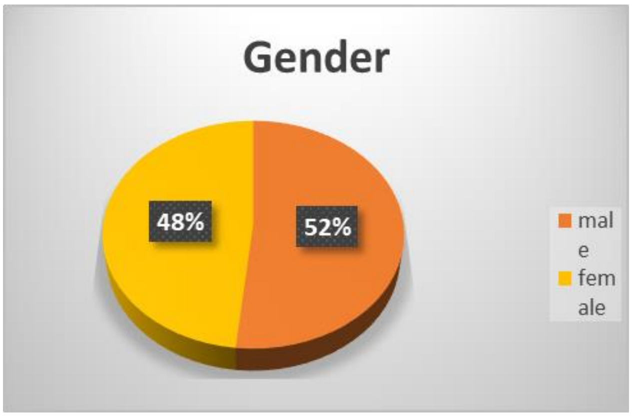

Figure 17: Distribution gender of Ikotun resident respondents
Source: field survey, 2021.

Figure 17, shows the distribution by gender of the built environment professional respondent, by gender 52% of respondents are male and 48% are women. By implication, the male respondents are more than the women by 4%.

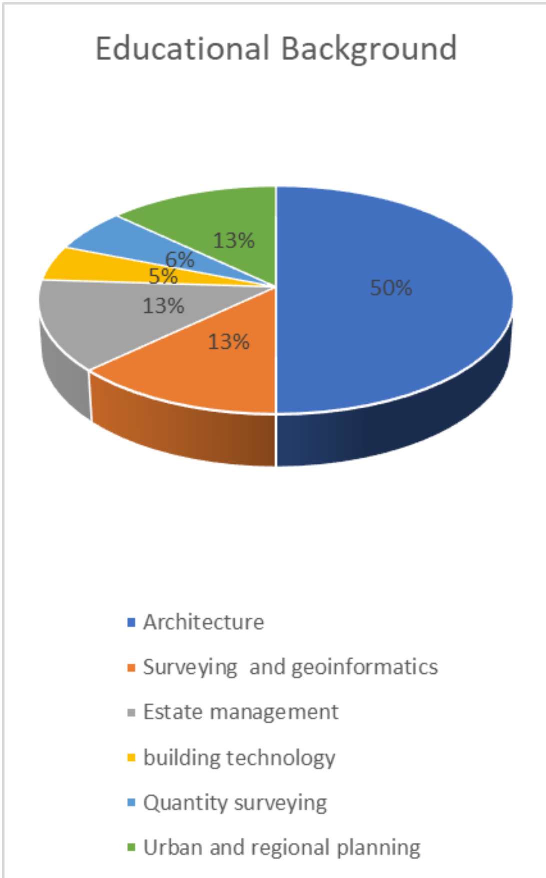

Figure 18: Distribution educational background of built environment professional respondent.
Source: field survey, 2021.

Figure 18, shows the distribution of professionals in the built environment and their contribution to the research questionnaire. Architects hold 50%, land surveyors hold 13%, estate managers hold 13%, building technologist hold 5%, quantity surveyors hold 6%. And finally urban and regional planners hold 13%.

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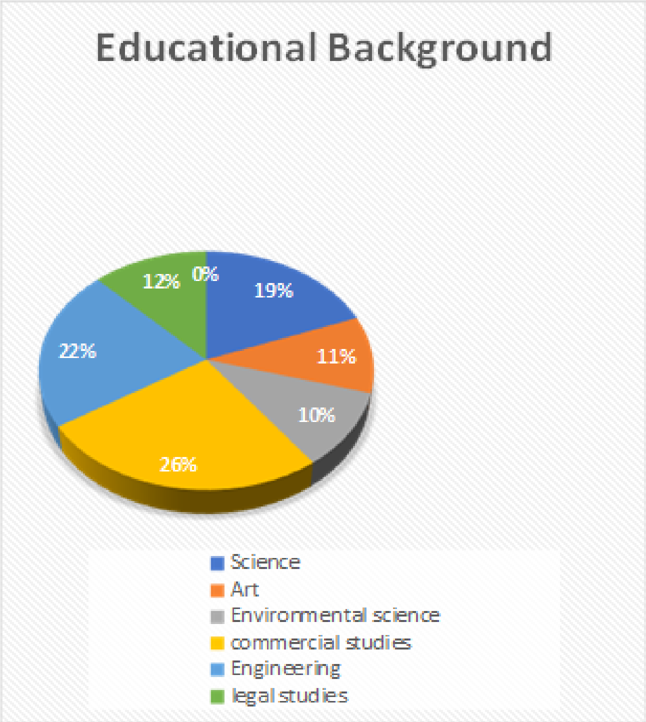

Figure 19: Distribution of educational background of Ikotun resident respondents.
Source: field survey, 2021.

Figure 19, shows various educational backgrounds of respondents who participated in the survey. Science inclined respondents hold 19%, Art holds 10%., environmental sciences hold 10%, commercial studies hold 25%, engineering holds 24%, and legal studies holds 12%, will no education background hold no percentage.

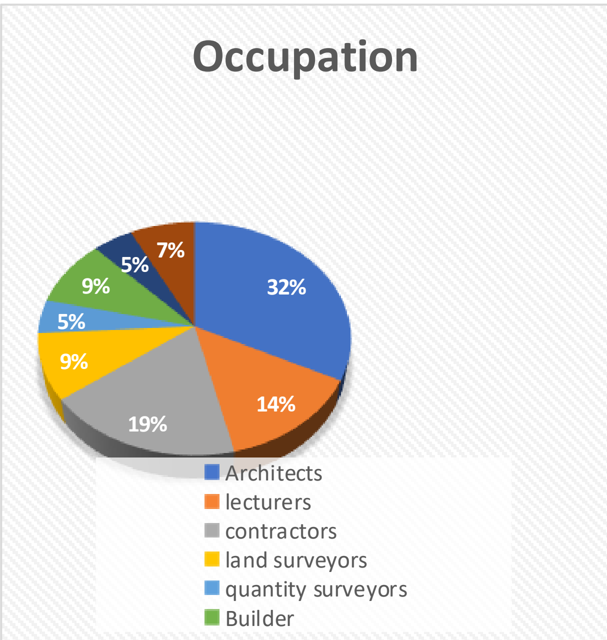

Plate 20: Distribution of occupation amongst the built environment professional respondents.
Source: field survey, 2021.

Plate 20, shows the occupation of respondents. Architects hold 32%, lectures hold 14%, contractors hold 19%, land surveyors hold 9%, quantity surveyors hold 5% and builders hold 9%, estate manages hold 5%, planners hold 7%.

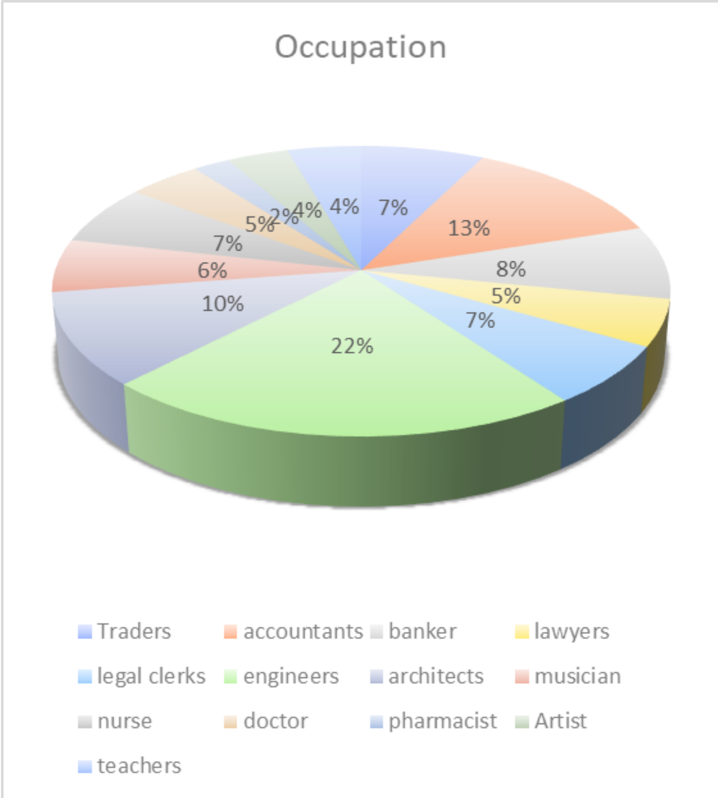

Figure 21: Distribution of occupation of Ikotun resident respondents.
Source: field survey, 2021.

Figure 21, shows the various occupations of respondents who reside in Ikotun. 7% is held by traders, 13% by accountants, 8% by bankers, 5% by lawyers, 7%by legal clerks, 22% by engineers, 10 by environmental specialist. 6% by musicians, 7% by nurses, 5% by doctors, 2% by pharmacists, 4% by artists and 4% for teachers.

c. Data Analysis According to Research Questionnaires and Case Studies

This section breaks down data obtained from case study observation and questionnaire data analysis to answer all questions the research is aimed at answering.

- **Research Question One**: What are the Various Building Orientation Options, Approaches and Process?

This research question is to determine all building orientations options available in design. The researcher made use of three mediums to answer this question which are: literature review, case studies and questionnaires.

The literature review revealed the existing building orientation approaches already in use in design, the case studies sample some orientations existing in the area of study as seen in the research methodology, while the questionnaire sourced more random extensive building orientation and layout options used in Ikotun, which are as follows:

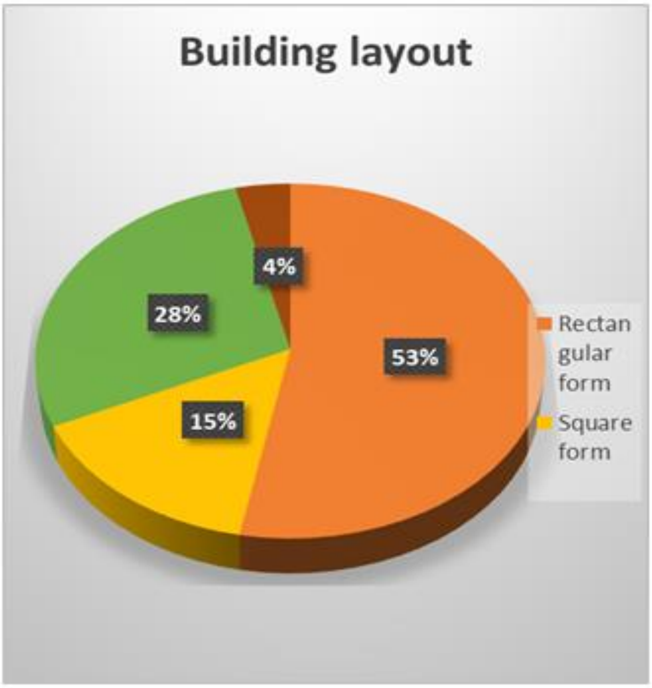

Figure 22: Distribution of building layouts in Ikotun.
Source: field survey, 2021.

Figure 22, shows the various types and building layouts and percentages allocate to each from retrieved questionnaires. 53% of rectangular forms, 15% for square form, 28% for regular forms, and 4% to circular forms.

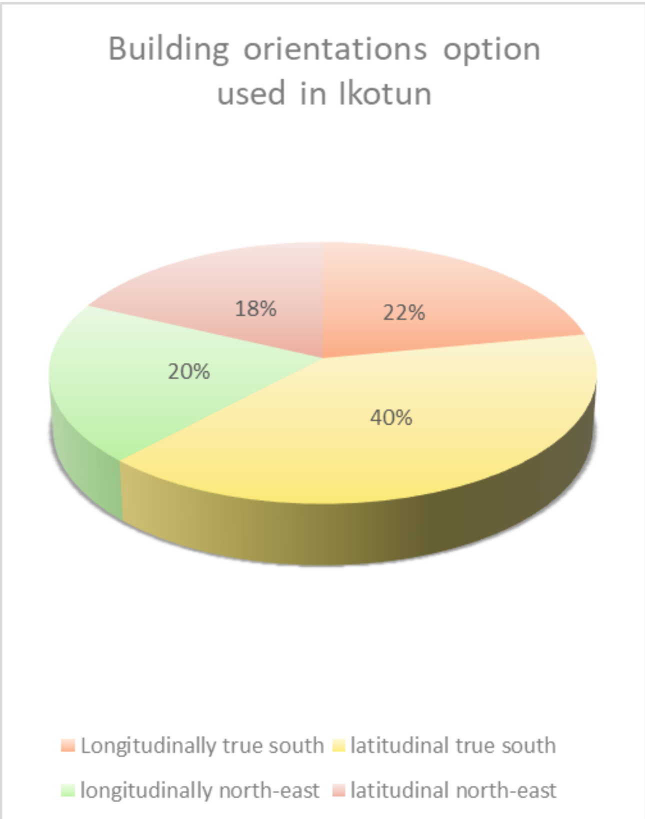

Figure 23: Distribution of building orientation styles used in ikotun.
Source: field survey, 2021.

Figure 23, shows the existing building orientation option used in Ikotun presently as sourced from ikotun resident respondents at random. 32% are longitudinally true south which means their longer axis faces the south, 27% are latitudinal true south which means their shorter axis are faced towards the south. 23% longitudinally north-east which means the longer axis is faced towards the north-east. And 18% latitudinal north-east this means the shorter axis is faced towards the north-east.

- **Research Question Two:** Is There a Relationship between Building Orientation Options and Building Comfortability?

The second research question is aimed at assessing if building orientation has an effect on building comfortability which is in terms of air quality, thermal comfort and lighting responds to building orientation choice. Data used here were from the two questionnaires set out to both the built environment professional respondents advising on experience in design with effective building orientation options and its relation to building comfortability and the Ikotun resident respondents on their experiences within their buildings. Data analysis is as follows:

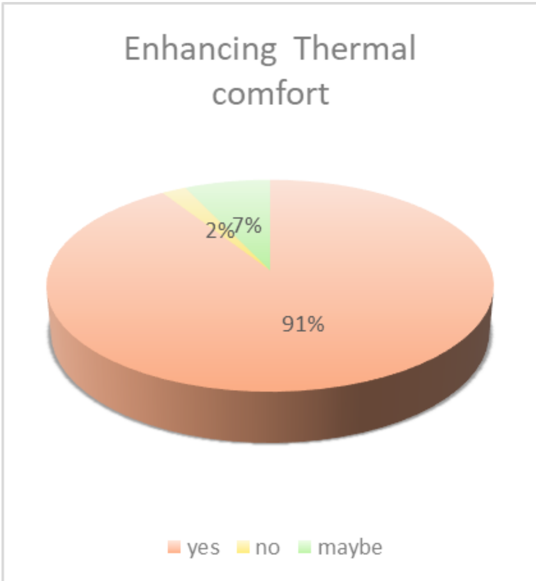

Figure 23: Distribution of opinions of professionals on the relationship between building orientation and enhancing thermal comfort.
Source: field survey, 2021.

Figure 23, shows a very high majority of 80% professionals believe that building orientation has its effects on thermal comfort, 17% are unsure and 3% disagree.

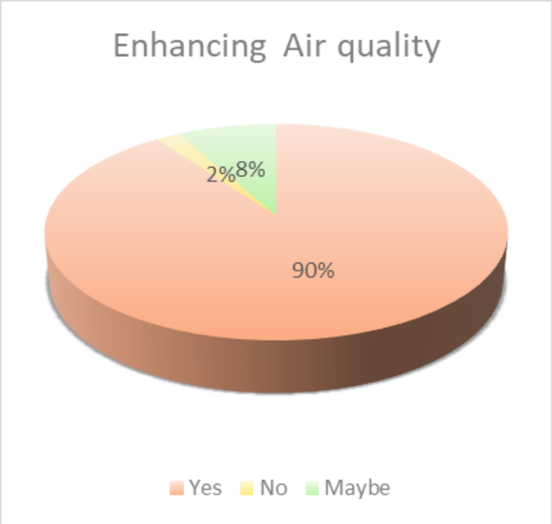

Figure 24: Distribution of opinions of professionals on the relationship between building orientation and enhancing air quality.
Source: field survey, 2021.

Figure 24, shows a very high majority of 90% professionals believe that building orientation has its effects on thermal comfort, 8% are unsure and 2% disagree.

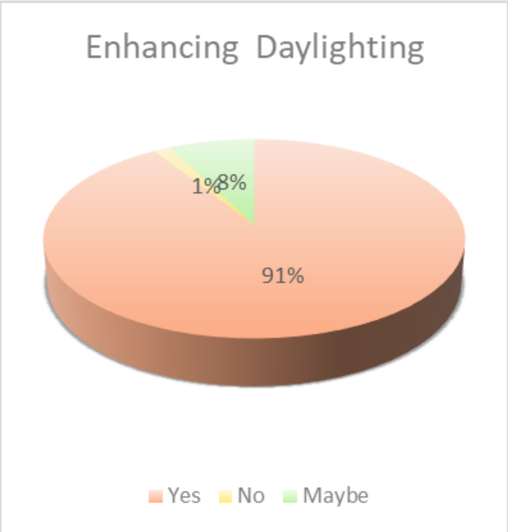

Figure 25: Distribution of opinions of professionals on the relationship between building orientation and enhancing daylighting.
Source: field survey, 2021.

Figure 25, shows a very high majority of 91% professionals believe that building orientation has its effects on thermal comfort, 8% are unsure and 1% disagree.

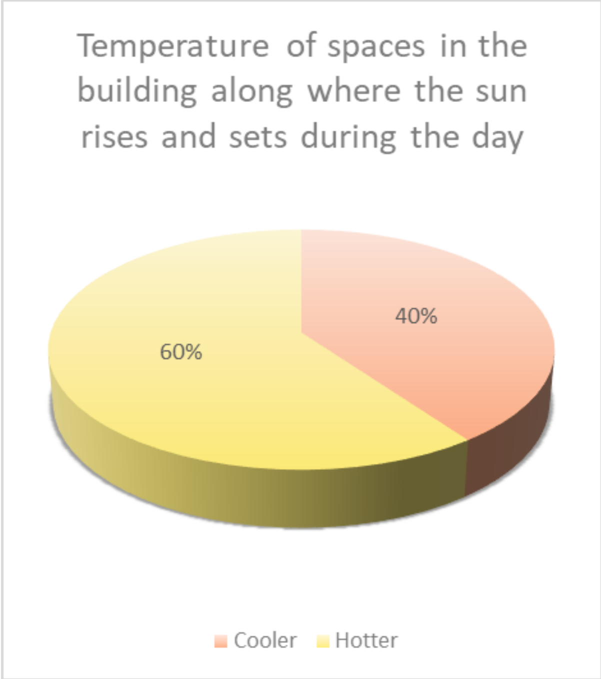

Figure 26: Distribution of opinions of Ikotun residents on the relationship between building orientation and thermal comfort during the day.
Source: field survey, 2021.

Figure 26, shows a percentage of 74% resident's opinion of the thermal comfort within rooms along the sun path during the day which consists majorly of latitudinal true south orientation by 40%, 5% longitudinally true south, 7% latitudinal north-east and 8% longitudinally north-east.

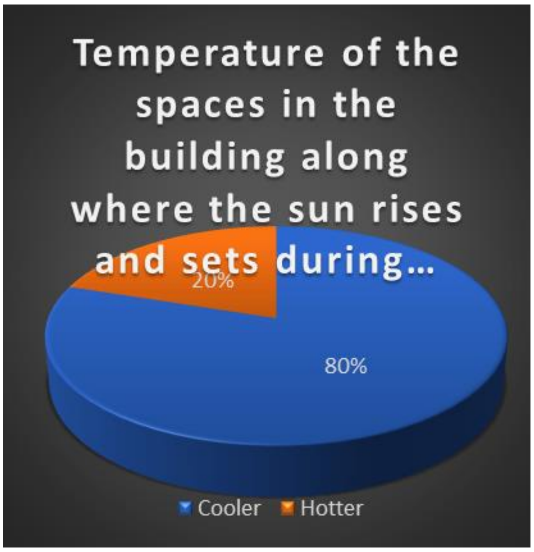

Figure 27: Distribution of opinions of Ikotun resident on the relationship between building orientation and thermal comfort at night time.
Source: field survey, 2021.

Figure 27, shows the number of respondents who believe it is cooler at night at the parts of the building where the sun rises and sets at night time. 80% agreed to this and 20% did not.

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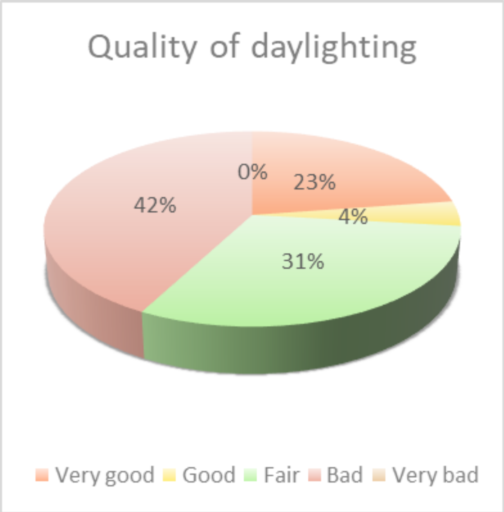

Figure 28: Distribution of opinions of Ikotun residents on the relationship between building orientation and quality of daylighting.
Source: field survey, 2021.

Figure 28, shows the varying quality of daylighting ranging from very good to very bad.

23% of Ikotun resident respondents experience very good daylighting quality, 4% experience good daylighting quality, 31% experience fair daylighting quality, 42% experience bad daylighting quality and 0% experience very bad daylighting quality. This shows a bulk of residents have bad quality of daylighting.

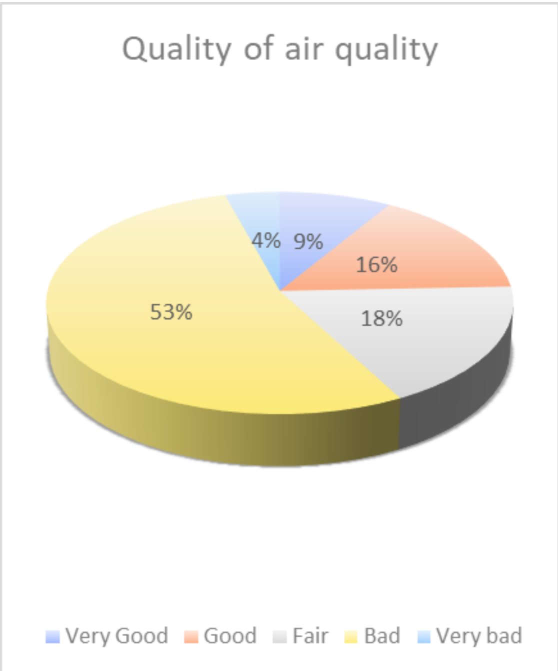

Figure 29: Distribution of opinions of Ikotun residents on the relationship between building orientation and quality of air quality.

Figure 29: field survey, 2021.

Plate 17, shows the varying quality of daylighting ranging from very good to very bad.

- **Research Question Three**: What Are the Benefits of Building Orientation on Building Envelope Performance?

This research question aims at examining and finding the benefits of building orientation on building envelope. The data accessed in this section is derived from the questionnaires sent to the built environment professionals, which are as follows:

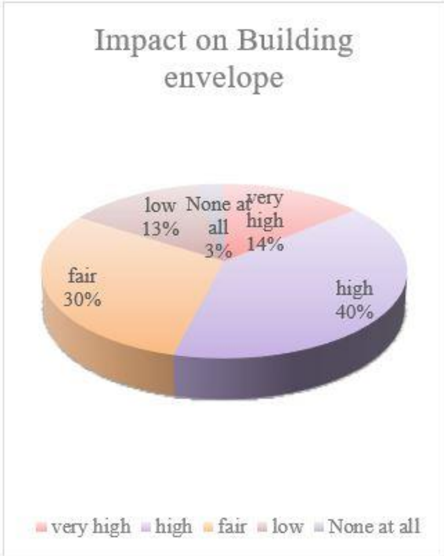

Figure 30: Distribution of opinions amongst the build professional respondents on the impact of building orientation on building envelope.
Source: field survey, 2021.

Figure 30, shows the percentage of professionals who believe that building orientation has an effect on building envelope. 14% believe there are very high impacts, 40% believe there is high impact, 30% believe the impact is fair, 13% believe the impact is low and 3% believe there is no impact what so ever.

- **Research Question Four**: What is the Impact of Building Orientation on the Occupants and their Environment?

This research question aims at taking opinions from the residents of different orientation options and examine their comfort level. They include:

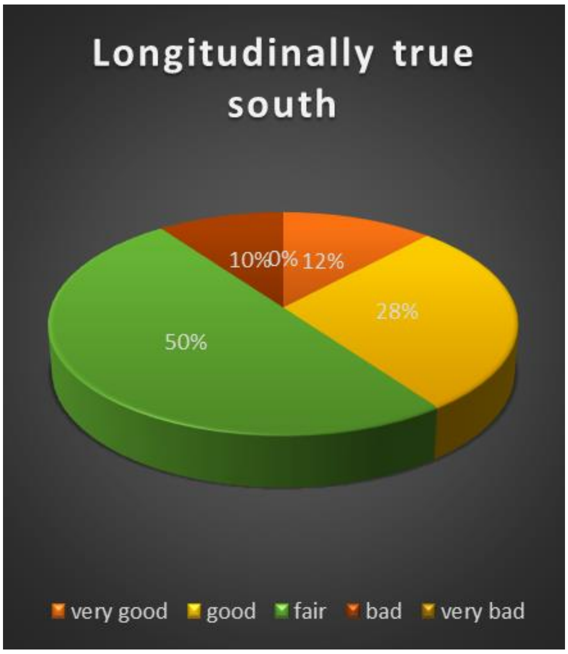

Figure 31: Distribution of opinions of longitudinally true south orientation occupant respondent.
Source: field survey, 2021.

Figure 31 shows the level of comfort occupants with a longitudinal true south orientation. Out of 307 Ikotun respondents 22% which equal 68 people have this orientation option 10% (22/100 * 307 = 68). Out of these 68 people 12% have very good comfort levels, 28% have good comfort levels, 50% have fair comfort levels, 10% have comfort levels and 0% have bad comfort levels. This analysis shows a majority have good and fair comfort levels.

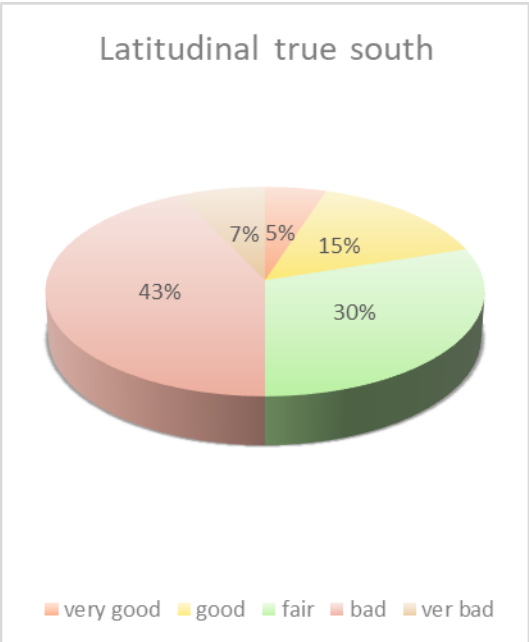

Figure 32: Distribution of opinions of latitudinal true south orientation occupant respondent.
Source: field survey, 2021.

Figure 32 shows the level of comfort occupants with a latitudinal true south orientation. Out of 307 Ikotun respondents this orientation holds 40% which equals 123 person (40/100 * 307 = 123). Out of these 123 people 5% have very good comfort levels, 15% have good comfort levels, 30% have fair 43% have bad comfort levels and 7% have very bad comfort levels. In this section there is a higher level of discomfort unlike in Plate 19.

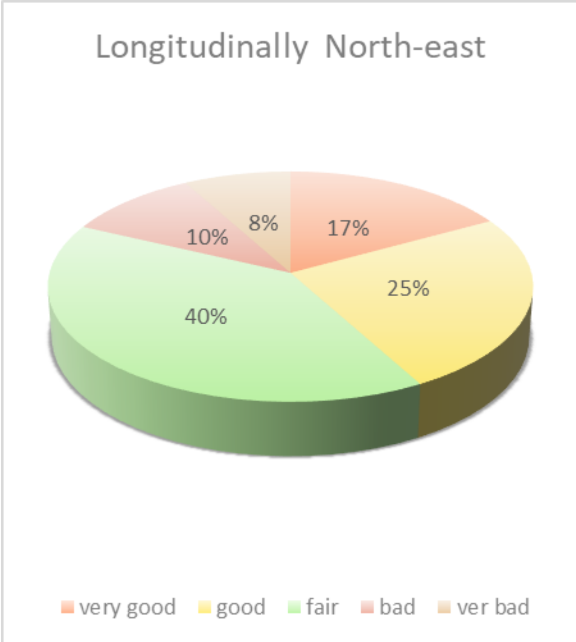

Figure 33: Distribution of opinions of longitudinally north-east orientation occupant respondent.
Source: field survey, 2021.

Figure 33 shows the level of comfort occupants with a longitudinally north-east orientation. Out of 307 Ikotun respondents this orientation option holds 20% which equals 61 persons (20/100 * 307 = 61). Out of these 61 persons 17% have very good comfort level, 25% have good comfort levels, 40% have fair comfort levels, 10% have bad comfort levels and 8% have very bad comfort levels. In this section a majority show a good level of comfort.

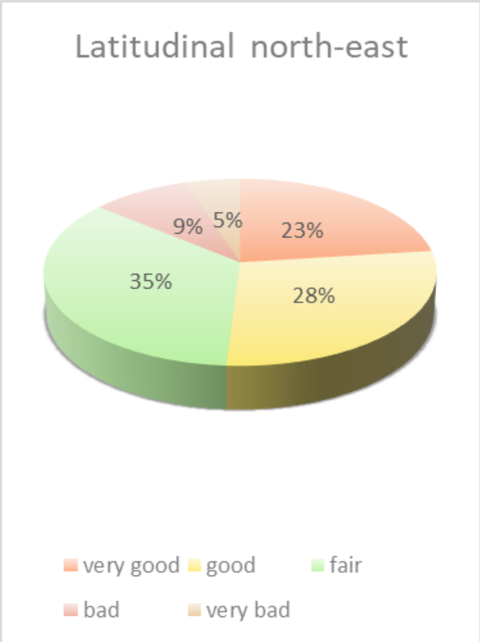

Figure 34: Distribution of opinions of latitudinal north-east orientation occupant respondent.
Source: field survey, 2021.

Figure 34 shows the level of comfort occupants with a latitudinal north-east orientation. Out of 307 Ikotun respondents this orientation option holds 18% which equals 55 persons (18/100 * 307=55). Out of these 55 persons 23% have very good comfort levels, 28% have good comfort levels, 35% have fair comfort levels, 9% have bad comfort levels and 5% have very bad comfort levels. This section as well shows a majority of high comfort levels.

IV. SUMMARY OF FINDINGS, CONCLUSION AND RECCOMMENDATION

- **Findings**

The findings from the research according to research question one shows there are four (4) building orientation options used in Ikotun which are: longitudinally true south, latitudinal true south, longitudinally north-east and latitudinal north-east. The second research question established that there is a relationship between building orientation and building comfortability, different building orientation options had different takes on comfort within the building during the day and at night, highest percent of comfort came from the longitudinally and latitudinal north-east then close behind is longitudinally true south, and latitudinal true south showed the most discomfort. The third research question established that building orientation has an effect on thermal comfort, natural daylighting and economy of building with various orientations experiencing different levels of access to these features. And lastly research question four establishes that building orientation does have an impact on its occupants and environment, because the different orientation options show varying comfort levels with their building, occupants in the latitudinal true south experience the highest amount of discomfort.

- **Conclusion**

Building orientation does have impacts on building performance which are its thermal comfort, access to daylighting, air quality and economy of building. The study also indicates preferable building orientation options for enhanced building performance.

- **Recommendation**

As a consequence of the results and conclusion, the report recommends:

Building orientation should not be neglected at the design phase but tackled till the most appropriate orientation with maximum benefits is attained, because the neglect of building orientation takes its effect on the design and occupants over time and efforts can only be made to artificially enhance the building comfortability.

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