Investigating The Daylighting Status and Associated Energy-Efficient Design Strategies in The Selected Museums of Southwest Nigeria.

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Abstract

This study investigated the daylighting status and strategies engaged in the selected museums of Southwestern states in Nigeria. Museums are generally known as traditional places where artefacts are stored and displayed for the purpose of entertainment, enlightenment, recreational, cultural and educational advancement purposes. The integration of natural daylighting into museums spaces is an ambiguously critical factor especially as the sun rays toed the paths and panes of fenestrations to the display points where the artefacts are positioned. The effects of daylighting exposure to the museum artefacts depends greatly on the length of exposure to light rays and object tolerance. The aim of this project is to investigate the daylighting status of museum design in order to improve the architectural design in terms of associated energy-design indices with inclusive daylighting design strategies of the ultramodern art museum for Oyo state. The study methodology engaged questionnaires, interview, literature reviews and case study evaluation; in order to improve daylighting strategies in museum building. It also examined the adequate features relevant for integrating daylighting strategies in the design of museum. Questionnaires were administered and analyzed using Statistical Package for Social Science (SPSS) through descriptive analysis of the data. The analysis showed that there are cogent parametric-energy design indices in the existing architectural designs that are applicable in forms, spaces, materials, techniques, installation and strategies to museums in the tropical climatic regions. It further showed that the use of clerestory windows, atriums, light tubes and anti-solar glass/windows were considered to be most adequate daylighting features sufficient for daylighting optimization. It finally recommended an architectural model design specific to all tropical museum (cultural) building species in a holistic form and spaces, and planning. These would enable a high-level patronage and optimization for entrepreneurial benefits within the confine of museums and other culture-related buildings in the tropical climate.

Keywords: Daylighting-status, Energy-design, Strategies, Museums

1. Introduction

Museum is a building where historical arts, artefacts, paintings, sculptures are stored, preserved, studied and displayed for the purpose of enlightenment and advancement of the frontier of knowledge. It informs, educates, orientate the public about the historical facts and records, the cradle of civilization, ethical-historical norms, cultural artefacts and various achievements of scientific and technological significances alluded to such artistic archival works. It is an institution used for the preservation of objects that satisfactorily illustrates the works and ideas of man and increases the understanding of the people (Aderonmu, Adesipo, Erebor, Adeniji, & Ediae 2019). Therefore, investigations were primarily premised around the climate-based modeling approach to improve on architectural designs and construction techniques. Museum can be described as a building or structure that conserves collections of artefacts consisting of different artworks, cultural and historic significance; making them accessible to the public through exhibitions (Macdonald, 2008). According to Okonkwo (2016) there are various perspectives of what a museum stands for to a variety of individuals; either as entertainment arena or a place for enlightening the mind; however regardless of which, it is a storehouse of knowledge (Edward, 2007) and an educative archive. In a generic sense, Museums are generally known as traditional places where artefacts are stored and displayed for the purpose of entertainment, enlightenment, recreational, cultural and educational advancement

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purposes. The integration of natural daylighting into museums spaces is an ambiguously-critical factor especially as the sun rays toed the paths and panes of fenestrations to the display points where the artefacts are positioned. The effects of daylighting exposure to the museum artefacts depends greatly on the length of exposure to light rays and object tolerance in terms of colours, textures, fragility and delicacy nature of materials in which the artefacts are made up of. In this study, several daylighting methods were explored and certain energy-related algorithmic indices were synthesized from analysis of responses of questionnaires so as to derive architectural design recommendations. Therefore, this study aimed its investigations at the status of daylighting and associated design strategies of the selected museums in the tropics of Southwest Nigeria; to recommend energy design indices necessary for the architectural design of ultramodern museum for Ibadan, Oyo state.

2. Literature Review

Museum designs evolved from Architects throughout history; but the anthropometric planning of spaces the museum's collections is been exhibited is still highly affected by the actual mission and aim of the museum. Museums provide numerous advantages to its guests, the communities, and nation in general. It provides great possibilities to self-coordinated scholars and audience via gaining knowledge and investigation of various modern and historical elements which covers individuals of different ages, interests, background and capabilities. Museums are also a place where visitors and the communities are entertained, stimulated and introduced to both historical and new innovation ranging from cultural lifestyles to revolutionary ideas of a particular society. Therefore, curriculum of architectural education that trains Architect-designer should be upgraded to combat the challenges in the areas of daylighting, appreciation of space and objects in museums spaces; Valero, Giuliani, Caffaro, Basile, Peron, Dalla, Bellia, Fragliasso, Beccali, Bonomolo, Nocera, Costanzo, 2021). It is an essential strategy for achieving energy efficiency and visual upmost satisfaction. It gives proper supply of lighting for appropriate colour rendering and has a quality which gives appropriate human responses to visual objects displayed. It also bring the experience of feeling of joy and brightness which gives a tremendous influence on viewers (Li & Lam, 2001); (Luigi et.al 2019).

In Nigeria, museums are becoming desolate and underutilized through the downward trend of patronage of the museums caused by the impending loss of cultural identity. Proper preservation of objects is vital to the museum based on the fact the collection structure gives fulfilment to the mission statement of museums and its development (Espacio, 2014; Shafavi, Tahsildoost, Zomorodian, 2020). The worth and level of interest in the heritage and artefacts displayed in any museums of a society will continue to depend primarily on the museum's designs, the preservation of the artefacts exhibited, the collections of the museums, and the experienced derived through circulation (Byrne, K., Muller, K., Floray, S., Knapp, T., Hitchcock, A., Black, L., Vogt-O'Connor, D., Copp, B., 2006).

Lighting used in an exhibition area is a critical factor in the display of an artwork. Usage of gallery lighting differs based on the type of the building size or layout, exhibition spaces and the artworks to be displayed. Also the lighting strategy to be used for two-dimensional objects will differ from three-dimensional objects (Hegazy, Yasufuku &Abe, 2022). According to Arthur van der Zaag (2017) various lighting strategies are based on the type and nature of the materials sensitivity to lights. Proper lighting strategies will give the viewer an experience of both the physiological, sociological and psychological influence perceived from the artworks.

The essential aim of lighting design and set up is to create most effective condition for viewingobjects(Manzoor,Othman,Sadowska,Sarosiek,2022;Valeroet.al2021).The tolerance of light of an artwork's and artefacts will depend on the materials used to create the work and the degree and length of exposure to light in the course of the exhibition. Creative daylighting strategies can be employed to tackle the need for low lighting levels by larger window area to total indoor volume (Jimoh and Ogunrayewa, 2015). Other issues which need to be taken into consideration are the use of natural daylight versus artificial light and the influence of such light on both the artwork and artefacts and how it helps the viewer's experience. This research work intends to investigate the relevant daylight strategies for museums in order to propose a befitting ultramodern museum for Oyo state.

Gradual degradation and deterioration of artworks and artefacts of Nigerian museums has been observed due to the improper and inadequate preservations method through the exposure to lights and moist in the exhibition and storage spaces. Various attempts have been made by museums to preserve both the modern and ancient antiquities and artefacts of Nigeria. There is therefore a remarkable need for the creation of a competently considered preservative museum using daylighting strategies to create greater appropriate preservation and circulation spaces for Nigerian artefacts that will resolve the lapses and deficiencies and proffer solutions to preserve our heritage and uphold our national relics. The following research questions will be considered in this study: (i) what are the existing daylighting strategies to be used? (ii) How can daylighting strategies be used in museums design? (iii) what are the optimum uses of daylighting to museum design? (iv) How will daylighting strategies improve the museum design? This study therefore investigated the existing museums in Nigeria in order to integrate daylighting strategies into the architectural design of ultramodern museum for Ibadan, Oyo state. The objectives are to: investigate the daylighting strategies in the exiting museum designs, identify significant problems related to daylighting strategies in the existing museum, examine daylighting strategies relevant to ultramodern museum design, design an ultramodern museum integrated with characteristics and methods of daylighting strategies.

2.1 Brief Descriptions of Selected Museum Buildings

2.1.1 National Museum Onikan, Lagos

The National Museum Onikan, Lagos is cited at the Central District of Lagos along Onikan Station Road bounded towards the south-east by Awolowo Road and North-west by Tafawa Balewa Square and by the east by Lawson Street. The museum was built and designed by the colonial government in 1956 as an initiative measure of collecting and preserving Nigerian's artefacts in order to improve the cultural history after the loss of numerous imperative antiques during the colonial era instigated by the English Archaeologist Kenneth Murray.

2.1.1.1 Architectural style

The museum exhibits a typical traditional colonial era architectural character with the use of courtyard bounded by corridors that link the various areas of the building e.g., offices, storage facilities, etc. The main building is two storeyed while the other supporting buildings are bungalows or totally separated like the kitchen and toilet building.

Plate.1 Front view of the National Museum Onikan, Lagos

Plate.2: view showing the Asymmetrical Courtyard Compositions

The asymmetrical pentagon grass lawn courtyard as seen in plate 2 is enclosed around by both the two storied section of the museum, the laboratories and the exhibition halls. Natural stone finishes were also

used on the exterior walls as seen in plate 1 and various sculptural supports were used along the courtyard edges; a feature found in Yoruba traditional palaces and entrance porches.

Plate 3*:* View showing the Reception Hall also showing the museum shop

Plate 4 View of the supporting Building facilities; Museum Kitchen and Craft village

2.1.1.2 Functional Space Analysis

The entrance of the main building complex is directly opposite the site's entrance; with natural landscape features infused to enable thermal comfort at the drop-off points of the roundabout (plate 5). Other site features include the recreational park, playground, kitchen, craft complex, Nigerian Government gallery and other service facilities. The main building entry is a double-volume hall comprising of the reception and the sales outlet at the ground floor level and offices at the upper level. The museums building houses various spaces like; library, seminar hall, stores, offices, laboratories, exhibition halls and so on as shown in figure 1:

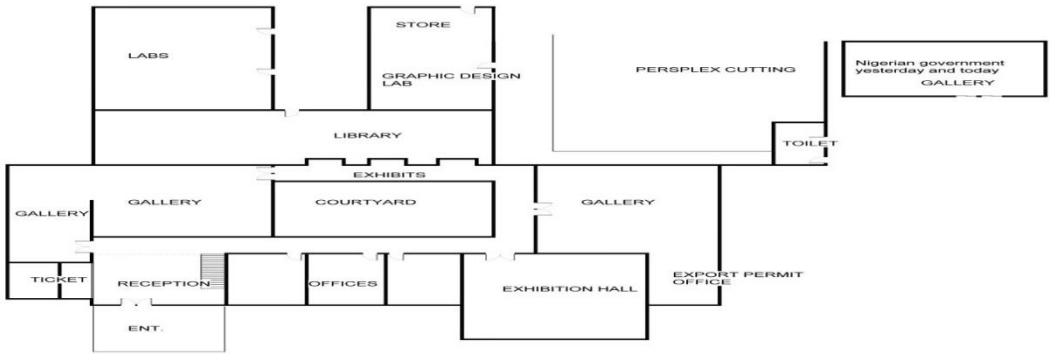

Figure 1 Floor plan of the National Museum Onikan, Lagos

Plate 5*:* View showing the landscape around the entrance of the museum building

2.1.2 National Museum of Unity, Ibadan, Oyo State

The National Museum of Unity Ibadan located at Aleshinloye, Jericho Ibadan was one of the four urban museums initiated after the civil war in Nigeria (1967-1970) by the Federal Government during the tenure of General Yakubu Gowon in the 1973 as an act of endeavours to improve unity among Nigerians. The museum was opened on April 4, 2002.

Plate 6*:* Front view of the National Museum of Unity showing the entrance gate

The museum exhibits are classified into four (4) galleries comprising of; Unity gallery, Masquerade gallery, Pottery gallery, and Displayed objects gallery.

The museum complex comprises of galleries consisting of permanent and temporary exhibition, auditorium, event hall, kitchen, craft village, playground and bar. The museum consists of various departments like account, finance, Internal Audit, Education, Research, Archaeology, Conservation, Heritage and Site, Documentation, Curatorial, Administrative and Planning.

Plate 7: Interior view of the gallery displays

The museum of unity, Ibadan is located close by to one of the popular markets in Nigeria; Aleshinloye market. The museum is bounded by the Department of State Security headquarters and South-West Local Government secretariat building. The site slopes towards the north-west with the presence of clusters of trees and has a drainage system joining the municipal drainage system as shown in plate 8.

Plate 8*:* View of the landscape features used at the entrance of the museum

2.1.2.1 Architectural Style

The museum layout consists of an infusion of octagons (8 sides) linked with hallways connecting the hexagons together with a courtyard at the center of the exhibition galleries. The building is a single floor structure with a frame structure of columns and beams. Construction materials include concrete masonry units with glass/ aluminum windows.

Plate 9: View of the courtyard linking the different types of galleries

2.1.2.2 Space Analysis

The building complex has its entry close to the entrance accessible with the vehicular drop-off and pedestrian walkway. The building houses various spaces like; exhibition galleries, administrative offices, storage, library, laboratories, seminar room, etc. The museum comprises of 5 exhibition halls; four of which are for permanent exhibition while one is for temporary exhibition which is the closest to the entrance hall. Each departmental office is likewise octagon in shape connected by a courtyard at the centre.

2.1.3 National History Museum, OAU, Ile-Ife, Osun State

The National History Museum is located at Obafemi Awolowo University (O.A.U.) Ile-ife Osun State.

Plate 10: Front View of The National History Museum, OAU- Side lighting

The building was constructed by Platform Concept LTD managed by Architect Patrick Ehinmowo and other engineering services done by Mrs Aabowa & Co (Nig) LTD. The museum started with collections of zoological objects before the addition of archaeology and cultural anthropology collections.

The museum seat on an 8.12 square meter land area bounded at the north by Science and Technology Computer Auditorium and by the west by Department of Pharmacy. The site slopes towards the south and has a level lower than the access road leading to the site.

Plate 11: View showing the entrance porch of the museum

2.1.3.1 Architectural Style

The architectural design style was replicated in the analogy of the southwest-Nigerian traditional palace building with elevated gable roof style at the entrance porch of the palace. It is often used to accommodate the traditional drummers and other guests awaiting the emergence of a King from the core of the palace.

In a few palaces, the volumes and heights of such roofs were at times used for storage of traditional equipment and tools. The roof design serves the ideology of design focal points of major attraction to the museum building. The roof covering is made of aluminum roofing sheet materials but designedly patterned in traditional clay tiles.

Plate 12: Side view of the museum showing the roof Dynamic characteristics

The museum site is located on the valley side of the access road, hereby channelling a walk way by a gentle slope leading to the entrance of the building.

2.1.3.2 The Roof

The museum building has a brownish-red long span aluminium roofing sheets with a stone coated finish designed to have an appearance of a roof tiles. The roof eave has a soffit finish of PVC ceiling strips.

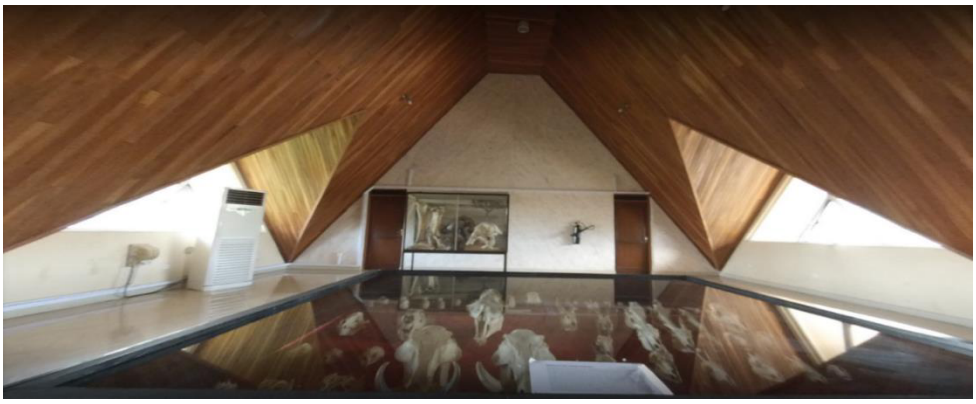

Plate 13: Interior view of the Wall finishes used at the first floor of the museum

In plate 13, daylighting strategy was achieved through the interior spaces by side-lighting via the roof structures. It exposed the geometry of the museum forms and spaces to the sky. This method is advantageous but adequate measures need to be taken by Architect energy-efficient designers to safeguard the artefacts and other fragile objects within the gallery and exhibition spaces.

Plate 10 *:* View of the Roofing sheet

In plate 14, the museum roof design is geometrically dynamic and adequately strategized to admit daylighting. The fenestrations were also shielded by the overhanging gable ends of the roofs to protect the interior spaces from being exposed to the direct rays

of the daylighting. This method also assists in the preservation of the colours, textures and strength of the artefacts**.** The only demerit was that the window glasses were ordinary clear glasses which if exposed to solar rays may affect the state of the material objects displayed in the interior spaces.

2.1.3.3 Space Analysis

There are two floors in the museum. The ground floor comprises of a large gallery showcasing objects on cultural history and geology, while the first-floor gallery focuses on zoology and skeleton displays. Other spaces in the museum includes; offices, library, lecture halls and laboratories. The visitors are welcomed to a large reception and directed to the gallery either on the ground floor or first floor accessible only through the staircase.

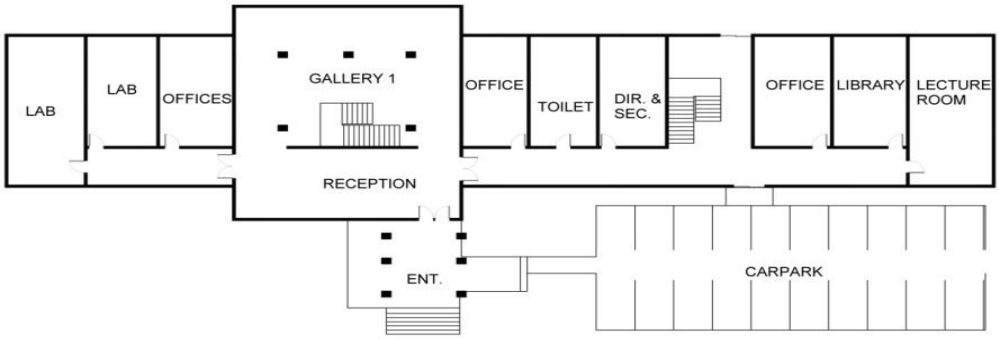

Figure 2*:* Layout of the Ground floor of the museum

3. Methodology

The study was carried out to investigate daylighting status and strategies and associated design problems in the design of selected museums from (n=99) respondents selected from three (3) museums that were examined in south west Nigeria. The study methodology engaged primary data questionnaires, interview, and observation. While secondary data were obtained from literature reviews and documentations and archival materials. The case study evaluation was also engaged to assess the associated energy-efficient design problems of the selected museums in southwest Nigeria; National Museum of Unity, Oyo state, National Museum Onikan, Lagos state and National History Museum Ile-ife, Osun state. Questionnaires were administered and analyzed using Statistical Package for Social Science (SPSS) through descriptive analysis of the data. The results from the structured questionnaire from the selected locations; ninety (n=90) questionnaires were collected with nine(n=9) uncollected. The recovered questionnaires were analysed using IBM SPSS statistics software.

4. Findings and Discussions

4.1 Respondent Profile

4.1.1 Gender

The pie chart in figure 3 indicates the percentages of gender of the respondents that 67% (60 numbers) were male and 33% (30 numbers) were female. These results show that the museum is visited/patronized by more male than female.

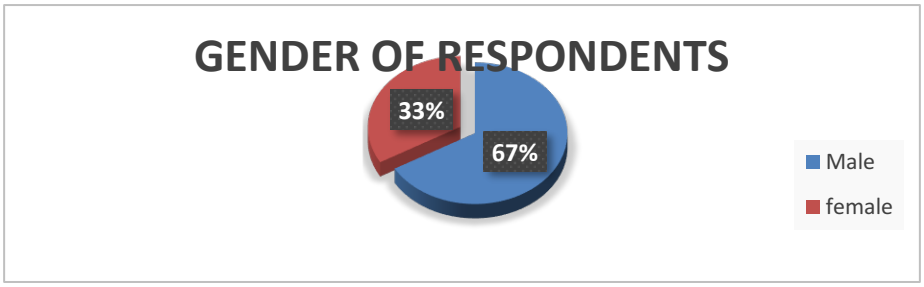

Figure 3: Gender of respondents

4.1.2 Age

From the figure 4, 83.3% of the respondents were between the age range of 21-30 years, 16.7% were between 31-40 years while the 1% of the respondents did not state their age. It implies that more younger respondents visited museums more than the others in the age categories.

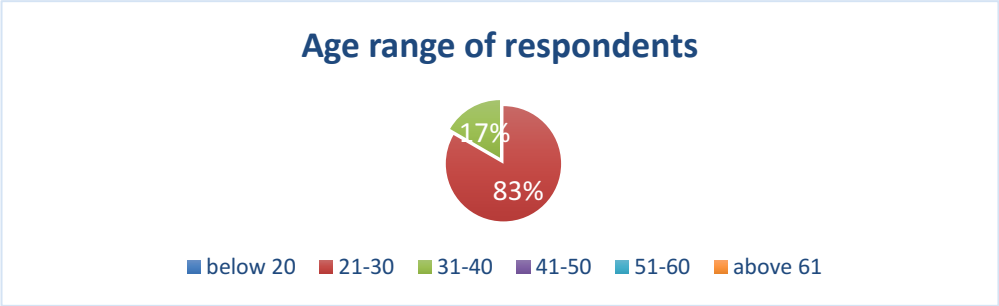

Figure 4: Age range of respondents

4.1.3 Educational qualification

The educational qualification analysis is based on the level of formal education attained by the respondents. Figure 5 shows that 3% of the respondents have either OND/HND degree, 60% have a B.Sc./B.Tech degree, 37% of the respondents have a M.Sc/M.Tech degree and 2% have Doctorate degrees (PhD). It pointed to the fact that more (60%) B.Sc./B.Tech degree holders patronized museums more than the other categories of the respondents.

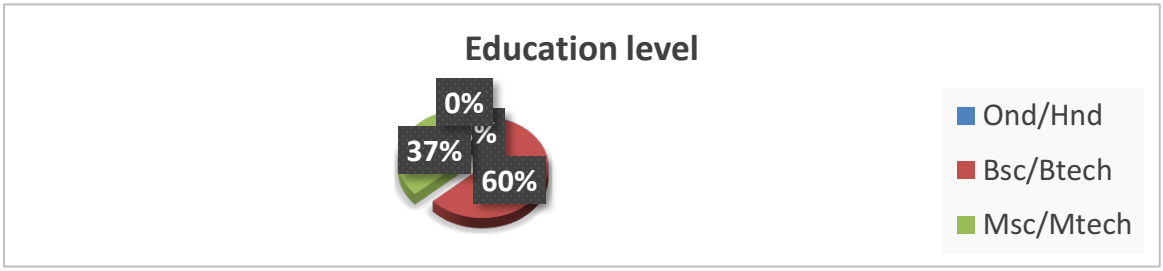

Figure 5: Education qualification of respondents

4.1.4 Numbers of Museum Visits

Figure 6 shows the number of times the respondents have visited a museum to know their level of understanding of Museum spaces. 27% of respondents that have visited the museums just once, 40% have been to the museum 2 times, 23% have visited 3 times, 7% have visited the museum 4 times and 3% of the respondents have visited the museum 6 times or more on yearly basis.

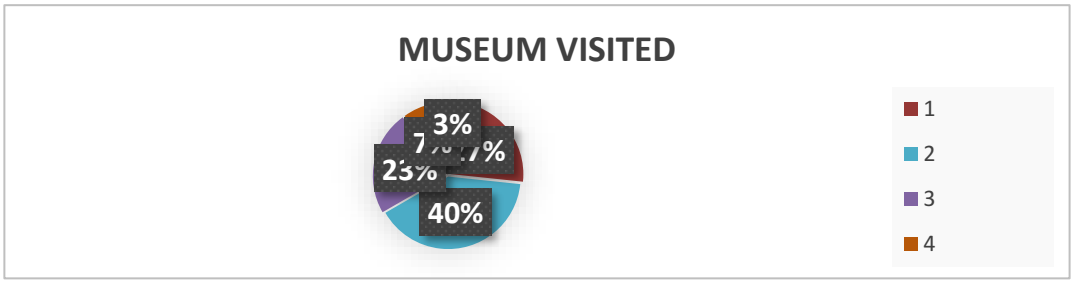

Figure 6: Number of museums visited

4.1.5 Frequency of visits

The less numbers of respondents who frequently visit the museum were 7%, 77% rarely visit the museum, 3% indicates they come once every six months and 13% of the respondents visits the museum also on a yearly basis. It indicates that only 7% who visited museums frequently are likely to have good understanding of museum spaces and the lighting methods being used per museum buildings.

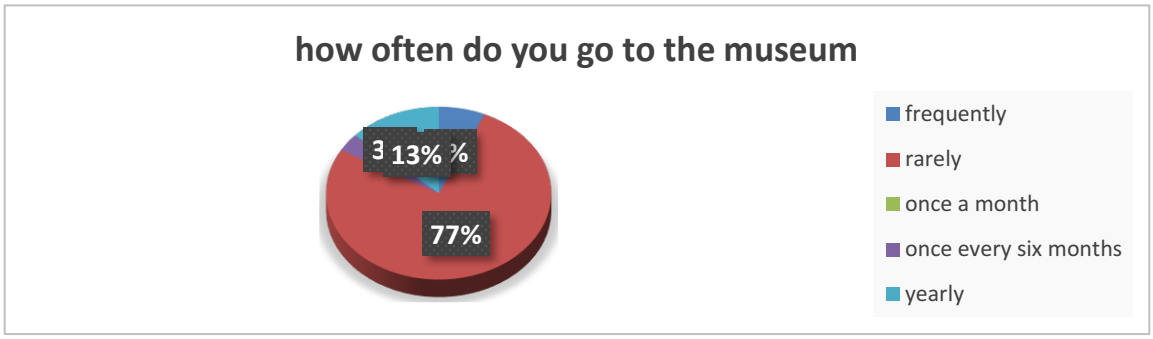

Figure 7: frequency of museum visitation

4.2 Investigating the Daylighting Strategies in the Existing Museums

The Table 1 shows the respondents' view about their perception on the lighting strategies existing in the museum. Questions were asked on their level of satisfactory using the likert scale of 1 to 5. Five questions were presented to them about the quality of lighting strategies currently been used in the museum spaces and exhibition halls. This is to help inform about the comfortability of the respondents on the various lighting strategies utilized in the museum.

From Table 1, most 51(56.7%) respondents perceived that the lighting in the museum spaces was good enough, while some 36(40%) were generally unsatisfactory with the amount of natural lighting (daylighting). In terms of roof height, more respondents 45(50%) were satisfactory while only few3(3.3%) were highly unsatisfactory.

Table1: frequency and percentage of lighting strategies in museum

S/N	Variable	No. of respondents	Highly unsatisfactory (%)	Unsatisfactory (%)	Neutral (%)	Satisfactory (%)	Highly satisfactory (%)
1	The lighting of the exhibition halls was good enough	90	3(3.3%)	18(20%)	18(20%)	51(56.7%)	0(0%)
2	The amount of natural light was adequate	90	0(0%)	36(40%)	24(26.7%)	27(30%)	3(3.3%)
3	The room height in the exhibition halls was adequate	90	3(3.3%)	21(23.3%)	9(10%)	45(50%)	12(13.3%)
4	Displayed artefacts were lighted adequately	90	3(3.3%)	9(10%)	18(20%)	42(46.7%)	18(20%)
5	The artefacts depended on only artificial lighting to be displayed	90	9(10%)	33(36.7%)	20(22.2%)	10(11.1%)	18(20%)

Also, on the visual accessibility of the artefacts, most 42(46.7%) respondents felt satisfied on the way the artefacts were lighted adequately. Only 33(36.7%) respondents opined that the museum depended only on artificial lighting for the artefacts to be displayed. 3.3% of the respondents indicated were highly unsatisfied with the quality of the current lighting used in the exhibition halls, 20% shows they were unsatisfied, 20% of the respondent where neutral about the lighting quality and 56.7% indicated their level of satisfaction of the light quality been used in the museum visited. This result as seen in figure 8 indicates that the respondents were quite satisfied with the general lighting of the exhibition halls.

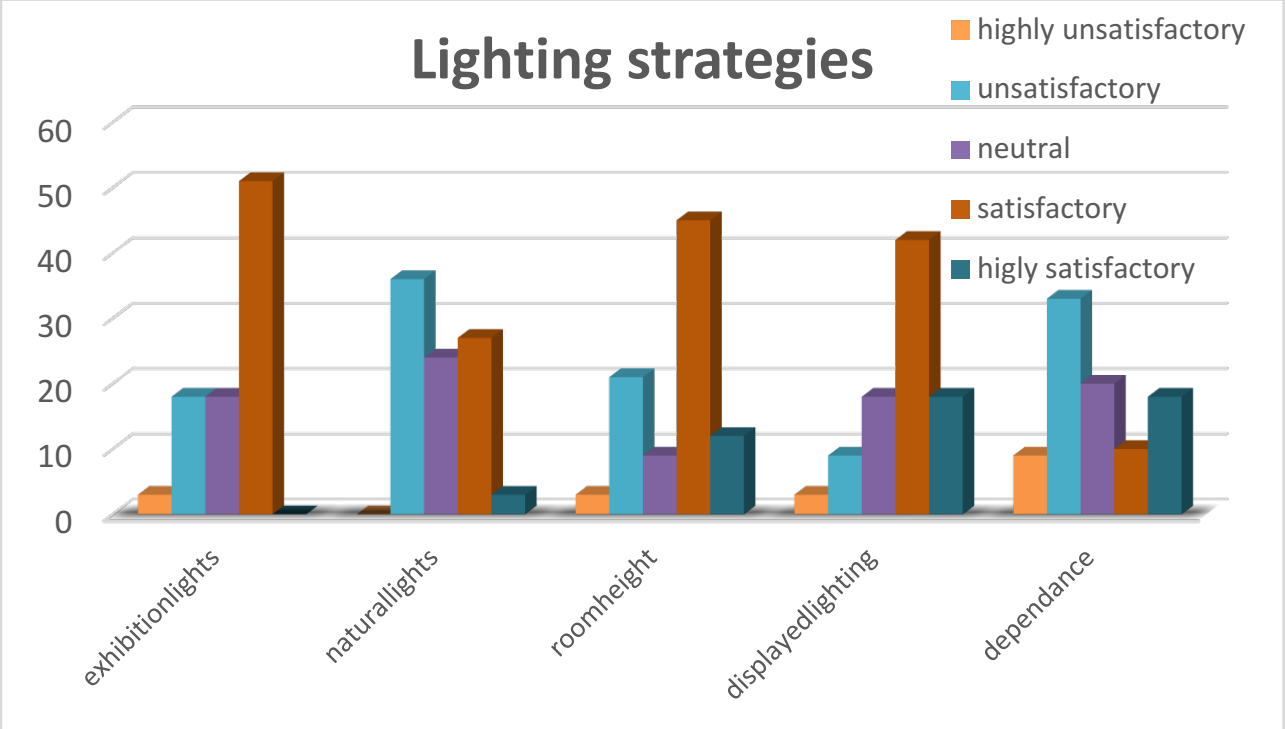

Figure 8: lighting strategies satisfactory level

As seen in table 2, the highest mean value (3.700) shows the respondents' satisfactory level of the artefacts been adequately lighted for display. The next (3.300) mean value indicated satisfaction level on the exhibition hall.

Table 1: Descriptive statistics of lighting strategies

S/N	Variable	N	Minimum	Maximum	Mean	Std. Deviation	Rank
1	The lighting of the exhibition halls was good enough	90	1.00	4.00	3.3000	.90504	1st
2	The amount of natural light was adequate	90	2.00	5.00	2.9667	.91737	2nd
3	The room height in the exhibition halls was adequate	90	1.00	5.00	3.4667	1.09339	3rd
4	Displayed artefacts were lighted adequately	90	1.00	5.00	3.7000	1.01062	4th
5	The artefacts depended on only artificial lighting to be displayed	90	1.00	5.00	2.9444	1.30135	5th
	Valid N (list wise)	90					

The lighting described as been good enough shows that adequate consideration was being placed on the lighting strategies in the museum spaces. The lowest mean value is at 2.944 which show the amount of unsatisfactory level with the museum dependent on artificial lights for displayed of their artefacts. These results as shown in figure 9 signify that more natural lights should be incorporated in the design of an exhibition halls.

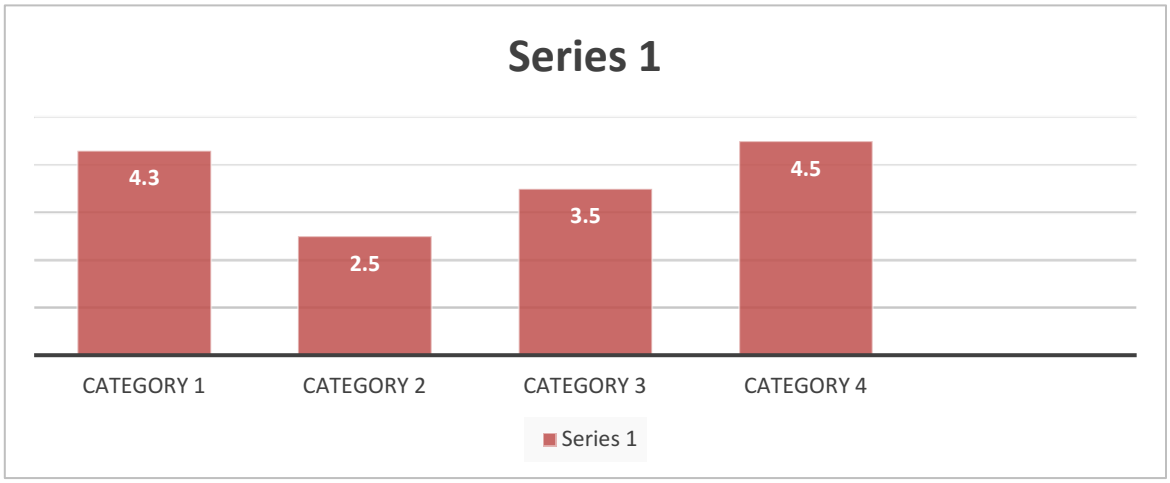

Figure 9: Mean graph of the lighting strategies

4.4 Associated Energy-Design Problems in Natural-Daylighting of Museum Spaces

This objective is designed to investigate the specific problems related to daylighting strategies in the museum design. Questions were asked to determine the perception of respondents using the likert scale of 1 to 5 ranging from highly unsatisfied to highly satisfied respectively:

Table 2: Frequency and Percentages of Related Daylighting Problems

S/N	How would you describe the following?	No of respondents	Highly unsatisfactory (%)	Unsatisfactory (%)	Neutral (%)	Satisfactory (%)	Highly satisfactory (%)
1	illumination of the exhibition spaces	90	3 (3.3%)	21 (23.3%)	12 (13.3%)	48 (53.3%)	6 (6.7%)
2	Ventilation in the exhibition spaces	90	3 (3.3.%)	15 (16.7%)	39 (43.3%)	24 (26.7%)	9 (10%)
3	Visibility of the objects displayed	90	5 (5.6.%)	26 (28.9%)	8 (8.9%)	31 (34.4%)	20 (22.2%)
4	Sufficient circulation in the exhibition spaces	90	6 (6.7%)	12 (13.3%)	24 (26.7%)	45 (50%)	3 (3.3%)
5	Lighting of the circulation and exhibition space	90	0 (0%)	24 (26.7%)	21 (23.3%)	33 (36.7%)	12 (13.3%)
6	The glare on the exhibition space is desirable	90	12 (13.3%)	27 (30%)	30 (33.3%)	21 (23.3%)	0 (0%)
7	heating, cooling and ventilation control in the building	90	12 (13.3%)	36 (40%)	15 (16.7%)	24 (26.7%)	3 (3.3)
8	The temperature inside the building	90	6 (6.7%)	15 (16.7%)	21 (23.3%)	45 (50%)	3 (3.3%)
9	The air quality inside the building	90	6 (6.7%)	21 (23.3%)	21 (23.3%)	33 (36.7%)	9 (10%)
10	positioning of windows in the building	90	12 (13.3%)	20 (22.2%)	18 (20%)	34 (37.8%)	6 (6.7%)

The table 3 shows the frequency and percentage of the respondent responses to the ten (10) questions presented to them on the significant problems faced with daylighting in the museum.

The respondents were asked about their perception of the illumination of the exhibition spaces in the museum. The results as seen in figure 10, shows that 3.3% are highly unsatisfied with the illumination in

the exhibition spaces, 23.3% are unsatisfactory, 13.3% were not sure about their perception of the space, 53.3% of the respondents were satisfied and 6.7% of the respondents were highly satisfied with the daylighting status of the exhibition spaces.

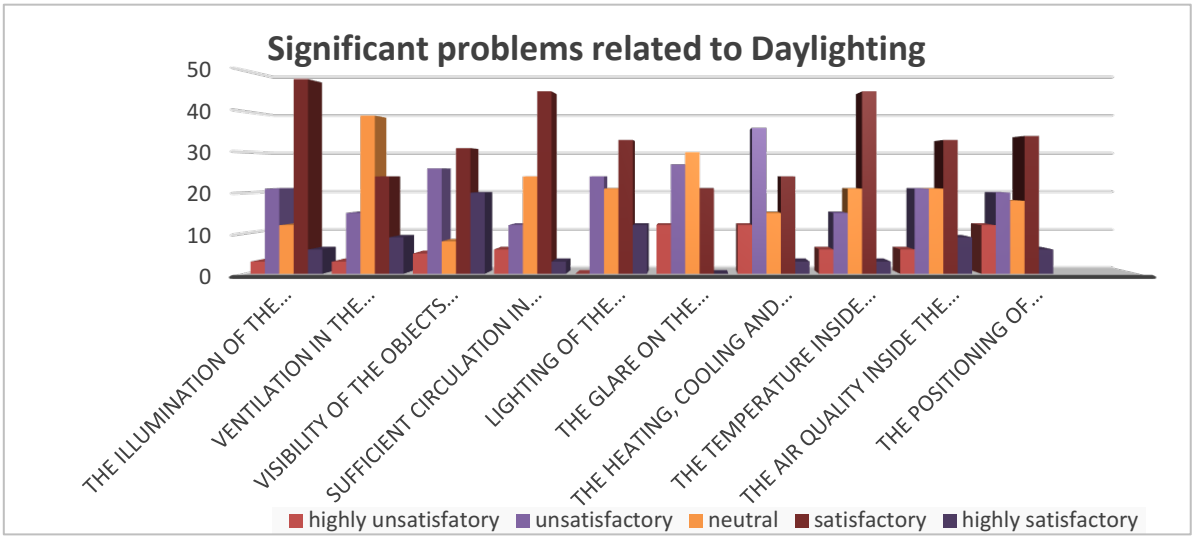

Figure 10: significant problems related to daylighting

The ventilation in the exhibition space perception responses indicates that 3.3% of the respondents are highly unsatisfied with the ventilation, 16.7% are unsatisfied, 43.3% indicated uncertainty about the ventilation, 26.7% are satisfied and 10% of the respondents were highly satisfied with the ventilation in the exhibition space as shown in table 4.3. The majority of the respondent showing indecision on the ventilation of the exhibition space indicated that users have experienced various ventilation levels. While in the exhibition space, probably depending on the time of the day they visited, as a total percentage of 36.7% were satisfied compared to the total percentage of 20% of respondent who were unsatisfied.

The visibility of the displayed objects enquiry gave a result of 5% of the respondent been highly unsatisfied, 28.9% are unsatisfied, 8.9% of the respondent are neutral, 34.4% of the respondent indicate they are satisfied and 22.2% are highly satisfied with the visibility level of the displayed objects. The results as seen in figure 4.8 indicates proper level of object visibility have been considered mostly in the museums.

Concerning the circulation in the exhibition spaces, a total percentage of 53.3% weighs towards being satisfied in comparison to a total percentage of 20% weighing towards being unsatisfied and 26.7% indicated neutral state. The lighting of the circulation and exhibition space indicates that 26.7% of the respondent were unsatisfied, 23.3% are neutral about it while a total percentage of 50% were satisfied.

The desirable level of glare in the exhibition spaces show results of 13.3% being highly unsatisfied with glare in the exhibition, 30% of the respondent indicates being unsatisfied with glare, 33.3% are neutral about their perception and 23.3% of the respondent shows they are satisfied with glare. A total percentage of 43.3% of the respondents weighing towards being unsatisfied with glare indicates adequate consideration should be put into the reduction or avoidance of glare into the exhibition.

The heating, cooling and ventilation system is investigated among the respondents and indicated that 13.3% were highly unsatisfied with the HVAC system, 40% of the respondent were unsatisfied with the system used in the building, 16.7% were neutral, 26.7% of the respondents were satisfied with the system and 3.3% of the respondents were highly satisfied with the HVAC system. This result indicated that there was a major HVAC system problem in the museum buildings; as there were 53.3% of the respondents unsatisfied with the lighting conditions in museum buildings. This conformed with the outcome of researches with the absence of certain energy consuming equipment with low energy performance index (Jimoh & Onazi, 2021)

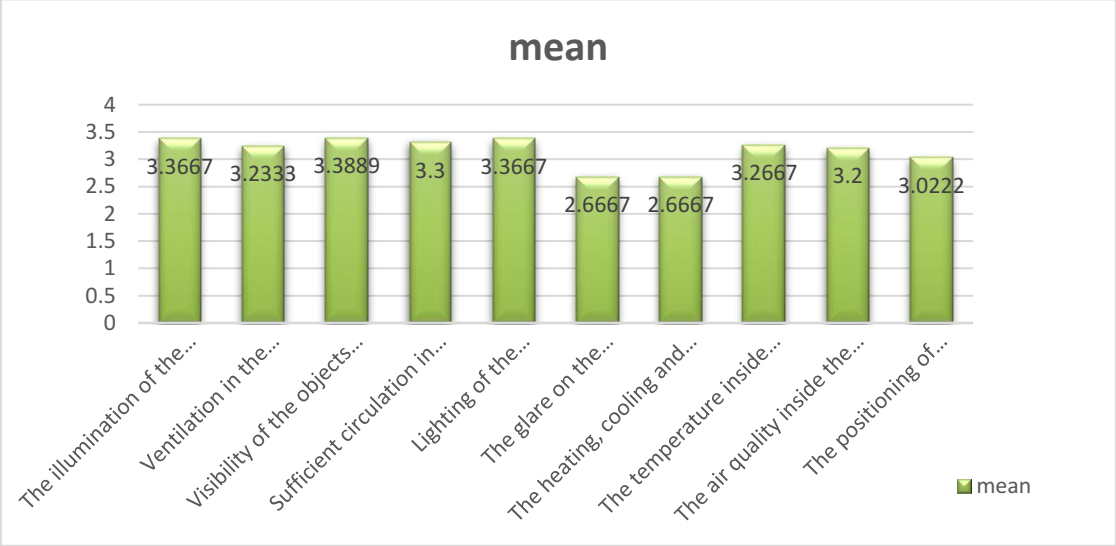

Figure 11: Mean deviation of related problems

The temperature and the air quality inside the building shows that the percentages of the respondents that are highly unsatisfactory are both 6.7%., 16.7% and 23.3% respectively indicates unsatisfactory, 23.3% of the respondent are neutral for both temperature and air quality, satisfactory respondents are 50% and 33% respectively and 3.3% and 10% respectively are highly satisfactory respondents. These results as seen in figure 4.8 show that respondents are generally satisfied with the temperature and air quality of the museum.

The positioning of windows is essential in achieving adequate daylighting strategies and the respondents' perception about their likeness of the current window positioning in the building. 13.3% of the respondent are highly unsatisfied, 22.2% indicated a satisfactory experience, 20% shows a neutral feeling, 37.6% of the respondents specify satisfactory and 6.7% specify highly satisfactory.

Table 3: Descriptive statistics of Associated daylighting Energy-Design Problems

Associated Energy-Design Indices/Problems	N	Minimum	Maximum	Mean	Std. Deviation
The illumination of the exhibition spaces	90	1.00	5.00	3.3667	1.02168
Ventilation in the exhibition spaces	90	1.00	5.00	3.2333	.96045
Visibility of the objects displayed	90	1.00	5.00	3.3889	1.26930
Sufficient circulation in the exhibition spaces	90	1.00	5.00	3.3000	.97669
Lighting of the circulation and exhibition space	90	2.00	5.00	3.3667	1.02168
The glare on the exhibition space is desirable	90	1.00	4.00	2.6667	.98300
The heating, cooling and ventilation control in the building	90	1.00	5.00	2.6667	1.11174
The temperature inside the building	90	1.00	5.00	3.2667	1.00337
The air quality inside the building	90	1.00	5.00	3.2000	1.11375
The positioning of windows in the building	90	1.00	5.00	3.0222	1.18963

5. Recommendations

This work recommended that the use of clerestory windows, atriums, light tubes, anti-solar windows, other daylighting materials, algorithmic techniques and strategies should be explored and integrated into energy-designs by Architects and Engineers in the professional landscapes as the status of the some of the investigated museums have been considered to be most adequate daylighting strategies with significant indices sufficient for energy optimization. In addition, passive features and solar shading devices *like honey combs, overhangs, cantilevers, projected window hoods, porches, courtyards, fin blades and extended roof eaves* are also recommendable in these investigations. This study developed a canon of architectural design model for an ultramodern museum for Oyo state, Nigeria.

6. Conclusion

It finally concluded with an architectural model design specific to all tropical museum building and its typologies in terms of forms and spaces, and planning. For ethical considerations and professional exigencies, the completed architectural drawings of the recommended as proposal in this work but reserved for advanced studies hereafter.

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