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Original Article

Environmental Considerations in The Design of Sustainable Academic Buildings in Jabu, Ikeji-Arakeji, Osun State, Nigeria

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ABSTRACT

A well-planned academic building design supports the advancement of collaborative learning among students. It helps improve the overall wellbeing of students and lecturers in academic institutions. Passive design employs a number of methods and ideas that may be applied to buildings in a variety of climates worldwide. By taking advantage of the natural environment, the creation of a sustainable micro-climate is the key to developing a passive construction. Knowing climate features and classification can aid in suggesting alternatives even before site planning and analysis. An observation checklist was utilised for the purpose of this study to evaluate some academic buildings in Joseph Ayo Babalola university (JABU), to ascertain the current state of the buildings and provide methods and strategies by which the design of the building can impact in order to improve the learning capabilities of students. This paper seeks to explore various passive design strategies that can be incorporated in the design of academic buildings. Such a design, with careful planning, can encourage greater collaboration between teachers and students, information exchange, and even the development of student agency. From a pedagogical and a professional standpoint, the design of academic spaces is important in ensuring a sustainable output of qualitative education for nation building. It is hereby recommended that academic buildings and spaces for interactive learning be energy efficient to eliminate high cost of fueling and maintenance of generators which is not ecofriendly and not sustainable, financially and environmentally.

Keywords: academic buildings, collaborative learning, Jabu, Passive design, passive design strategies, sustainability

INTRODUCTION

Academic facilities are the focal point of any educational institution. Regardless of the level, they all have a common goal, which is to enhance the quality of the learning environment in the institution to raise the standard of education. A growing amount of research has discovered that school amenities can significantly affect the performance of teachers and students. Academic facilities have an impact on hiring, retaining, committing, and working hard of teachers, these facilities also have a profound impact on students' behavior, engagement, learning, and academic growth. Thus, studies typically come to the conclusion that it is very challenging to serve a large number of children with complex needs in the absence of proper facilities and resources. In regards to an academic facility design, five main areas need to be considered, they are; acoustics/noise, air quality, lighting, temperature, and space. Though improving the quality of academic facilities is an expensive undertaking, passive design strategies offers a way to provide a design that maintains a comfortable temperature within the building using the climate and natural elements to get the optimum benefit and to reduce or eliminate the independence on mechanical systems for heating, cooling and lighting. Because well-designed passive buildings emit fewer greenhouse gases and air pollutants, they help to create a more sustainable environment. Effective passive structures consider hidden environmental advantages in addition to energy conservation. Some of these strategies include daylighting, natural ventilation, and solar energy (Agboola, 2011).

Academic buildings in Nigeria are seen to lean heavily on the use of mechanical design strategies, which is not optimal especially nowadays when global warming and emission of greenhouse gases is on the increase. It is crucial that academic institutions

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adopt passive design strategies as they will promote sustainable design and overall aid in the preservation of the natural environment as well as increase human comfort levels. This study is aimed at assessing the passive design strategies that can be used to make the academic buildings in Jabu more energy efficient, which will create a more conducive atmosphere for the users of the buildings. This will be achieved by analysing the principles of passive design strategies that can be incorporated into the design of the academic buildings in Jabu, Ikeji-Arakeji, Osun state The scope of this study is limited to academic building design in Jabu, Ikeji-Arakeji, Osun state with emphasis on the passive design strategies and its impact on the wellbeing of students and staff. The area of study is the Joseph Ayo Babalola university (Jabu), a private Nigerian university that is fully residential and was established in 2004. It has 6 college buildings namely; Agricultural Sciences, Environmental Sciences, Humanities, Law, Management Sciences, Natural Sciences and Social Sciences, Health Sciences. It has a population of over 4000 students

LITERATURE REVIEW

Development of Academic buildings and their importance to students' outcome

Every society's development is crucial, and it has been determined that education is the cornerstone of all social progress and all human endeavors (Archibong, 2010). At the beginning of the 19th century, when modern advancement was beginning, there was a demand for mass education, which led to the construction of vast structures in metropolitan areas for the purpose of educating pupils (Dudek, 2015). Adults preparing children in learning and skills preparation was how education began in antiquity. This was accomplished verbally, through apprenticeship, which typically occurs at the site of training without a specific structure or building for learning. As civilizations developed beyond what could be taught in this way, official settings for learning and knowledge transmission, known as schools, started to emerge (Assmann, 2003). Higher education, in particular university education, has gained popularity recently because of its capacity to foster social and economic advancements fueled by the application of new information. A university is a structured setting for conducting research and disseminating knowledge (Jekayinfa, Yusuf, Yahaya, & Yusuf, 2010). Colleges that are semi-autonomous and typically house living and dining facilities for students make up universities. The colleges are made up of classrooms, and amenities that are not unique to any one college but are required by all colleges are shared and used by them all. Libraries, lecture halls, workshops, and labs are just a few of these amenities (Adler, 2005). These academic facilities are housed in structures that are frequently referred to as academic or educational buildings. The structures also have areas for administration, recreation, and other social amenities. It is evident from the background material on the history, components, and significance of academic buildings in a university setting that their primary function is to offer the educational facilities necessary for research, knowledge generation, and transmission. There are five primary facets of academic facilities namely; acoustics/noise, air quality, lighting, temperature, and space Therefore, as part of their design process it is important to include the incorporation of passive design strategies as these will promote sustainability by relying mainly on natural resources rather that mechanical services which will result in added cost in construction. These strategies will also help to provide a conducive and eco-friendly space for its users

Passive design

Burning fossil fuels like coal, natural gas, and other fuels results in a significant amount of greenhouse gases, which is one of the main causes of global warming. The earth's atmosphere becomes entrapped with these gases, raising the temperature of the planet. We need to lessen our reliance on these non-renewable resources because they are a major contributor to this problem. As heating and cooling utilize the most electricity, passive design solutions enable us to maintain thermal comfort inside a building without the usage of energy. Based on the local climate, passive design strategies are chosen. The type is mostly determined by temperature and humidity. A significant component of environmental design is passive design, which employs a number of methods and ideas that may be applied to buildings in a variety of climates worldwide, including orientation, ventilation, shading devices, thermal mass, insulation, daylighting, and so forth. The key concepts of passive design for tropical structures are;

to avoid heat gain, encourage natural ventilation, make use of natural light and create cool outdoor areas

Passive design strategies in the tropical climate

As mentioned previously, location is a major factor to consider when chosen the best possible passive design strategies, and with the study area situated in the tropics. Passive designs compatible with this climate zone should be analyzed. Tropical climates are characterised by hot, wet summers and high levels of humidity. The most important passive design strategy in the tropics is to open up houses for maximum cross ventilation. Use of lightweight materials for the walls and roof is recommended because they do not store much heat. The building envelope serves as a barrier between the real and virtual climates while creating a home (Altan, Hajibandeh, Tabet Aoul, & Deep, 2016). Along with the technology used, building envelopes are crucial for achieving the appropriate level of comfort. The follow strategies are discussed below.

Orientation- In the tropics, a structure should be orientated to allow for the most ventilation and natural light input while allowing the bulk of walls and windows to be easily sheltered from direct sunlight (Aksoy & Inalli, 2006). Buildings in tropical climates should be oriented with the longest axis facing the east-west direction, to take advantage of windward breezes that help with cooling and block off too much sunshine that can lead to overheating.

Building shape (Massing)-Passive designing includes site planning as a key component. Every component's placement has an impact on how the site's microclimate is governed. In various climates, zoning and massing assist in creating the appropriate microclimate. If massing of the building blocks is constructed in accordance with climatological needs, it helps reach levels of thermal and visual comfort. Building components channel or hinder wind flow and provide adjacent areas with shading. The design and geometry of the building blocks can affect the direction and speed of the wind.

Landscaping-The combined effect of hard surfaces in our cities is known as the urban heat island effect. Hard surfaces absorb heat and then re-radiate it, creating a hotter microclimate. Reducing the extent of paving and other hard surfaces that reflect and/ or store heat and replacing these with vegetation will result in a cooler building and more enjoyable outdoor areas. Planting areas with dense vegetation and creating shaded areas will achieve even greater temperature reductions.

Thermal mass- In tropical climates, the use of lightweight construction materials with low thermal mass is preferable. High thermal mass materials work best in temperate climates where there is a significant change in temperature between night and day. Warm nights mean that heat is not flushed from the thermal mass and instead radiates back into the building. Use of high thermal mass construction materials is therefore generally not recommended in the tropics.

Insulation- Insulation controls the rate at which a building loses or gains heat. In the tropics, reflective insulation installed under roof sheeting is highly effective as it does not trap heat inside the building. Ventilating the ceiling cavity can also help to dry the area out, reducing the chances of mold growth. Insulation materials are given an R value, which rates the material's resistance to heat flow. The higher the 'R' value the greater the insulating effect. An R value is not a measure of reflectivity and so is less effective as a measure of insulating effect.

Windows – In a tropical climate, windows should ideally be shaded from direct sunlight. Where effective shading cannot be achieved, insulating windows against heat transfer can reduce cooling costs. Louvres and casement style windows allow building users to control how much natural air enters the building. The following measures can help reduce heat input through glass; Tinted glass, Reflective coatings and other Advanced glazing technologies-

Natural lighting- Maximizing the amount of natural light that enters a structure should be a design goal. As a result, there may be a large reduction in energy use and demand for artificial illumination. However, the advantages must be weighed against measures to control heat gain and glare. Because of this, all glass needs to be protected from the sun's rays or glazing techniques that lessen heat transfer. Through the following solutions, natural light can be brought into a space; skylight, atria, light shelves, clerestory windows and light tubes

Water bodies and vegetation- The modification of urban temperature through landscape approach can be achieved by incorporating sustainable landscape design practices via the interplay of natural vegetation in the hot-humid (Thani, Mohamad, & Idilfitri, 2012) A versatile solar and wind penetration controller for buildings is vegetation. It lessens the amount of direct sunlight that strikes and heats up building surfaces. It also lowers the temperature of the outside air, which affects how much heat is transferred from the outside to the building exterior and inside. It may also be utilized as a component of interior shading. When used in this way, plants raise the shade coefficient, a metric for how well shading devices work, while maintaining external vistas. Plants can be employed as inexpensive, versatile shade elements because they also grow toward the sun and their growth varies with the seasons where the structure is located.

RESEARCH METHODOLOGY

Earlier related literatures were reviewed to justify the area of choice for research as well as the most appropriate methods to adopt in order to obtain data. The research type that was finally chosen for this study was the qualitative research method. This method in relation to the research, entailed the collecting and analyzing data on issues related to passive design strategies used in academic buildings in Jabu. This research method would explain the action plan for achieving each of the specified goals. Information from a direct personal observation schedule relating to passive design strategies used in academic buildings was gathered as primary data. Secondary data were created using information from government publications, books, scientific papers, newspapers, journals, the internet, and other unpublished materials. For the purpose of this research the instruments used in the collection of data were an observation checklist and related literature. It consists of a section consisting of variables that tackle the main five areas of design consideration in an academic building namely; acoustics/noise, air quality, lighting, temperature, and space. A random sampling technique was used to select 8 buildings that would be evaluated for the study as shown in Table 1. Descriptive statistics were employed as the method of data analysis for this study, and it was used to identify the passive design techniques applied in the chosen academic buildings in Jabu. SPSS was used to compile the data, and Microsoft Excel Spread Sheet Program templates were used to display it.

Table 1: Academic building sample size

S/N	Academic building type	Selected academic building
1	Main library	Jabu library
2	College	College of law
3	Lecture theatre	College of law Lecture theatre
4	College	College of environmental sciences
5	College	College of Health Sciences
6	Lecture theatre	Mass comm. Lecture theatre
7	College	College of postgraduate studies
8	College	College of social sciences

DISCUSSION OF FINDINGS

At the end of using the observation checklist to carry out the study, the parameters mentioned in the literature review were used to evaluate the selected academic buildings and the data acquired is discussed below.

Orientation of building

The data displayed in Figure 1 shows that out of the academic buildings evaluated, 67% of them had their building oriented to south- west, while the remaining 33% had their building oriented to the north-west. It was advised from the findings that in the tropics, it is best for the buildings to be have a north-south orientation in order to take full advantage of wind ward breeze that will add in cooling and help to block out excessive sunlight that would cause overheating. In conclusion, all case studies did not consider building orientation in their design.

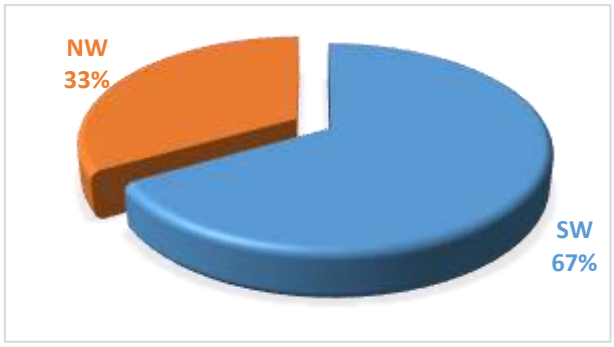

Figure 1: Orientation of buildings

Average number of windows per wall in rooms

Windows are important building elements as their quantity in a room will add in the admission of natural ventilation in a space. It is important to provide at least 2 windows per wall in a room to allow adequate amount of air to enter into the space. The data displayed in Figure 2 shows out of the 6 case studies evaluated, 16% of them had an average of 1-2 windows per walls in their rooms, 17% of them had an average of 3-4 windows per walls in their rooms while the remaining 67% of them had an average of 6 windows and above per walls in their rooms. In conclusion majority of the case studies provided the recommended number of windows per wall in a room.

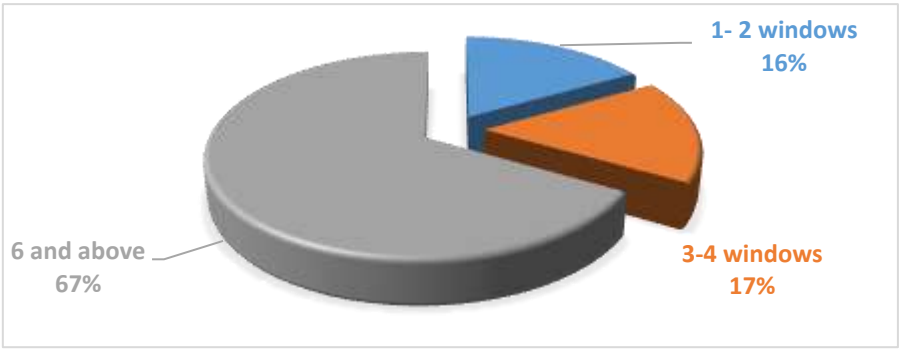

Figure 2: Average number of windows per wall in rooms

Type of window glass treatment

When it comes to the windows, the type of treatment of the glass is another technique in passive design that helps to reduce the amount of heat admitted in a space through the glass of the windows. It was advised from the findings to use tinted glass, reflective coating and other glazing technologies for the windows The data for this variable shows that none of the academic buildings utilized this technique in the reduce the heat gain in the buildings.

Placement of windows

Placement of windows is key when designing to take advantage of the direction of air flow. For the findings it was advised that windows should be placed facing the direction of the north-east and south-west prevailing winds. Figure 3 shows that out of all the academic buildings evaluated, 17% positioned their windows towards the north-west, 16% positioned their windows towards the south-east. These academic buildings being as they did not position their windows in the direction of the prevailing winds, will have to most likely rely on air-conditioning systems which will result in added cost to the building the remaining 67% positioned their windows towards the south west. In conclusion majority of the case studies positioned their windows appropriately.

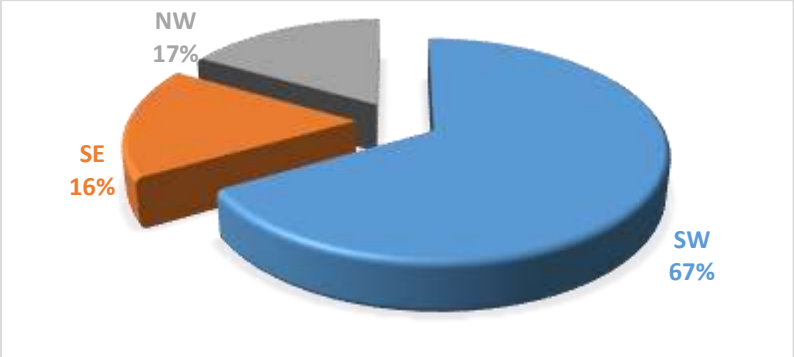

Figure 3: Placement of windows

Presence of shading devices for windows

Windows aside from being used to administer natural ventilation into a space, need to be shaded from direct sunlight and it was advised form past literatures to provide shading devices for windows. It was found out form the field work that none of the case studies provided shading devices for their windows which will result in glare and increase of heat gain in the spaces which will cause discomfort for the users of the space, this can also be seen below in Plate I.

Plate I: Approach view of the College of Health Sciences

Presence of water bodies or vegetation

Figure 4 displays data that shows that out of all the academic buildings evaluated, 71% of them had trees present in close proximity to them, this is extremely beneficial as vegetation serves as a versatile solar and wind penetration controller for buildings. The remaining 29% of the academic buildings did not have trees planted close to them, this will be an issue as the trees would have helped to lower the amount of heat transferred into the buildings. In conclusion, the presence of trees was considered for majority of the evaluated buildings.

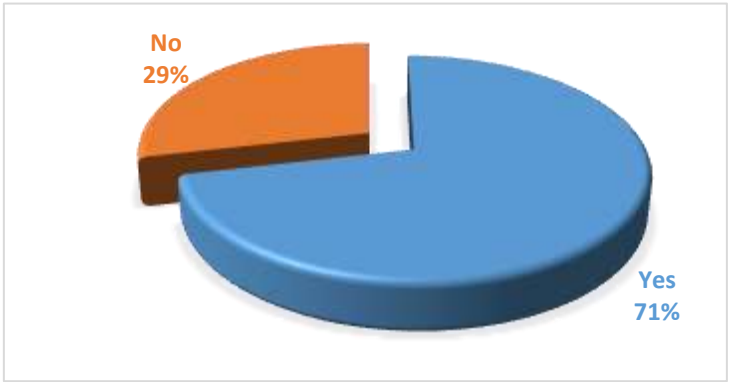

Figure 4:Presence of water bodies or vegetation

Construction material for walls

In tropical climates, the use of lightweight construction materials with low thermal mass is preferable because they respond quickly to cooling breezes allowing the building to cool faster. Therefore, it is typically not advised to use high thermal mass building materials in the tropics. The results from the data showed that all the case studies used concrete which is a high thermal mass construction material. It is recommended that the buildings should be adequately shaded to prevent heat gain and insulated internally to lessen heat transmission.

Colour of paint for interior walls-light, dark, reflective

The data retrieved for this variable showed that all the evaluated academic buildings used light colors for their interior walls. It was advised from the findings that light colours should be used to improve the effectiveness of natural lighting as dark or reflective colours would have provided a disadvantage as they attract heat which will in turn create an overall incondusive atmosphere for users of the buildings.

Presence of natural lighting elements

As stated by past literature, buildings should be designed to maximize the amount of natural lighting that enters them. The data displayed in Figure 5 shows that out of all the academic buildings evaluated, 50% of them made use of natural lighting devices, specifically the use of clerestory windows. This window provides an added advantage of allowing hot air to escape quicker from a room. The remaining 50% of the academic buildings that did not provide any natural lighting elements face the problem of having to rely mainly on artificial lighting. In conclusion only half of the evaluated buildings provided this.

Figure 5: Presence of natural lighting devices

Presence of courtyards

The data displayed in Figure 6 shows that out of all the academic buildings evaluated ,57% of them had courtyards while the remaining 43% did not. The ones that have courtyards have the advantage, because as a part of the courtyard is heated by the inclined direct sunlight, the rest will remain cool due to shade from the adjacent wall, raising the hot air due to the stack effect. In conclusion majority of the buildings provided this.

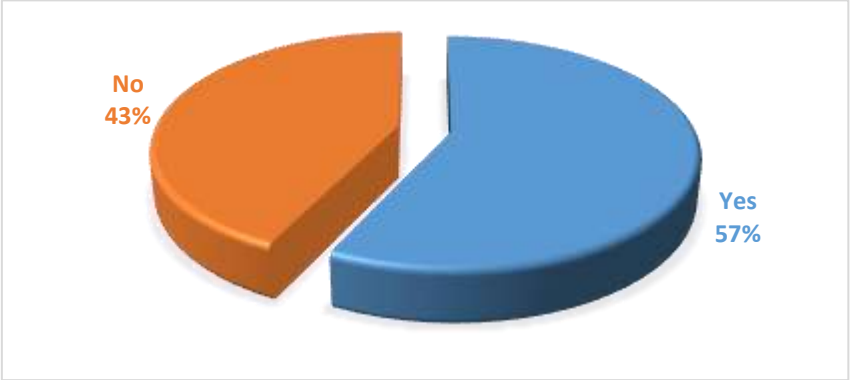

Figure 6: Presence of courtyard

CONCLUSION AND RECOMMENDATIONS

In Jabu it was observed that their buildings are not energy efficient and the purpose of this study was to highlight passive design strategies that can be used to improve on the buildings and provide recommendations for future designs. It was observed from the findings that out of all the parameters used to evaluate the selected academic buildings, the first one that was seen to have been neglected is the orientation of the building. In the tropics, it is advised to orient the buildings with the longest axis lying along the east-west direction to take advantage of windward breezes that help with cooling and block off too much sunshine that can lead to overheating. As seen from the results this orientation is not always possible, so in these cases it is recommended that those sides of the building exposed to the sun should have trees planted there to provide shade and help lower the amount of heat transferred into the buildings. The second parameter that was observed to have been ignored was the type of window glass treatment. From past literature, it was recommended that aside from shading the windows, extra measures that can be put in place to reduce heat transferring through the glass are, using tinted glass, using a reflective coating and other advanced glazing technologies. The results from the findings also showed that shading devices were not provided for the windows in majority of the evaluated buildings. It is advised that where effective shading cannot be achieved, insulating windows against heat transfer can reduce cooling costs. The choice of construction materials for all the evaluated buildings was seen to be concrete which has a high thermal mass and will transfer more heat into the building. It is recommended that the buildings should be well shaded, with trees to avoid heat gain and insulated internally to reduce heat transfer. Lastly, the selected academic buildings were checked to see if natural lighting elements were used aside from windows and only a few did, specifically clerestory windows. It is recommended that for future designs this as well as the incorporation of atriums, skylights, light shelves and light tubes should be considered.

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