Assessment of Architects’ Knowledge of Passive Design Strategies in Terminal Buildings among Architectural Firms in Lagos State

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Abstract. Buildings are responsible for over 40% of the global energy consumption in recent times. This has led to the advancement of various strategies for ensuring that building can still perform optimally with a reduce energy consumption level. Designers of modern building structure need to develop a new approach towards harnessing the attributes of nature and its immediate environment in order to achieve a great level of indoor comfort to the users. The concept of passive design planning and strategies has been known to achieve such thermal performance in building a structure and reducing energy consumption to the barest minimum. The study aims at conducting an assessment on the knowledge level of Architects conducting business in Lagos State of passive design strategies in terminal buildings. The study was a questionnaire survey with a sample size of 128 randomly selected registered architectural firms located in Lagos. Descriptive statistics were conducted on the data and the result was presented using Table. The study revealed that Architects in Lagos state have good knowledge about passive design strategies in terminal buildings as all the mean scores were above 3.0. While, building orientation, daylighting, natural ventilation and proper landscaping were identified as the most important among the strategies employed for the passive design of terminal buildings in the achievement of users’ thermal comfort and towards the accomplishing reduced use of mechanical technologies.

Keywords: Passive design, passive strategies, terminal building.

1. Introduction
“Buildings account for approximately 40% of global energy consumption and one-third of global Green House Gases (GHG) emissions. A significant proportion of the energy utilization is due to the spread of the heating, ventilating, and air conditioning (HVAC) installations in response to the growing demands for better thermal comfort within the built environment” [6]. The total amount of energy consumed in building sector is on a great scale and is expected to increase because of improving standards of living and growing world population. Artificial cooling of buildings requires huge power consumption [7]. It is important to achieve a high level of thermal comfort through natural means aided by passive cooling techniques. This contributes to the improvement of interior thermal comfort experienced in the building and brings the amount of energy consumed in the building to the barest minimum thus, resulting in an energy efficient building. Several studies have been conducted with the goal of addressing the results of the applications of passive strategies. In addition, due to the effect of climate change, many approaches were emanated most of which were based on the use of mechanical technologies or active designs in the achievement of thermal comfort for users especially in the developing countries [3]. However, in Nigeria research have also revealed that buildings are becoming more aesthetically pleasing rather than energy efficient resulting in the use of excessive energy in cooling of the buildings [8].

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Therefore, promoting sustainable development is seen as a priority in recent days and this is a result of rapid population growth, environmental impact and the advancement of developing countries. This cause leads to a great increase in the demand for energy to cater to the increasing population and activities in cooling of buildings. To resolve this situation with no trade-offs of human comfort, an integrated approach in building designs is suggested. Which entails the incorporation of various passive cooling techniques and building services from the initiation of the design stage for adequate energy consumption in the Nigerian climate. An energy efficient passive design helps in improving the indoor thermal comfort of building users with minimized energy consumption. For instance [4] indicated that air conditioning use has increasingly penetrated the market during the last few years which, has greatly contributed to the increase in energy consumption globally. Therefore, there is a need for the investigation to be conducted on the use of passive design especially based on geographical location. However, the focus of this study is to investigate the level of knowledge of Architects in Lagos State about passive design strategies adopted for terminal buildings.

2. Literature Review

2.1 Terminal Building
Terminals are structures through which passengers go through before and after boarding a transport medium. Literature has revealed that these terminals should be able to handle tranship of passengers by connecting the passengers and the transportation modes. Terminals are also referred to as points of interchange between the same or different modal system and their respective transport networks [8]. The number of time passengers spends in terminal buildings tend to be brief because terminals are meant to serve the purpose of boarding. Such a facility is usually made up of simple components such as ticketing office, waiting for the area and a limited amount of retail spaces.

Terminals must be designed to accommodate both the expected capacity and still give room for future increase in capacity [8]. This implies that the terminal should not only be designed based on the present need but a rather future increase of capacity must be put into consideration. Therefore, modern terminal requires massive investments and are among the largest structures ever built. A utilization rate of 75 to 80 percent is considered to be optimal, therefore, anytime the usage of a terminal is beyond the aforementioned level congestion is said to arise, which ends up undermining the reliability of the terminal facility [8]. In the design of any facility or infrastructure, it is paramount that the selection of a suitable geographical location be well considered so that the facility can serve its expected purpose.

2.2. Passive Design and Strategies
Passive designs are steps taken by a designer in other to achieve thermal comfort of the users. This could also be seen as means, ways, strategies through which thermal comfort can be achieved in a building by making use of the natural energy flow. This is achieved by considering the use of appropriate building materials and landscaping features while the building orientation is also considered alongside [12]. This, in essence, enables interactions and distribution of energies mainly from renewable sources such as solar, wind, etc. Adoption of passive design leads to the reduction in the use of mechanical technologies in the achievement of thermal comforts for the building user [2]. Passive designs are achieved through various design strategies that focus mainly on the use of the resources in the natural environment in a way that all the three dimensions of the passive design (lighting, ventilation, and heating) is enhanced. The climate of the immediate environment and the comfort of the users are vital elements to be placed into consideration when a designer considers the use of passive design [12].

The ultimate goal of passive design is to eliminate the need for any active mechanical systems to maintain occupant comfort, although this goal is said not to be a very realistic goal for most commercial building projects. Passive design solutions are the most cost-effective and are easy to use during the design and construction of new buildings. Thereby, passive design strategies are best implemented during the initial design phase of new construction projects, although they can also be effectively
employed during retrofits of existing buildings but may be more challenging, because the average commercial building has a lifespan of 70-75 year.” [9].

[4] Indicated that there are different strategies that can be employed in other to achieve a passive design which are:

I. **Passive heating**: Passive heating focuses on the use of energy generated directly from the sun to achieve sufficient indoor thermal comfort without the usage of features that are energy-intensive in nature. Two major approaches can be adopted by a design in the achievement of passive heating which are direct heat gain and double walling systems. Other approaches that can be used in the achievement of passive heating includes use of glazing and shading devices.

II. **Passive cooling and ventilation**: Passive cooling is a passive design strategy that enables designers to achieve a thermally comfortable and serene environment for its occupants. It focuses on the reduction of heat gain and removal of internal heat from building interiors. This could be achieved using insulation for reduction of heat gained, thermal mass for storage of heat, radiative cooling to reduce dependency on mechanical cooling, natural ventilation for reduction of energy use and increase of air flow. In addition, other methods include the increment of air movement, proper landscaping, use of evaporative cooling features, adoption of shading devices and glazing features and use of building envelopes and proper orientation of the building. Furthermore, passive cooling strategies are often enhanced when they are designed in parallel with passive ventilation strategies, which provide increased airflow when the outdoor air temperature is low enough to flush heat from the building.

III. **Passive Water Strategies**: This strategy enhances the use of domestic hot water and portable cold water. It involves the introduction of passive design into the use of water in a building. Some of the approaches through which this can be achieved are a collection of rainwater, heating up of water using natural occurring heat source and recycling and use of greywater.

IV. **Daylighting and Lighting Controls**: this strategy enables the designers to make use of natural lighting in the achievement and maintenance of adequate indoor lighting, thereby reducing the dependency of the building on electric lighting sources. Lighting controls help in adjusting the use of artificial lighting by considering the users lighting requirement, occupancy, and ambient light levels. This could be achieved using occupancy, photo-sensors and daylighting sensors. Daylighting has often been recognized as a useful source of energy saving and visual comforts in buildings” [5], Natural lighting also help achieves happiness and well-being of the users. Sun lighting can be controlled through the use of shading devices and proper orientations of windows. Therefore, great emphasis should be placed on the need to create a link between the passive design strategies adopted by the designer and the end-users comfort level while designing buildings or facilities. This is because it is impossible for designers to deliver a sustainable building without considering the need of the end users. Since, thermal comfort is that state at which users expresses satisfaction due to the way he senses the immediate environment.

3. **Research Method**

The data presented in this paper were drawn from a bigger research project designed to investigate passive design and planning strategies implemented in terminals buildings in Lagos State, Nigeria. The research approach was a survey and the data used was purely quantitative in nature. The study population consisted of all registered architectural firms located in Lagos State resulting in 206 firms based on data provided by the Architects Registration Council of Nigeria (Architects Registration Council of Nigeria, 2013).

The sample size was calculated using the Yamane Equation for finite population = N / 1 + N (e) 2…………………………………………………………………………………..(1)

Where, n = sample size, N = population size (206), e = level of precision (0.05) based on a 5% margin of error and 95% confidence level.
Therefore, study sample size \( n = \frac{206}{1 + 206 (0.05)^2} = 128.75 \) (approximately 128)… (2)

The sampling method adopted for the study was a random selection of firms among the registered architectural firms in Lagos to make up the sample size. However, one employee was selected to represent the firms in the filling of the questionnaire.

The questionnaire used consisted of 4 thematic sections. Section A covered the bio-data of the respondents, Section B covered respondents’ level of understanding with basic concepts in relation to the use of architecture in achieving the passive design. In addition, Section C investigated the level of importance of the passive strategies adopted by the respondents in the design of terminal buildings while Section D covered the extent of influence of the adopted passive design strategies on users’ thermal comfort in the terminal building as perceived by the respondents. The researchers between December 2018 and February 2019 administered 128 copies of the questionnaire, while, 110 copies were retrieved and suitable for analysis making about 86% of the total administered. Descriptive statistics were used for the analysis of the data using the Statistical Package for Social Sciences (SPSS) version 21. The results were presented in Tables.

4. Results and Discussion

Based on the objectives of the study, this section presents the result of the study and discusses it in line with literature.

4.1 Personal Profiles of the Respondents

Table 1 shows the result of the personal profile analysis of the respondents in the research

| Variables               | Categories of users | Percentage (100%) |
|-------------------------|---------------------|-------------------|
| Gender                  | Male                | 65                |
|                         | Female              | 35                |
| Age of respondents      | 18-27 years         | 20                |
|                         | 28-37 years         | 14                |
|                         | 38-48 years         | 47                |
|                         | 48 and above        | 19                |
| Educational Respondents | ND                  | 8                 |
|                         | HND/B.Sc.           | 63                |
|                         | Master’s Degree     | 21                |
|                         | Ph.D.               | 8                 |
| Occupation of Respondents | Civil Servant      | 10                |
|                         | Private Sector Employed | 54            |
|                         | Self Employed       | 33                |
|                         | Retired             | 3%                |

Table 1 revealed that majority of the respondent is male, while many of the architects fall within the age range of 38-47 years. In addition, Table reveals that highest among the Architects had National Diplomat (ND) holders as their highest level of qualification, next to which is the Bachelor of Science. While 54% of the respondents were privately employed. This result implies the majority of the employee in Lagos State are male, Adults and have some level of education which makes them suitable for the study.
4.2 Respondents’ level of understanding of the various concepts associated with passive design in buildings

Table 2 shows descriptive statistics of the respondent’s knowledge of key concepts as regards the use of passive strategies in the design of terminal buildings. The result as presented in Table 2 indicated that the participants in the survey generally had a good knowledge of all the passive design concepts investigated in this study as all the mean score values were above 3.0. This is because any value below 3.0 implies that respondents are not familiar with the concepts while values above 3.0 imply they are familiar with the concepts under study. However, Table 2 further showed that the respondents are most familiar and have the best understanding with passive design concepts such as the daylighting (mean score=3.84), natural ventilation (mean score=3.77), building orientation (mean score=3.56) and sun shading devices (mean score=3.55), as these four strategies of passive design were ranked from 1st to 4th respectively.

Table 2: Descriptive statistics of the respondents of passive design concepts

| Passive Strategies         | Mean Score | Std. Deviation | Rank |
|----------------------------|------------|----------------|------|
| Daylighting                | 3.84       | .86233         | 1st  |
| Natural Ventilation        | 3.77       | .99226         | 2nd  |
| Building Orientation       | 3.56       | .96343         | 3rd  |
| Sun Shading Device         | 3.55       | .93491         | 4th  |
| Indoor Space Quality       | 3.53       | 1.04670        | 5th  |
| Building Material          | 3.49       | 1.01136        | 6th  |
| Building Mass              | 3.43       | 1.04451        | 7th  |
| Indoor Air Quality         | 3.29       | .83880         | 8th  |
| Landscaping                | 3.22       | 1.12830        | 9th  |

4.3 Respondents perception on the importance of strategies in achieving passive design in terminal buildings

Table 3 reveals the respondent’s opinion about how important the strategies adopted by their firms had helped in achieving passive designs in terminal buildings. The result has presented in Table 3 revealed that all the strategies investigated in this study are important towards the achievement of passive design in terminal buildings. However, building orientation, daylighting, natural ventilation, landscaping with mean score values of 4.32, 4.30, 4.27, 4.10, respectively were identified by the respondents as the features of passive design with the highest level of importance in the design of terminal buildings. This is because the aforementioned strategies ranked from the 1st to 4th among all the strategies investigated in this study. This implies that in achieving a passive design in terminal building it is important that much attention is placed on proper orientation, daylighting, natural ventilation and landscaping of the building in other to achieve thermal comfort by the users of the terminal. As this strategy was established as some of the key strategies towards the achievement of passive design in buildings [3].
Table 3: Respondents perception on the Level of importance of strategies in achieving passive design in terminal buildings

| Passive Design Strategies                | Mean  | Std. Deviation | Rank |
|-----------------------------------------|-------|----------------|------|
| Building Orientation                    | 4.32  | .64867         | 1st  |
| Daylighting                             | 4.30  | .79621         | 2nd  |
| Natural Ventilation                     | 4.27  | .72831         | 3rd  |
| Landscaping                             | 4.10  | .81218         | 4th  |
| Shading Device                          | 3.79  | .95874         | 5th  |
| Indoor Air Quality                      | 3.74  | .82035         | 6th  |
| Building Material                       | 3.67  | .91980         | 7th  |
| Building Mass                           | 3.63  | .96602         | 8th  |
| Internal Layout of the Building         | 3.55  | .96390         | 9th  |

5. Conclusions
This study conducted an assessment to reveal the knowledge level among Architect conducting business in Lagos State about passive design strategies used in the design of terminal buildings. The result of the study revealed that the knowledge of Architect about all the strategies investigated was quite good. While more importance was placed on proper building orientation, the adequate harnessing of daylighting, designing to accommodate natural ventilation and proper landscaping of the immediate environment among the strategies employed for the passive design of terminal buildings. This, in essence, helps in the achievement of thermal comfort of users since the immediate climate of the proposed terminal building has been mostly considered. This assertion aligns with a statement from [13] which, indicated that in the use of passive design for any building or facility it is important that the microclimate and the user's comfort be well-thought-out.

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