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ARTICLE

# Evaluation of Thermal Comfort in the Design of Student Hostel at Federal University of Technology Minna, Nigeria

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ABSTRACT

Buildings are designed to offer protection to the occupants against harsh outdoor environment thereby enhancing optimal indoor comfort. Over the years, there have been a rise in population of students applying for admission into tertiary institution, which has led to an increase in the number of students that resides at the university hostel. These rise in the number of students, has brought about overcrowding and stretching of facilities, with spaces which were originally intended for four students are now been habited by six to eight students thereby causing imbalance in the general indoor climatic condition. The study is aimed at investigating thermal comfort in student's accommodation in tertiary institutions towards achieving a better thermal condition in the hostel environment. The objective is to evaluate the thermal performance in the student hostel accommodation, and also to identify passive ways of controlling thermal performance in student dwelling buildings at Federal University of Technology Minna main campus, Gidan Kwano. For the purpose of this research work, primary data were collected through the use questionnaire, case studies and observation. Secondary data were collected from available literature, internet, and studying of similar existing facilities. The study revealed that most student hostel possessed few elements of passive cooling technique which in turn deprives students a quality conducive environment. The research recommends that soft landscaping elements should be adopted and deciduous trees planted in the environment for cooling effect during hot and humid period, provision of two openings in each room if possible. This can be achieved through proper building orientation, use of high thermal mass to reduce heat absorption, use of high thermal mass with night cooling, roof, ceiling and attic insulation. Designing in a hot climate area requires lots of consideration, which is mentioned above so as to incorporate a general conducive indoor thermal comfort for the users.

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## 1. Introduction

Students, travelers, and bag parkers primarily use hostels as a form of accommodation. In Nigeria, hostels are referred to as student housing or long-term housing for drug-dependent individuals or homeless people**.** The hostel is primarily used by students who travel long distances to school and pursue their educational goals. Because they share rooms, sit in the same communal areas, and play games together, the hostel serves as a means of bringing people from diverse backgrounds together (cultures, faiths, economic status, and age groups). They develop a sense of priority and self –reliance as a result of living in an educational environment where their attitude is properly regulated and their intellect is equally cultivated in an intellectual direction [8]. It is the most physical and ancient evidence of civilization in a country, and it serves as a showcase for a society's cultural, social, and economic ambitions [2].

Student housing has become a significant source of concern as the student population has grown as a result of increased interest in higher education over the years. The growing population has sparked an increased interest in identifying and exploring the most feasible approaches to achieve a thermal efficient, conducive academic hostel environment, which includes everything from inadequate infrastructure to congestion. The significant of having a thermal efficiency and a functional student hostel in Nigerian federal institutions cannot be overstated, as students are expected to be in a healthy mental state in order to carry out their academic responsibilities [9]. A strong student residence system is necessary because student residence encompasses more than physical safety; it also encompasses the maintenance of a healthy and social behavioral balance, a student's productivity may be related to his or her living situation [10].

## 2. Theoretical Background

A German school teacher, Richard Schirmann, introduced the student hostel and recognized that groups of children need a night shelter to discover the countryside. He opened the first hostel of the building, where he worked as a teacher. In 1912 he was transferred in the town of Altenain to the nearby Altena castle and Schirmann always organized his pupils on rural excursions before setting up the student dormitories. During night visits, the students took shelter in the farmhouses and schools, moved desks, and other equipment for bedding. These transformed the school rooms into better rooms, which gave rise to the concept of the hostel, called the Youth Hostel. The German Youth Movement has been developed and hostels are established to accommodate young people who attend outdoor training to get fresh air and to develop a healthy life away from the chaotic cities that seem to dismiss their cultural values and community lifestyles. Young people take part in scouting, climbing, walking, mountain biking, etc. These activities offer young people enough opportunity to improve their health and social well-being physically. Normally, these hostels were closed for many afternoons because guests went adventurously.

There are different types of hostels for homeless people, travelers and parkers. Hostels have many shapes, and some hostels are dormitories with the possibility of accommodating doubles, quads and some are single or double, depending on their purpose and services. Also, the security in hostels presents an opportunity for late night interaction and discussion which in all sense aid in shaping and sharpening the student's life to better appreciate his or her role in and responsibility to the society in which he or she lives [6].

Richard Schirrmann copied and implemented the idea of hostelling in various countries and spread quickly and eventually led to Hostelling International being formed (HI). Hostelling International comprises over ninety different associations of youth hostels from over eighty different countries, representing more than four thousand, five hundred young hostels. Several hostels have catered more to children of school age (through school trips/excursions), parents to their children and adventurers seeking to learn new cultures, while other hostels have catered to those who enjoy indoor and outdoor activities like hilly walking, climbing and biking [7].

## Thermal Comfort

Various factors relating to work depend on thermal comfort. It has the potential to change the distraction levels of the occupants and thus their performance and execution of daily activities. In addition, warm discomfort has not been linked to symptoms of Sick Building Syndrome. The U.S. Environmental Protection Agency's Building Assessment Study and Evaluation Study reports higher internal temperatures, even within the proposed warm soothing reach, increased worker symptoms. As the winter temperatures are more different between indoor and outdoor air, the number of manifestations is significantly higher than in late spring.

The human body's thermal balance relates to the absorption of the food digestion system, which includes procedures for converting food into live matter and vitality, gives the human body vitality [12]. Basal metabolism is the least amount of vegetative heat generation needed to sustain critical unintended body functions, such as respiration, cardiac beat, blood circulation and internal organ activity. Muscular metabolism is muscle heat creation during work or activity. The body is not very efficient in turning chemical energy into physical energy, and approximately 80% of produced energy has to be wasted as heat. Apart from basal and muscle metabolism, the heat can be collected from your environment by conduction, convection and radiation. Heat can also be lost from the body through conduction, convection, radiation and evaporation [11].

## Orientation

The orientation of a building is important to consider while designing it, especially in terms of solar and wind exposure [3]. Buildings should be positioned to maximize solar gain in mostly cold regions, whereas the opposite is recommended in predominantly hot regions. Both circumstances can occur on a regular basis in places with significant seasonal fluctuations [4]. In a chilly area, an orientation somewhere east of south (particularly $15^0$ east of south) is preferred since it exposes the unit to more morning sun than afternoon solar, allowing the house to begin to heat during the day. Wind can be beneficial or harmful in the same way. Sun and wind orientation must frequently be balanced. Shading and deflecting devices can be incorporated into the design to either exclude or redirect the sun, just as wind can be diverted or directed to the appropriate extent [5].

## 3. Data Collection and Method of Assessment

A survey conducted by a number of students with substantial experience of the thermal condition of the hostel environment in the hostel setting. Questionnaires given to students residing in the hostel enhanced the accuracy and validity of the data. The survey took a proper examination of the building structure in order to provide credible structural information. The survey sampled three main hostels at the Gidan Kwano main campus of the Federal University of Technology Minna; the Boys hostel, the Girls hostel and the newest hostel. The questionnaires were carefully delivered morning, midday and evening to the respondents to determine their thermal feeling votes for these periods. Case study is a dominant approach in architectural research and characterized by a predetermined choice of the case to study enhancing multiple methods of data collection [13]. Several criteria were defined for an adequate case study; consideration of existing buildings with similar functions, the building site for the evaluation of thermal comfort, the study location atmosphere and materials for building design.

## Validity and Reliability of Instruments

Content validity refers to the extent to which a scale measures the concept it is intended to measure [1]. The validity of the instrument was obtained with the alpha from Cronbach. The questionnaire was given to students who exclusively lived in the hostel environment to determine and achieve dependability of the device, in order to acquire precise and valid data on their thermal perception of the hostel environment. For each scale, Cronbach's alpha was calculated using SPSS 22. The scales had satisfactory values and the internal reliability coefficients of respondents were 0.611 (Table 3). This is called to be the modest and sufficient.

| Cronbach's Alpha | No of Items |
|---|---|
| .611 | 39 |

## Data Presentation and Analysis

The number of questionnaires sent and the response rate for the study are shown in Table 1. The thermal environment in the student hostel was assessed; only 130 out of a total of 150 questionnaires were filled out and returned. This reflects an 87% response rate. As a result, the response rate obtained for this study is deemed adequate for the analysis.

**Table 1.** Respondents' response rate

| Location | Distribution (No) A | Returned (No) B | % of response rate (B/A *100) |
|---|---|---|---|
| Boys hostel | 50 | 45 | 90% |
| Girls hostel | 50 | 45 | 90% |
| Newest hostel | 50 | 40 | 80% |
| Total | 150 | 130 | 87% |

Source: Author's field work, 2021

**Table 2.** Case Processing Summary

| | | N | % |
|---|---|---|---|
| Cases | Valid | 127 | 100.0 |
| | Excluded[a] | 0 | .0 |
| | Total | 127 | 100.0 |

Source: Author's field work, 2021

Likewise deletion is based on all variables in the procedure.

**Table 3.** Reliability Statistics

| Cronbach's Alpha | N of Items |
|---|---|
| .611 | 39 |

Source: Author's field work, 2021

The entire questionnaire was valid and the reliability test was 0.611 which signals a moderately reliable questionnaire.

**Table 4.** Gender Statistics

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Male | 57 | 44.9 | 44.9 | 44.9 |
| | Female | 70 | 55.1 | 55.1 | 100.0 |
| | Total | 127 | 100.0 | 100.0 | |

Source: Author's field work, 2021

Table 4 above shows that more than 55.1% of the respondents were female while 44.9 were male.

**Table 5.** Age Statistics

| | | Frequency | Percent | Cumulative Percent |
|---|---|---|---|---|
| Valid | Below 18 years | 11 | 8.7 | 8.7 |
| | 18-28 years | 107 | 84.3 | 92.9 |
| | 29-39 years | 8 | 6.3 | 99.2 |
| | 40-50 years | 1 | .8 | 100.0 |
| | Total | 127 | 100.0 | |

Source: Author's field work, 2021

Table 5 identifies 84% of respondents are aged between 18 and 28 years, while 8.7% are under 18 years of age.

**Table 6.** Class Level Statistics

| | | Frequency | Percent | Cumulative Percent |
|---|---|---|---|---|
| Valid | 100 level | 20 | 15.7 | 15.7 |
| | 200 level | 25 | 19.7 | 35.4 |
| | 300 level | 25 | 19.7 | 55.1 |
| | 400 level | 24 | 18.9 | 74.0 |
| | 500 level | 30 | 23.6 | 97.6 |
| | Masters | 3 | 2.4 | 100.0 |
| | Total | 127 | 100.0 | |

Source: Author's field work, 2021

Table 6 displays the surveys disseminated at several levels: 23.6% for 500 level students, 19.7% for 200 and 300 level students, 18.9% for 400 level students, 15.7% for 100 level students and 2.4% for master's level students.

**Table 7.** Thermal Comfort Simulation

| PMV | -3 | -2 | -1 | 0 | +1 | +2 | +3 |
|---|---|---|---|---|---|---|---|
| Thermal sensation | Cold | Cool | Slightly cool | Neutral | Slightly warm | Warm | Hot |

Source: Author's work, 2021

The questionnaire index of Percentage Dissatisfied (PD) is calculated. The number of respondents who indicated discomfort on the thermal comfort feeling scale of 7 points was used to determine the PD index. The expression of discomfort is known when the respondent responds between (-2, -3) and (+2, +3) to any of the thermal sensation inquiries. The PD is determined accordingly.

$$PD = \frac{Number\ of\ questionnaire\ having\ discomfort\ label}{Total\ number\ of\ questionnaire} \times 100$$

**Table 8.** Thermal Sensation Morning

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Cold | 16 | 12.6 | 12.6 | 12.6 |
| | Cool | 42 | 33.1 | 33.1 | 45.7 |
| | Slightly cool | 28 | 22.0 | 22.0 | 67.7 |
| | Neutral | 23 | 18.1 | 18.1 | 85.8 |
| | Slightly warm | 8 | 6.3 | 6.3 | 92.1 |
| | Warm | 6 | 4.7 | 4.7 | 96.9 |
| | Hot | 4 | 3.1 | 3.1 | 100.0 |
| | Total | 127 | 100.0 | 100.0 | |

Source: Author's field work, 2021

Responds from Table 8 indicates that 33.1% of the respondent feel cool and 22% feel slightly cool, only 18.1% feel neutral about thermal performance in the morning.

$$PD = \frac{16 + 42 + 6 + 4}{127} \times 100 = \frac{68}{127} \times 100 = 53.5\%$$

From the calculation above, 53% of the respondent shows discomfort of the thermal performance in the morning.

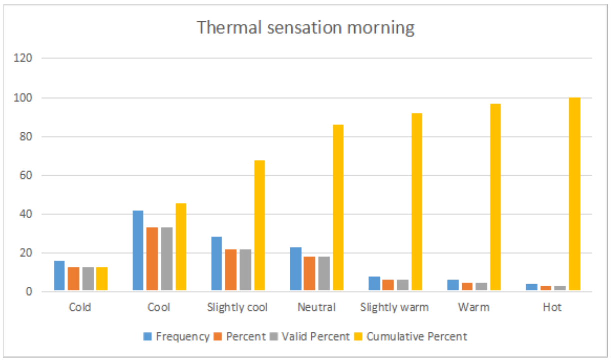


**Figure 1.** Indications for thermal sensation morning

Source: Author's field work, 2021

**Table 9.** Thermal Sensation Afternoon

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Cold | 1 | .8 | .8 | .8 |
| | Cool | 2 | 1.6 | 1.6 | 2.4 |
| | Slightly cool | 4 | 3.1 | 3.1 | 5.5 |
| | Neutral | 22 | 17.3 | 17.3 | 22.8 |
| | Slightly warm | 5 | 3.9 | 3.9 | 26.8 |
| | Warm | 19 | 15.0 | 15.0 | 41.7 |
| | Hot | 74 | 58.3 | 58.3 | 100.0 |
| | Total | 127 | 100.0 | 100.0 | |

Source: Author's field work, 2021

Table 9 identifies the thermal sensation in the afternoon with 58.3% of the respondent feel hot, 15% feel warm while only 17.3% feel neutral about the thermal performance in the afternoon.

$$P = \frac{1+2+19+74}{127} \times 100 = \frac{96}{127} \times 100 = 75.6\%$$

It is inferred that 75.6% of respondents are unhappy with thermal performance in the afternoon. According to the bar chart below, the highest thermal sensation vote for afternoon is slightly hot.

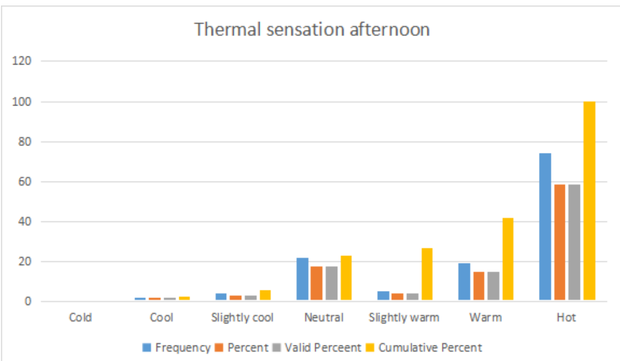


**Figure 2.** Indications for thermal sensation afternoon

Source: Author's field work, 2021

**Table 10.** Humidity Sensation Afternoon

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Very Dry | 2 | 1.6 | 1.6 | 1.6 |
| | Dry | 10 | 7.9 | 7.9 | 9.4 |
| | Slightly Dry | 19 | 15.0 | 15.0 | 24.4 |
| | Neutral | 40 | 31.5 | 31.5 | 55.9 |
| | Slightly Humid | 32 | 25.2 | 25.2 | 81.1 |
| | Humid | 18 | 14.2 | 14.2 | 95.3 |
| | Very Humid | 6 | 4.7 | 4.7 | 100.0 |
| | Total | 127 | 100.0 | 100.0 | |

Source: Author's field work, 2021

Table 10 indicated the responds on afternoon humidity conditions in the hostel environment voted by 1.6% very dry, 7.9% dry, 15.0% slightly dry, 31.5% were neutral on votes, 25.2% slightly humid, 14.2% humid, and 4.7% very humid. If not for neutral votes of 40 occupants, 32 respondents voted the largest condition of slightly humid and 2 stands the lowest responds of very dry condition. Below is the bar chart indices.

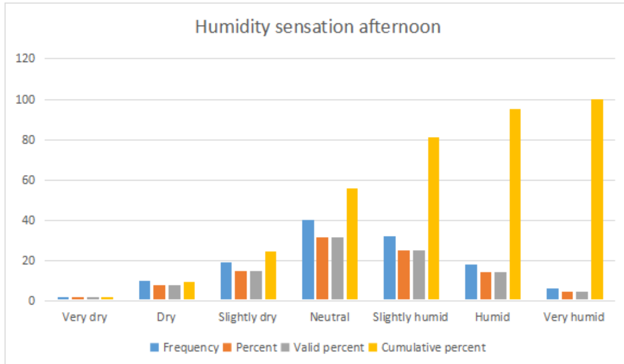


**Figure 3.** Indications for humidity sensation afternoon

Source: Author's field work, 2021

**Table 11.** Humidity Sensation Evening

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Very dry | 2 | 1.6 | 1.6 | 1.6 |
| | Dry | 26 | 20.5 | 20.5 | 22.0 |
| | Slightly dry | 18 | 14.2 | 14.2 | 36.2 |
| | Neutral | 42 | 33.1 | 33.1 | 69.3 |
| | Slightly humid | 22 | 17.3 | 17.3 | 86.6 |
| | Humid | 15 | 11.8 | 11.8 | 98.4 |
| | Very humid | 2 | 1.6 | 1.6 | 100.0 |
| | Total | 127 | 100.0 | 100.0 | |

Source: Author's field work, 2021

Table 11 identified votes counted of students feelings on evening humidity from very dry condition to be 1.6%, dry 20.5%, slightly dry 14.2%, 33.1% for neutral, 17.3% slightly humid, 11.8% to be humid, and 1.6% very humid. 22 occupants voted for slightly humid and 42 were neutral. Below are indices on the bar chart.

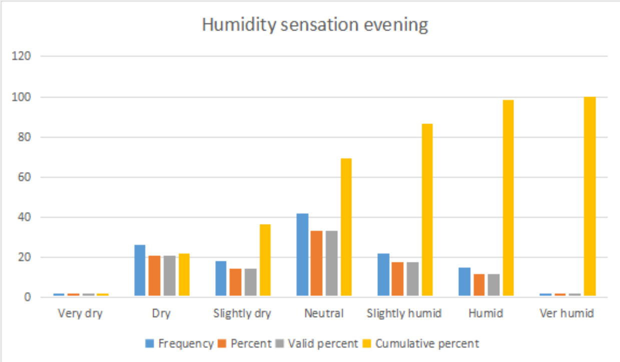


**Figure 4.** Representation on humidity evening

Source: Author's field work, 2021

**Table 12.** Air Freshness Afternoon

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| | Very low | 32 | 25.2 | 25.2 | 25.2 |
| | Low | 36 | 28.3 | 28.3 | 53.5 |
| | Slightly low | 29 | 22.8 | 22.8 | 76.4 |
| | Just right | 17 | 13.4 | 13.4 | 89.8 |
| Valid | Slightly breeze | 7 | 5.5 | 5.5 | 95.3 |
| | Breeze | 4 | 3.1 | 3.1 | 98.4 |
| | Very breeze | 2 | 1.6 | 1.6 | 100.0 |
| | Total | 127 | 100.0 | 100.0 | |

Source: Author's field work, 2021

Below is the bar chart indications for air freshness in the afternoon.

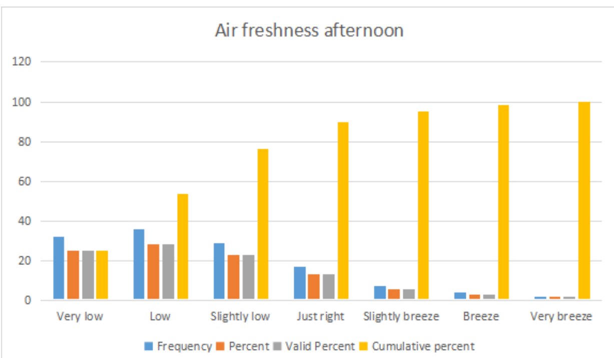


**Figure 5.** Responds from air freshness in the afternoon

Source: Author's field work, 2021

Table 12 and Figure 4 indicate that air freshness in the afternoon stands at 28.3 % low with 36 respondents and 1.6% very breeze with only 2 respondents. That means at afternoon periods, the air freshness is lesser compared to amount of heat experienced in the afternoon periods.

**Table 13.** Air Freshness Evening

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| | Very low | 11 | 8.7 | 8.7 | 8.7 |
| | Low | 14 | 11.0 | 11.0 | 19.7 |
| | Slightly low | 23 | 18.1 | 18.1 | 37.8 |
| | Just right | 27 | 21.3 | 21.3 | 59.1 |
| Valid | Slightly breeze | 37 | 29.1 | 29.1 | 88.2 |
| | Breeze | 11 | 8.7 | 8.7 | 96.9 |
| | Very breeze | 4 | 3.1 | 3.1 | 100.0 |
| | Total | 127 | 100.0 | 100.0 | |

Source: Author's field work, 2021

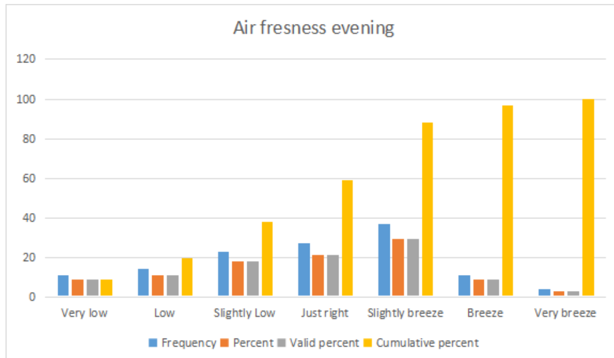


**Figure 6.** Air freshness in the evening

Source: Author's field work, 2021

Table 13 and Figure 6 identify the sensational feelings of evening air. 37 respondents with 29.1% voted for slightly breeze condition while the lowest from 4 respondents went for 3.1% of very breeze. Such reactions indicate breezy air at evening time at Federal University of Technology Minna hostel environment.

## 4. Summary

The overall findings of the analysis suggest that thermal comfort assessment in the design of student hostels shall significantly improve comfort and provide a pleasant atmosphere for students. This research has also shown that certain control measures must be used to enhance pupils' thermal performance. The poll findings showed that 55.1% of respondents were female, 49.9% male, 84% were 18-28 years and 8.7% were under 18 years of age. The surveys were divided into several levels, including 23.6% of 500 students, 19.7% of 200 and 300 graduates, 18.9% of 400 graduates, 15.7% of 100 students and 2.4% of masters' students.

### 4.1 Recommendations

(1) During warm and wet times when the inside cannot be cooled by natural air, soft landscaping elements and faces should be utilized and leafy trees should be grown in order to create that micro climate within and inside the hostel space.

(2) Designs in wet and hot atmosphere should take into cognizance, the placement of the various apertures in the design to guarantee the greatest air pressure differential between entrance and exit, ideally with two openings in each room.

(3) Shading devices such as wings and vertical fins should be introduced in design structure to reduce the amount of radiation within and increase the flow rate.

(4) Private developers in real estate should partner with the Federal Government to construct adequate hostel facilities to cater for the growing population of students into Federal Universities

(5) There should be proper legislation on laws prohibiting overcrowding in student hostels

(6) Considering Minna having hot weather condition, thermal friendly materials should be used in constructing student hostel; clay bricks have quite a friendly nature towards hot weather condition.

(7) Architects should put into cognizance the site orientation in order to minimize radiation of sun into the hostel as a result of sunrise and sunset. Large window openings will provide influx of natural air to ventilate and lighten the interior space.

### 4.2 Conclusions

Natural ventilation is an aspect of green design that requires natural ventilation on the basis of observational and analysis of different case scenarios in order to produce thermal comfort or cooling effect in the interior of the rooms. The orientation of the building, the design layout, the shape of the building, the window size, the wing, the shading devices such as vertical and horizontal finishing, the opening location, the enveloping of the building, vegetation, landscape and the integration of the courtyard and atrium are all examples. Like the stack effect, natural ventilation is based on buoyancy and temperature differential. It was also found that the window type utilized influences the volume of air entering and exiting a structure; casement windows enable 100% of air flow, while sliding windows only allow 50% less passive ventilation. In order to provide general thermal comfort in the interior of the user, it is necessary to build a thermal site in a warm climate, as stated above.

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