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Thermal Comfort Evaluation of Two Naturally Ventilated Architectural Studios in Akanu Ibiam Federal Polytechnic Unwana Ebonyi State –Hot –Humid Environment

[1]Alozie, G. C, [2]Ifebi, O. C & [3]Eze M.U
[1]Department of Architecture, Abia State University Uturu
[2]Department of Architecture, Chukwuemeka OdimegwuOjukwu University Uli
[3]Department of Estate Management, Abia State University Uturu

Abstract
This paper presents the study of indoor thermal comfort carried out in two (2) architectural studios on a first floor of Akanu Ibiam Federal Polytechnic Unwana Faculty of Environmental Studies. The field study was conducted during a hot summer and lasted for 30days the hours 08hrs to 16.00hrs. The study was carried out to assess thermal conditions of the studios during lecture hours. Objective data analysis obtained showing the environmental condition of the studios, and subjective analysis through questionnaire were used to evaluate the thermal sensation of the students. In all environments, thermal adaptation can be based on three different ideologies, namely behavioral, physiological accommodation and psychological training. The maximum acceptable temperature in the study was derived through Predicted Mean Vote (PMV) while the comfort level came from the survey results. The study recommended that functional architectural designs, orientation buildings material application, kind colour and passive techniques will improve studio comfort in hot humid climates such as Unwana.

Keywords: *Thermal Comfort, National Ventilation Architectural studio, Hot Humid Environment.*

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Background to the Study

Thermal comfort is an important factor in all architectural studios, because it affects student's productivity (Alozie, 2015). ASHRAE 55 (2004) defined Thermal comfort as the satisfaction towards a given environment. In any functional space the thermal adaptation can be attributed to three different processes - behavioral, physiological accommodation and psychological training. The evaluation of thermal sensation is based on the international standards like ISO, and ASHRAE and takes into consideration parameters related to individuals and their environments. Indoor thermal comfort could be altered with environmental elements like heat from electrical lighting, poor ventilation, high humidity, and poor performance of building envelopes. The assessment of thermal comfort helps us to find the quality of indoor environment and in the optimization of energy we require to achieve desired comfort levels.

Architectural studios require appropriate temperature and humidity controls that responds to students' and staff sensitiveness, as continued environmental stress can drain student's physical and mental resources, which ultimately affect their performance. Indoor environmental variables like air temperature, relative humidity, mean radiant temperature, air velocity, clothing levels during lecture hours, amount of physical activity done in studios affects human thermal comfort sensation. Fanger's PMV model based on the steady state heat transfer theory is the standard basis of thermal comfort (Fanger, 1970). Nayak, Hazra and Prajapati (1999) specified the importance of the comfort temperature.

Ones reaction towards the tolerance of higher temperature depends on expectations, personality and rate of work at that particular time (Murakami. S, Oaka. R, Shiraishi. Y 1996). A study of thermal comfort in a given location enables us determine the acceptable range of environmental parameters, and enables the architecting recommendations and determination of building materials best adapted to each climate type (Odim, 2006). Along and with the control of physical variables, adjustments the amount of furnishing in a space and lighting levels could probably provide solution in improving thermal comfort (Alozie, 2014).

A field study on the environmental conditions and occupants comfort carried out revealed, from the subjective assessments, that the occupants in tropical environments have higher heat tolerance and can adapt to the environment beyond the ASHRAE comfort zone (Garde, 2004).

Area of study

Akanu Ibiam Federal Polytechnic is an institutional campus in Unwana in Ebonyi State Nigeria that experience hot humid climate. The maximum air temperatures during summer (May and June) varies between 32°C and 40°C and the minimum air temperatures during dry season varied between 18°C and 20°C. The average monthly relative humidity ranges from 65% (June) to 86% (November) and the vapour pressure varies between 20.6hpa and 34hpa (Barbour et al, 1981).

The institution houses several academic blocks of which architecture block was selected for this study. Indoor environmental variables like air temperature and relative humidity were measured. The thermal properties of the built surfaces were similar in all the studios, and materials used for built surface include sand crete walls, aluminum long span roofs and polyvinyl ceilings, cement/sand screed and ceramics tiles floor. The environment has plenty vegetation cover in its surrounding.

Methodology

The air temperature and relative humidity data were measured continuously on a 30minutes interval basis using data loggers, between 8 am and 4 pm on a typical dry season semester. The study was carried out to assess the thermal comfort condition in architectural studios during the study hours. The Data loggers were hung in the 2 studios at 1.5m above ground level, and a third one hung at the same 1.5m height outside the building in a shaded area of the building to measure out-door thermal conditions of temperature and relative humidity.

Secondary data on air temperature and relative humidity was obtained from Nigeria Meteorological station in Abakaliki. Objective data analysis showing the environmental condition of the studios and subjective analysis through questionnaire, recorded the thermal sensation of the students.

The subjective response of the respondents, the temperature and relative humidity during daytime were compared to identify the maximum acceptable temperature for a thermally comfortable environment.

Results and Discussion

Analysis of the air temperature and relative humidity variations

The studios are used for lectures and design practices. Architecture Students need maximum concentration and environmental comfort to perform optimally. Thus the need for a thermally comfortable indoor environment. Table 1 show the average ambient air temperature and Table 2 shows the average relative humidity recorded.

Location/Time (hrs)	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00
Studio 1	32.7	33.0	33.5	34.0	34.3	34.4	34.5	34.4	34.6
Studio 2	32.1	32.3	32.8	33.4	33.8	34.0	33.8	33.9	33.7

Table 2. Daily Relative Humidity at Various Classrooms

	Relative Humidity Measurements								
Location/RH (%)	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00
Studio 1	65.25	62.24	59.37	57.41	56.84	57.23	57.73	57.59	60.84
Studio 2	66.31	63.95	61.09	58.51	57.14	58.75	59.47	58.51	62.55

Average air temperatures and relative humidity were recorded every 30 minutes from 08.00am and4.00pm. The air temperatures variations revealed distinct temperature difference with respect to indoor and outdoor environments, floor plans and window orientations and ranged from 32;1°c to 36;8°c. The roof of the studios was exposed to solar radiation and had significant impact on the indoor air temperatures.

At 8:00am the studio, I with opening on its west experienced lower temperature and studio 2 on the northeast orientation recorded the maximum temperature with a difference of 1.3°C. The increase in morning temperature was attributed to eastern orientation as studio 2 receives the morning sun from the east. Between 9:00am and 11:00am, the temperature difference between the studios was minimal and range from 0.4 °C to 1.1°C.

The outdoor temperature had a gradual increase to about 3.5°C between 9:00am to 11:00am. From noon the studio in the west wing showed gradual increase in temperature due to the vent on its western side and direct heat radiation from the roof. The temperature difference ranged from 1.35°C to 2.30 °C. Towards evening at 16:00 hrs the air temperature decreased gradually by 0.1 to 0.2 °C in the indoor and 2 °C in the outdoor environment. The temperature variation in the indoor environment varied according to the movement of sun and heat penetration through window openings.

During daytime, the relative humidity varied from 53.44% to 67.00% and maximum humidity is recorded. The humidity levels are high in the morning at 8:00 am and vary as the time goes on due to closed window openings in the night time. In the afternoon as the sun moved towards west and due to the surface cooling of the ground floor the ambient air temperature at ground floor become less. The elevated air temperature reduced the humidity at noon. The roof of the studios was directly exposed to solar radiation and had significant impact on the temperatures.

Analysis of Questionnaire Survey

Questionnaire was distributed to the students in order to evaluate their thermal perception, while measurements were taken. The questionnaire was divided into three parts like personal data, thermal aspects and comfort levels.

The results of the questionnaire survey were compared with the measured data to comprehend the thermal sensation of the users in the studios. The thermal perception of humans with respect to thermal sensation, feeling of comfort, satisfactory level of comfort in the place and overall conditions of acceptance were compared. The result on thermal sensation revealed that the respondents felt the heat, and it was tolerable in the studio in northeast, but the thermal perception of the respondents was hot in the studio in west due to the openings on the western side and the heat from the roof.

The users were not fully satisfied with the ambient air temperature in the studios. The overall conditions inside the studios were acceptable for the users as the indoor temperature got reduced gradually after lunch break in the noon. The studios provided a comfortable indoor environment as the occupants in tropical environment have a higher heat tolerance (Streshthaputra, Habert and Andrews 2004). The result scale ranged from -0.5 to +0.5 and the temperature is comfortably warm with the preferable air movement inside the studios.

Conclusion

A study on thermal comfort conducted in architecture studios of Federal Polytechnic Unwana to determine acceptable indoor temperature for students enhanced performance revealed from objective and subjective measurements that solar radiation is the main cause of the studios heating, as direct radiation increases indoor temperature. In order to reduce indoor temperature the exposed surfaces needs to be protected by vegetation, shades and fins, as increase in air temperature accelerates discomfort and in turn affects the performance of the students. With the good air ventilation system the studios comfort levels could be improved. The study recommended that functional design, proper specification of building materials, colour and passive technique application will enhance comfort in hot humid environments like Unwana.

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Appendix 1

Study on Indoor comfort and Air quality in a Studio classroom of Institution Building

I like your participation in answering this questionnaire based on your thermal sensation, the inputs from this survey helps us to find out maximum acceptable temperature in a studio classroom.

Age: Sex: Time:

Clothing: Are you under fan: (Yes/No/Partial)

Please tick ( ) the suitable bubble against the various scales:

1. In which orientation your classroom is located

North	South	East	West	NE	NW	SE	SW

2. How do you feel about the thermal environment in the room (Thermal sensation)?

Cold	Cool	Slight cool	Neutral	Slightly warm	Warm	Hot

3. What is your feeling of comfort in the room?

Top Cold	Comfortably Cool	Comfortable	Comfortably Warm	Too warm

4. At which satisfactory level the temperature of the place is?

Very satisfied	Satisfied	Dissatisfied	Very dissatisfied

5. At present what would be your liking in the level of air movement in the room?

Lesser air	No change	More air

What can be the humidity level in the room?

Lesser	As it is	More

6. Would you prefer mechanical ventilation and air-conditioning?

Cooler	As it is	Warmer

7. Is the thermal environment acceptable?

Yes	No