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# Investigating the Applicability of Adaptive Comfort Model in a Naturally Ventilated Student Housing in Nigeria

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## Abstract

Thermal comfort, influenced by thermal sensation is an important building performance indicator. In the context of this work, the applicability of adaptive comfort model (ACM) to simulate the thermal comfort level in a naturally ventilated hostel building at Obafemi Awolowo University, Ile-Ife, Nigeria was investigated. The applicability of ACM was investigated by determined the neutral and comfort temperature in addition to comfort range temperature of the occupants using the environmental data derived from field measurements and information from questionnaire survey. A total of 288 responses participated in the three months short-term thermal comfort field study. The results obtained were compared with the recommendations of ASHRAE Standard 55, ISO 7730 Standard and results of previous field studies located in the warm-humid tropics. The predicted neutral temperature was found to be 26.8 o C. The acceptable ranges of comfort temperature around thermal neutrality were 24.3-29.3 o C and 23.3-30.3 o C for 90

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***Index terms***— adaptive comfort model, applicability, naturally ventilated hostel.

hermal comfort, influenced by thermal sensation is an important building performance indicator [1,2]. Thermal comfort has been defined in different ways. In ASHRAE Standard 55 [3] thermal comfort is defined as 'that expression of mind which expresses satisfaction with the thermal environment'. Thermal comfort and satisfaction with the thermal environment is a complex phenomenon, and therefore complicated to predict in the design phase [1]. Therefore, accurate models for predicting thermal comfort during the design phase of a building can be beneficial in avoiding malperformance in the use phase. In the past many researchers carried out laboratory and field studies to investigate the parameters which affect thermal comfort.

Author: Department of Building Obafemi Awolowo University, Ile-Ife, Nigeria. e-mails: eolanipe@oauife.edu.ng; ollybbay@yahoo,co.uk Several models have been developed during the past years in order to predict human thermal comfort in various climatic conditions [4,5]. Fanger's PMV-PPD model is among the most well-known and probably most referred thermal comfort index commonly used in practice to predict thermal comfort in the design process of a building especially in airconditioned spaces [1,4,6,7,8,9]. However, the direct applications of PMV-PPD model for indoor environmental design in NV buildings led to overestimation of occupants' comfort and dissatisfaction levels [10,11,12,13,14,15,16]. There are a number of other theoretical and practical reasons why the steady-state heat balance approach gives the wrong predictions of thermal sensation in the variable conditions that are found in NV buildings in the tropics [13,16,17,18,19,20,21,22,23,24,25]. The inapplicability was apparently due to the limitations of the model regarding differences in different subpopulation, ignorance of adaptive behaviour that occurred in real buildings and symmetrical distribution of the model as well as characteristics of the input data. Many field researchers [26,27] further attributed the inapplicability of the model to what they collectively called 'context-effects'. Steady-state comfort theory was first challenged by **??**icol and Humphreys [28] in 1972. They also put forth the concept of adaptation of occupants. The adaptive models have been integrated in ASHRAE standard 55 [8]. The adaptive standard defines the "optimum" temperature as a function of the mean monthly outdoor temperature of a location. It includes also an acceptable range of temperatures based on criteria that either 80% or 90% of the occupants will be comfortable within those respective ranges. According to studies [1,15], the adaptive algorithms seem to be more efficient for naturally ventilated buildings. Detailed researches ??29; 30] have also pointed that the application of adaptive comfort standard in real building offers a huge potential in energy saving. In the context of climate change and global warming, the inclusion of adaptive thermal comfort concept in the thermal comfort standards which allows adopting new energy efficiency strategies and consistently meeting the requirement of sustainable development makes it more relevant to present context. However, the need of worldwide investigation of the applicability of ACM in different types of NV buildings and climates has been reported in many publications [6,15,29,31,32]. The research here involves the assessment of the applicability of ACM model in evaluating indoor climate in a naturally ventilated hostel building in a warm-humid tropical environment of Ile-Ife. Specifically, the study determined the neutral temperature (Tn), comfort temperature (Tc) and acceptable comfort range temperature of the occupants in the selected hostel using the environmental data derived from field measurements. In addition, the occupants' perception of their thermal environment was also was also investigated.

The study is based on a case study carried out on an undergraduate female hostel at Obafemi Awolowo University, Ile-Ife, during the dry season of the year 2013. The aim was to investigate the applicability of ACM in predicting indoor thermal conditions in this hostel building. The approach to the thermal comfort survey was underpinned by the adaptive thermal comfort paradigm as adopted by Djongyang and Tchinda [31], based on the adaptive theory that physiological and adaptive factors play equally-central roles in the perception and interpretation of thermal comfort. The whole of measurements were carried out on the basis of a special protocol for the assessment of the Indoor Environmental Quality (IEQ) [33] The hostel selected for the case study, is of medium size and rectangular in shape. It is a reinforced concrete building and the envelopes were made of aerated sandcrete block. The hostel with a 3400 m2 built-up area consists of three floors (Fig. 1). The hostel was selected in order to give representative sample of typical Nigerian university student housing. The main features of the hostel is summarised in Table 1. NC: number of occupant, V = volume, F = floor area, W/F = window to floor area, EXP = exposure, VS = ventilation system b) Measurement of the physical and personal parameters

The measurement of the physical thermal comfort parameters was carried out by mean of a special comfort data logger, Kestrel 4500 (handheld and pocket weather tracker) with sensors for air temperature, relative humidity and air velocity. Kestrel 4500 is ideal because it measures air velocity, temperature and relative humidity (RH) with sensory accuracy of ±0.3 m/s, ±0.3oC and 1.6% respectively. The measurements were conducted from morning until evening (9 an-7 pm) with an interval of 1 hour. This was necessary to capture the different conditions and rapid environmental changes at different times of the day. To maximize the reliability and minimize the effect of the measurement accuracy on the assessment of the thermal environment, the measurement of thermo-hygrometric parameters characterizing the environment and the instruments used for the assessment of physical variables were done according to the procedures reported in the ISO 7726 Standard [34]. The meteorological data were obtained from the weather station operated by the Department of Physics, Obafemi Awolowo University, Ile-Ife located very close to the hostel building studied. Data collected included air temperature, relative humidity, wind speed and direction and global solar radiations.

# 1 c) Subjective investigation

To take into account subjective matters in the assessment of thermal comfort conditions of the hostel, the physical measurements were accompanied by subjective investigation. The subjective investigation was conducted by mean of a questionnaire survey designed in compliance with ASHRAE standard 55 [3] containing four sections: personal information (age, height, weight) and second section provided information on clothing and activity level of respondents. Section three discussed thermal comfort assessment; in this case students were asked a judgement on the perception, preference and acceptability of air temperature, relative humidity and air velocity. The last section was devoted to the behavioural adaptation, which was not discussed in this paper. The questions of this section were formulated in compliance with the recommendation of ISO 10551 Standard [35] and deal with acceptability of the environment (would you accept/this thermal environment rather than reject it). On the basis of the answers to the questionnaire some indicators of the subjective thermal comfort were formulated, in particularly:

-TSV: Thermal Sensation Vote obtained by questionnaire expressed on the typical 7-point scale [3] and calculated as a mean value of the votes attributed to the environment. -TPV: Thermal Preference Vote obtained by questionnaire expressed on the typical 3-point scale [27] and calculated as a mean value of the votes attributed to the environment. -Percentage of people accepting /not accepting based on the acceptability criterion and calculated on the basis of occupants who felt the thermal environment not acceptable. Finally, statistical analyses were carried out by mean of SPSS version 16.0. The assessment of the quality of the thermal environment was carried out by comparing the measured indoor environmental parameters, neutral, comfort and comfort range temperatures obtained with the limits suggested by ASHRAE standard 55 [3] and ISO 7730 [7].

# 2 a) Neutral Temperature (Tn)

The neutral temperature is defined as the temperature at which people will on average be neither warm nor cool. A simple method used in thermal comfort studies for the calculation of neutral temperature is to access the relationship between thermal sensation and indoor climate through regression analysis. However, Humphreys [36] have showed that regression analysis is liable to error of feedback. For purpose of practical predictions, Auliciems and de Dear [37] adaptive model was employed to estimate Tn. It has been indicated from the previous thermal comfort field studies ??12; 16, 38; 39, 40] that a neutrality temperature calculated using this model provided the centre point for comfort zone. In addition, the relationship is a good indicator for calculating the neutral temperature (Tn) under warm conditions. Auliciems and de Dear reported a strong positive correlation between the observed neutral temperature and the mean outdoor temperature. Comfort temperature always associated with adaptations and was calculated based on Humphreys [41] and Auliciems [42] models. Humphreys and Auliciems both reported strong positive correlations between the observed comfort temperature and the mean temperature prevailing in indoors and outdoors.

Using Humphrey's model, the comfort temperature (Tc) for was estimated from mean hourly outdoor temperature (Tm) in o C, using the equation: Tc = 0.53To + 11:9 (r = 0:97)

(2)

Employing Auliciems model, the absence of thermal discomfort is predicted by simple equation in terms of mean indoor (Ti) and outdoor temperature (To) in o C: Tc = 0:48Ti + 0:14Tm + 9:22 (r = 0:95)

The input outdoor data was obtained from the nearest weather station (Department of Physics Meteorological Services).

# 3 c) Data analysis

The responses from thermal comfort field measurement and questionnaire were entered into SPSS ver. 16.0 for a primary analysis. The data were transferred to Microsoft Excel for re-evaluation for careful quality assurance. Detailed descriptive statistics were performed on the environmental measurement, personal records and questionnaire survey. In addition, outcomes from this investigation were compared with other studies carried out in the warm to hot humid tropics. This offered further insight about similarities and differences of the parameters under investigation which enabled researchers to understand some of the reason that led to different outcomes in the determination of neutral and comfort temperatures. a) Results of physical measurement of thermal comfort parameters i.

Outdoor climatic data

# 4 Indoor climatic conditions

Statistical summaries of measured physical thermal comfort parameters are provided in Table 3 for the total data set broken down by months. In this section of report air temperature was used to characterise the indoor thermal condition of the hostel building. Air temperature is one of the most recognized parameter in thermal comfort studies. In January, the typical daily temperatures range varied from 28. conditions would be mostly typical of buildings built with concrete or brick walls and subjected to various warmhumid tropical outdoor climatic conditions. Comparing the obtained values with others field studies in the warm-humid tropics [6,16,43,44] conducted in buildings built with concrete or brick walls and subjected to various warm-humid tropical outdoor climatic conditions, the values of indoor air temperature obtained in this study are in close agreement and consistent with their results. A statistical summary of Neutral Temperature (Tn) and range of comfort temperature based on months and floor levels is presented in Table 5. For the month of January, the neutral temperature obtained on the average was 28.0 o C, for February it was 26.9 o C and for March it was 26.8 o C. For all data it was 26.8 o C. In general, the neutral temperature in January on the average was 1.1 o C higher than that of February and March. This is because in this month, prolonged harmattan season made respondents to feel more uncomfortable as they have limited option available for adaptation (i.e. higher clothing level and closing the windows to minimize the air movement). In relation to the floor performance, it was observed that the neutrality temperatures for the two floors were the same. However, the Tn value based on floor levels was higher in January than other two months. A mean comfort zone band around the thermal neutrality as suggested by ISO 7730, ASHRAE standard 55 and previous studies ??38; 39] was also determined. According to these standards and studies it is between these mean comfort zone bands that occupants' adaptive techniques work well. Besides, the mean comfort zone band is a pre-requisite for comfortable indoor environment. In line with the recommendation of ISO 7730 Standard [7], a mean comfort zone band of ±2.5 and ±3.5 for 80% has been considered for 90 and 80% acceptability, respectively. The range of comfort temperature around Tn corresponding to 80% and 90% acceptability is also defined in Table 5. As an example, in January, for 80% acceptability, the comfort zone was between 24.5 o C and 31.5 o C and for 90% acceptability the comfort range was within 25.5 o C and 30.5 o C or a range of 7 o C and 5 o C respectively. In terms of floor levels, for 80% acceptability, the comfort zone is between 24.9 o C and 31.9 o C for both the ground and second floors and for 90% acceptability, a range of 25.9 o C and 30.9 o C was obtained for the two floors. From the indoor temperature profile analysis of the hostel for these months, the temperature swing was in the range of 4.5 o C-5.3 o C. According to Singh et al. [38], for thermally comfortable indoor environment in naturally ventilated buildings in warm-humid climate, the indoor temperature variation must not cross 6.5 o C across all the seasons. It means that if a naturally ventilated building is designed where internal temperature swing is between 6.5-6.7 o C, the people of this climatic zone will feel thermally comfortable. The indoor air temperature swing was quite satisfactory for the naturally ventilated hostel studied. The comparison between predicted comfort temperatures by Humphreys [41] and Auliciems [42] models and the obtained neutral temperature is presented in Table 6. Both adaptive models have predicted the comfort temperature higher than the observed neutral temperatures. In general, the predicted comfort temperatures by Humphreys and Auliciems' adaptive comfort models for the three months of survey are higher in comparison to the neutral temperature obtained from de Dear and Auliciems [43]. In general, Auliciems model seems to give prediction about +0.7 ? C higher compared to Humphreys' model. This could be due to the inclusion of indoor temperature which their mean values were always higher than the mean monthly temperature. The neutral temperatures are found constantly lower than the comfort temperature predicted by Humphreys and Auliciems model. On the average, Humphreys model predicted accurately (Î?” = +0.9 c) Thermal comfort on the questionnaire survey i. Demographic information of respondents Table 7 shows the demographic characteristics of respondents. The subjects that participated in the survey were composed of female students. The total number of subjects in each month was 96 making a total of 288 observations. The average age of all was 24 years old, ranging from 16-34 years. The average length of residence for the entire sample was 6 months. The distributions of votes on perception are shown in Table 8 for typical days in these three months survey. The thermal sensations distribution is not the same across the different months. In the month of January, Table 8 shows that almost all the votes (91%) are within the central three category (-1, 0, +1) on the perception scale and 14.1% on the warm side (+2, +3). The mean thermal sensation votes (MTSV) was +0.45 indicating warmer than neutral conditions but within the comfort range. In February, with only 0.3 o C difference in indoor air temperature 85.9% of the thermal sensation votes were within the central category (-1 to +1), and 14.1% on the warm side (+2, +3). The MTSV was +0.56 also on the warmer than neutral but within the comfort range. In March, proportion voting within the comfort band on the sensation scale reduced to 82% when the mean temperature increased to 31.3 o C. The MTSV was slightly higher, but was still within the comfort band (MTSV =+0.73). The present investigation provides the possibility for comparison between results among studies conducted in naturally ventilated buildings specifically in warm-humid tropics. Table 9 shows the various values of Tn obtained based on Auliciems and de Dear [37] conducted in NV buildings in warm seasons around the world. A close match of indoor thermal neutral temperature was observed with those of previous studies. However, compared to studies where regression analysis was adopted in predicting the indoor neutral temperature in naturally ventilated buildings, the neutral temperature obtained in the present study was lower. The difference in the mean neutral temperature between these studies fell within 1.5 o C and 3.4 o C. These differences may be attributed to the feedback error in the linear regression as reported by Humphrey [36]. The differences may also be due to the wider indoor range found in the previous studies which may affects the predicted indoor comfort temperature. In addition, the discrepancy might as well be attributed to the slight low mean air movement recorded in this study compared to previous studies. Besides, the discrepancy between results might also be ascribed to differences in the outdoor air temperatures during the period under investigation and to the differences in habits and climatic parameters. The difference in the mean indoor neutral temperature between these studies could be also attributed to time factor. Furthermore, the microclimates of the surrounding areas under investigation also could affect the indoor thermal environment as the outdoor temperature may not necessary be the same as that reported by meteorological stations. Most importantly, the method of analysis might greatly responsible for the difference. b) A comparison with comfort models An optimal method is provided in the ASHRAE standard 55 [8] for determining acceptable thermal conditions in NV spaces, in which both indoor neutral and acceptable temperature range are determined by mean monthly outdoor air temperature. It is therefore useful to compare the results obtained in this study to investigate the applicability of adaptive comfort standard in the selected hostel building. According to the adaptive model in the ASHRAE 55, when the mean monthly outdoor air temperature is 27.0 ? C, for naturally ventilated spaces, 80% acceptability limits are between 22.5 ? C and 29.5 ? C. Employing Auliciems and de Dear [37] model the indoor neutral temperature on the average was 26.8 o C and the 90% (80%) acceptable range was 24.3-29.3 o C (mean daily outdoor air temperature was 29.6 o C). Based on these results and according to the recommendations of adaptive model in the ASHRAE 55, 80% of the occupants can accept the air temperature range of 24.3-29.3 o C, which was within the acceptability limits of adaptive model. The results of this comfort survey clearly indicated the applicability of the recommendation of ASHRAE Standard 55 [8] in the selected hostel. The outcomes of study also indicated the applicability of the recommendation of ISO 7730 Standard [7] and de Dear and Brager [45] of 7 o C for the range about the neutrality temperature for free running spaces. In addition, the maximum temperature on the average of 30.3 o C without significant air velocity matches well with the findings of the comfort surveys. ' A field study has been conducted in a naturally ventilated hostel building in Ile-Ife southwest of Nigeria during hot season. The neutral and comfort temperatures were determined using adaptive comfort model proposed by Auliciems and de Dear [37]. This study has allowed for the assessment of the applicability of adaptive comfort algorithms in Nigerian environment. The main outcomes of the field study can be summarised as follows: ? The thermal indoor climate was in general warmer than the ASHRAE Standard 55 during this season, however, more than 80% of the participants were satisfied with the indoor thermal conditions but wanted to have cooler environment. ? The predicted neutral temperature using adaptive comfort model was found to be 26.8oC for the population under investigation and 80% of the occupants can accept the air temperature range of 24.3-29.3oC, which is within the acceptability limits of adaptive model in ASHRAE Standard 55 [8]. ? The results of the study also reveal that the respondents involved could feel reasonably comfortable even up to a temperature of 31oC. This validated the use of a broader margin of about 3.5oC from the neutrality temperature for free running buildings accommodating people acclimatised to that particular climate. ? The occupants were less sensitive to the rise of temperature during the warm season. ? The adaptive comfort algorithms of ASHRAE standard 55 was in close agreement with the measured comfort votes. It predicts well the thermal comfort of subjects in this case study.

Based on the results presented here, it appears that the adaptive algorithms are more reliable to evaluate the thermal comfort in naturally ventilated buildings. Further analysis about the applicability in other building types is highly recommended as it may not be similar. [1]

Figure 1:

**1**

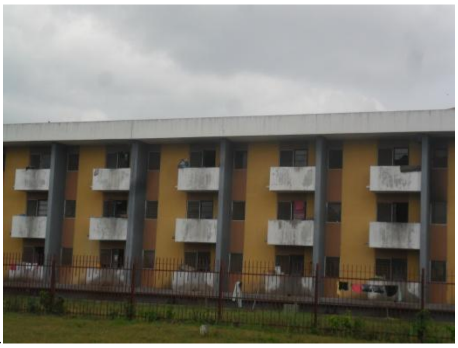


Figure 2: Figure 1 :

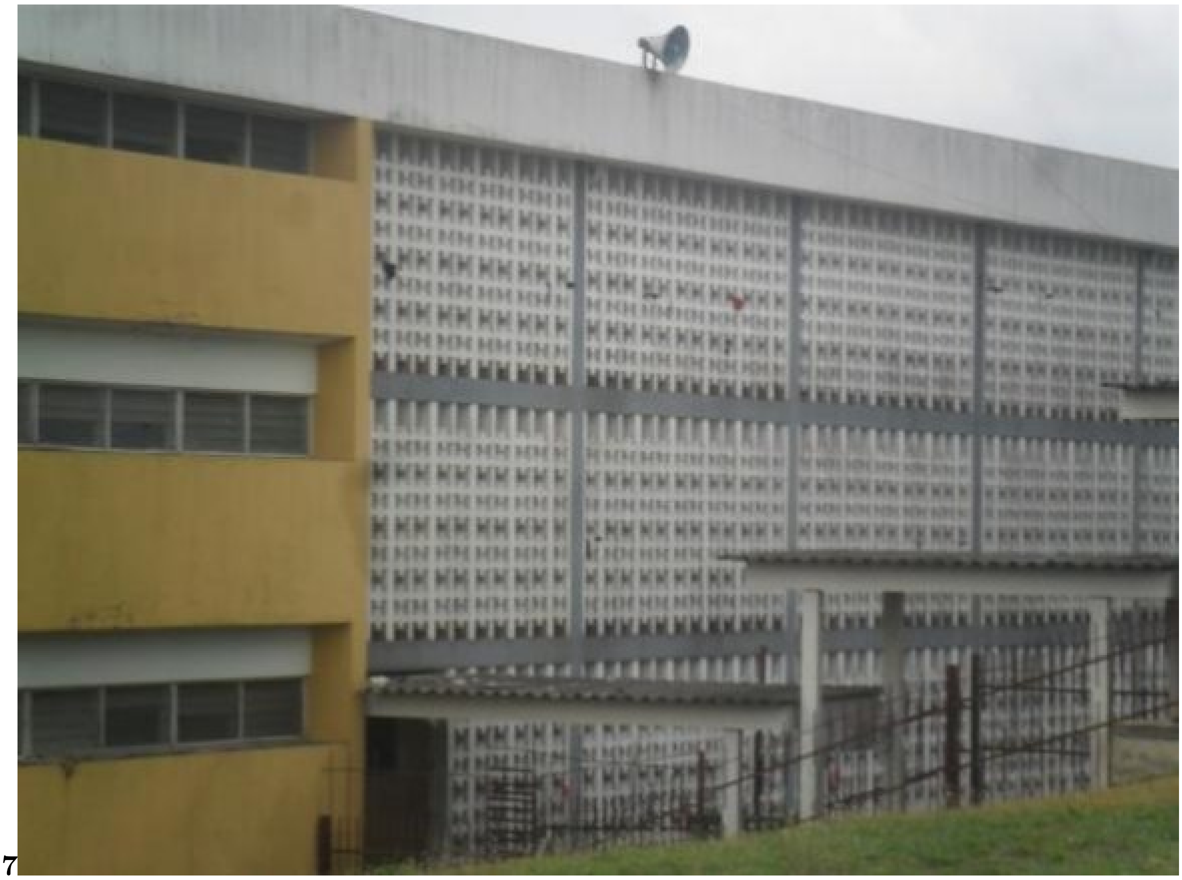
17


Figure 3: Tn = 17

1

| NC | V (m 3 ) | F (m 2 ) | H (m) | W/F | EXP | VS |
|---|---|---|---|---|---|---|
| 150 | 10200 | 3400 | 12 | 0.43 | E-W | NV |

Figure 4: Table 1 :

2

Figure 5: Table 2

**2**

| Month | Global solar radiation ((W/m 2 ) | Mean daily air temperature ( o C) | | Mean relative humidity (%) | |
|---|---|---|---|---|---|
| | | Maximum | Minimum | Maximum | Minimum |
| January | 346.17 | 32.6 | 22.5 | 49.34 | 28.86 |
| February | 390.91 | 32.9 | 25.1 | 85.82 | 42.88 |
| March | 394.45 | 31.8 | 26 | 84.02 | 51.19 |
| All months | 377.18 | 32.9 | 22.5 | 85.82 | 20.36 |

ii.

Figure 6: Table 2 :

**4**

Figure 7: Table 4

**3**

| Month | Temperature ( o C) | | | | Relative humidity (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | Min | Max | Mean | STD | Min | Max | Mean | STD |
| January | 28.4 | 33.5 | 30.9 | 1.71 | 31.8 | 71 | 46.16 | 12.45 |
| February | 28.1 | 33.7 | 31.2 | 2.36 | 30.8 | 75.5 | 45.72 | 13.99 |
| March | 28.5 | 34 | 31.3 | 1.86 | 32.8 | 66.3 | 44.48 | 14.03 |
| All months | 28.1 | 34 | 31.1 | 1.83 | 30.8 | 75.5 | 45.45 | 12.64 |

Figure 8: Table 3 :

**4**

| Month | Floor level | Temperature ( o C) | | Relative humidity (%) | |
|---|---|---|---|---|---|
| | | Min | Max | Min | Max |
| January | Ground floor. | 28.7 | 32 | 36.5 | 69.1 |
| | Second floor. | 28.5 | 34 | 31.8 | 71 |
| February | Ground floor. | 28.5 | 33.6 | 33.1 | 74.2 |
| | Second floor. | 28.1 | 33.7 | 30.8 | 75.5 |
| March | Ground floor. | 28.5 | 34 | 34.6 | 63.7 |
| | Second floor. | 28.5 | 34 | 32.8 | 66.3 |

b) Calculated adaptive thermal comfort algorithms
i. Neutral Temperature (Tn) and range of comfort range

Figure 9: Table 4 :

**5**

| Month | Floor level | Outside climatic parameters Ta ( o C) | RH (%) | Tn ( o C) | Neutral Temperature ( o C) 90% Accept. | | 80% Accept. | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Tn -2.5 | Tn+2.5 | Tn-3.5 | Tn+3.5 |
| Jan | Grd.flr. | 29.3 | 28.86 | 28.4 | 26.2 | 31.2 | 25.2 | 32.2 |

Figure 10: Table 5 :

**6**

| Month | Floor level | Mean (average) Outdoor Temp. ( o C) | Indoor Temp. ( o C) | Predicted comfort temperature Humphreys ( o C) | Auliciems ( o C) | Neutral Temp.( o C) |
|---|---|---|---|---|---|---|
| Jan | Grd.flr | 29.3 | 30.4 | 27.5 | 27.9 | 28.4 |
| | Sec.flr. | 29.3 | 31.1 | 27.5 | 28.3 | 28.4 |
| | All flrs | 29.3 | 30.9 | 27.5 | 27.2 | 28.0 |
| Feb | Grd.flr | 30.0 | 30.9 | 27.9 | 28.3 | 26.9 |
| | Sec.flr. | 30.0 | 31.4 | 27.9 | 28.5 | 26.9 |
| | All flrs | 30.0 | 31.2 | 27.9 | 28.4 | 26.9 |
| Mar | Grd.flr | 29.5 | 31.1 | 27.7 | 28.3 | 26.7 |
| | Sec.flr. | 29.5 | 31.1 | 27.7 | 28.5 | 26.5 |
| | All flrs | 29.5 | 31.3 | 27.7 | 28.4 | 26.7 |

Figure 11: Table 6 :

**7**

| N =96 | Height (m) | Weight (kg) | Age (years) | Body surface area (m 2 ) | Clothing insulation (Clo) |
|---|---|---|---|---|---|
| Mean | 1.68 | 58 | 19.6 | 1.65 | 0.58 |
| STD | 8.85 | 9.6 | 1.6 | 0.15 | 0.14 |
| Maximum | 1.92 | 92 | 27 | 2.14 | 0.73 |
| Minimum | 1.25 | 36 | 17 | 1.21 | 0.42 |
| ii. Thermal sensation votes of respondents | | | | | |

Figure 12: Table 7 :

**8**

| Month | | Thermal comfort scale | | | No of subjects | MTSV |
|---|---|---|---|---|---|---|
| | -3, -2 | -1, 0, +1 | +2, | +3 | | |
| January | 0% | 91% | 9% | | N =96 | +0.45 |
| February | 2% | 85.9% | 12.1% | | N=96 | +0.56 |
| March | 0% | 82% | 18% | | N=96 | +0.73 |

a) Comparisons with previous field studies for naturally ventilated buildings

Figure 13: Table 8 :

**9**

| Researchers | Country | Building type | Tn ( o C) | method of analysis |
|---|---|---|---|---|
| Zhong et al. [2012] | China | Residential building | 27.7 | Auliciems and de Dear [1986] |
| Mohazabieh et al. [2010] | Malaysia | Residential building | 26.5 | Auliciems and de Dear [1986] |
| Singh et al. [2010] | India | Residential building | 27.1 | Auliciems and de Dear [1986] |
| Wijewardane and Jayasinghe [2008] | Sri-Lanka | Factory buildings | 26.7 | Auliciems and de Dear [1986] |
| Djamila et al. [2013] | Malaysia | Residential building | 30.2 | Regression |
| Dhaka et al. [2013 | Malaysia | Hostel buildings | 30.15 | Regression |
| Adebamowo and Olusanya [2012] | Nigeria | Hostel building | 29.09 | Regression |
| Wafi et al. [2011] | Malaysia | Hostel building | 28.3 | Regression |
| Dahlan et al. [2011] | Malaysia | Hostel building | 28.3 | Regression |
| Feriadi and Wong [2004] | Indonesia | Public housing | 29.2 | Regression |
| This study | Nigeria | Hostel building | 26.8 | Auliciems and de Dear [1986] |

Figure 14: Table 9 :

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