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INVESTIGATION OF CUSTOMERS' COMFORT PERCEPTION IN THE HOT HUMID REGION'S RESTAURANTS

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ABSTRACT

Investigation of indoor thermal perception in restaurants is not only important for business perspectives but also improving the quality of the environment for employees and customers. This study was aimed to assess the customer's perception in two restaurants situated in Chongqing, China, a hot summer and cold winter region. The study was designed with a questionnaire for assessing customers' thermal sensation during their stay in these restaurants. The customers' responses (N=40) on closed ended likert questions were recorded in ASHRAE 7-point thermal comfort scale. By analyzing the respondents vote, a neutral thermal condition has been found in these restaurants. However, according to customers perceptions, there are some doings still can be done to improve of these conditions.

KEYWORDS: *Hot Humid Zone, Indoor Thermal Comfort, Discomfort, TSV, PMV, Dissatisfied, Customers' Perception, Restaurant, Chongqing, China*

1. INTRODUCTION

Human beings are sensitive to the slight change of environmental factors in a space which standard range are most subjective to provide effectiveness, satisfaction, phenomenological sense for physical comfort. Such a change can lead to lower working capability, discomfort and increase illness symptoms.

Thermal comfort sensation differs to the climatic condition and varies with the influencing factors. Temperature is such an influential factor on the indoor comfort that could reduce 30% productivity by increasing only 5.5^{0}C. Wyon (1996) and Livchak, Schrock, and Sun (2005) also showed the same results happened for a restaurant kitchen that needs more three people with every seven staffs for the same job. Hu, Liu, and Jiang (2006) found that the neutral temperature (22^{0}C) in classroom varies from 17.2^{0}C in winter to 27.1^{0}C in summer where it is recommended 25.3^{0}C for lecture hall in Malaysia (Yau, Chew, & Saifullah, 2011). Lstiburek (2002) mentioned that we cannot perceive the change within the range 25% and 60% of Relative Humidity (RH) and sensed by the human body of dropping 1^{0}C of temperature for the increase of every 15-fpm air velocity above 30 fpm. In a commercial kitchen, it is driven by radiant heat, envelope heat gain and loss, electrical appliances, people and lighting those affect the customers and workers. Simone and Olesen (2012) research on a commercial kitchen in Denmark showed that 41% employees mentioned the unacceptability of thermal environment and more 60%

requested to more air movement. The conducted experimental study by ASHRAE-55 (2013) revealed the perceived thermal comfort in a restaurant and recommended that the operative temperature should be 22^0C-26^0C in summer and 20^0C-21^0C in winter where the CIBSE recommended 21 ^{0}C and 22 ± 1^0C respectively (Lawson, 2001). According to HMDA (2010), it should be 23 to 26^0C in summer and 21 to 23^0C in winter with the RH 55% to 60% and <40% respectively.

2. MATERIALS AND METHODS

According ASHRAE-55 (ASHRAE-55, 2013), ISO-7730 (ISO-7730, 2005) standards and Fanger (1970), thermal comfort model is the combined function of four (04) environmental (i.e. Mean radiant temperature, Air Temperature, Relative Humidity (RH) or Water vapor pressure in ambient air) and two (02) personal physiological (i.e. Metabolic rate and Clothing insulation) factors those affect the thermal comfort of an occupant (He, Li, & Huang, 2015). To achieve the 80% acceptability in a space, the recommended operative temperature should be ranged from 20^0C to 23.5^0C in winter and 22.5^0C to 26^0C in summer based on 60% RH; approximately 1.2 met of metabolic rate and low air speed (Boduch & Fincher, 2009). This means the 10% or lowers Predicted Percent of Dissatisfaction (PPD) with the Predicted Mean Vote (PMV) between +0.5 to -0.5 would be acceptable for the thermal environment (ASHRAE-55, 2013). This PMV and PPD values provide the estimation of Thermal Sensation Vote (TSV) for the same mean radiant temperature and air velocity (Simone & Olesen, 2009). These values are subjective to survey which are based on the assumption of occupants' voting i.e. how warm or cool occupants feel that is gathered directly by asking occupants to evaluate their thermal satisfaction in response to the surrounding temperature. According to this scale, occupants response would be cold (-3), cool (-2), slightly cool (-1), neutral or neither cool nor warm (0), slightly warm (+1), warm (+2) and hot (+3) where -3, -2, +2 and +3 are considered as their dissatisfaction with that environment (ASHRAE-55, 2013; ISO-7730, 2005).

This study was conducted from in two restaurants namely CSC and Lotus hot pot, situated at Shapingba, Chongqing in China. This region is characterized by hot summer and cold winter in climatic conditions. The study has done through measuring physical parameters and questionnaire survey for understanding the customers' perception about indoor thermal conditions of these restaurants. The discussed findings of this study are basically based on the PMV given by the customers. The physical measurement of environmental parameters was done in support of questionnaire findings for analyzing occupants' perception of thermal comfort at that moment in this restaurant.

The aim of this study was to assess the customers' perception about the present indoor conditions in restaurant of a hot humid area. Based on objective, this study used proposed PMV method by ASHRAE-55 (2013) and ISO-7730 (2005) which is considered as the most rational and acceptable model for assessing and predicting occupants' thermal comfort (R. Yang, Liu, & Ren, 2015).

Physical Measurement

The physical measurement was carried out from 9 a.m. to 6 p.m. in the sunny days to assess the environmental influential factors by using the K-type thermocouple to measure the air temperature, Vernon's Globe Thermometer for radiant temperature, RH sensor for measuring relative humidity and omnidirectional anemometer used to measure the air velocity of indoor air. The environmental parameters were measured at 1.1 meters height from the ground which is the standard seated level (Daghigh, Adam, Sopian, & Sahari, 2009) of the occupants and recorded in every 20 minutes interval for two days. Having the measured environmental parameters data, the clothing insulation (0.87) and metabolic rate (1.2) were estimated according to Chinese GB Standard (GB/T-50785, 2012).

Questionnaire survey

A short questionnaire was designed based on ISO-10551 (2011) to assess the customers' indoor thermal sensation in these restaurants. There are 40 respondents (20 from each restaurant) were selected for this investigation. The respondents were selected in consecutive incoming in the restaurants. The questionnaire survey was done by the assistance of a Chinese master's student and the physical parameters were recorded by the investigator before starting the questionnaire survey.

The questionnaire was conducted during the eating time of the customers. The questions were asked in the Chinese language with introducing and discussing the aim of this study. The questions were begun with the last 30 minutes activities where the respondents were engaged.

Analysis of Customers' Vote

The acceptable thermal comfort environment was evaluated by using ASHRAE 7-point thermal comfort scale

(Table 1) and evaluated with standards like PMV value ranges between -0.5 to +0.5 and PPD below 10% (ASHRAE-55, 2013).

Table 1: ASHRAE 7-point thermal comfort scale

Vote	-3	-2	-1	0	1	2	3
Thermal Sensation	Cold	Cool	Slightly Cool	Neutral	Slightly warm	Warm	Hot
Wind Sensation	Too windy	windy	Slightly windy	Neutral	Slightly weak	Weak	Too weak
Humidity Sensation	Too Humid	Humid	Slightly humid	Neutral	Slightly dry	Dry	Too dry

3. RESULTS AND DISCUSSIONS

The investigator measured the environmental parameters and conducted questionnaire survey with the permission of the restaurant's authorities. The findings of this study are described in the following sections:

Environmental parameters

It was a sunny day and the study was carried out at 12pm to 5pm. During the survey, the windows were closed and fans, AC were off. The exhaust fans were on as for proper ventilation (Table 1). The measured indoor and outdoor environmental parameters are shown in Table 2.

The study found almost a similarity in indoor air temperature instead of significant differences in outdoor temperature. The humidity was more in the indoor environment of both restaurants. It was differed almost 1% in indoor than the outdoor humidity. The outdoor air velocity was very low during the investigation. It was 0.6 ms^{-1} in the outside of CSC and 0.5 $ms^{-1}$of the Lotus restaurants' outside. But there was no air velocity inside of both restaurants.

Table 1. General information during the study

Restaurant name	CSC Restaurant	Lotus Hot Pot Restaurant
Windows	Closed	Closed
Fan	Off	Off
Air conditioner	Off	Off
Ventilation	On	On

Table 2. Measured values of environmental parameters in the study areas

Environmental Parameter	CSC		Lotus	
	Indoor	Outdoor	Indoor	Outdoor
Dry-bulb temp (^{0}C)	19.2	18.1	19.5	16.2
Wet bulb (^{0}C)	15.9	16.4	18	15.1
Humidity (%)	77.5	74.4	86.9	85.3
Air velocity (m/s)	0	0.6	0	0.5
Chill (^{0}C)	19.2	19.2	19.7	16.5
Heat Index (^{0}C)	18.2	19.2	20.3	16.5
Dew Point (^{0}C)	14.4	15.2	17.5	14.2
Dens Alt (m)	534	525	588	470
Crosswind (m/s)	0	0.6	0	0.6
Hear wind (m/s)	0	0	0	0

Customers' Preoccupations

Preoccupation is important because of its significant influence on occupants' thermal comfort. In response to this question, 65% of respondents were replied on 'sitting' as their spent last 30 minutes before coming into this restaurant. The replied sitting related activities are working at the office, reading or in lecture and gossiping. Furthermore, 20% were walking in slope and flat land (roads) and the rest of 5% were engaged with washing clothes. On the other hand, 60% respondents of Lotus hot pot restaurant were engaged with sitting, 10% walking slope, 30% walking in flat lands.

Customers' Perception: Thermal Sensation

The assessed PMV and PPD values in studied restaurants had a significant resemblance (Figure 1). Most of the respondents from both of the restaurants voted for 'neutral' feelings. In CSC, more than half of the respondents (55%) felt 'comfortable', 35% 'slightly cool' and the rest of (10%) of the respondents voted for 'slightly warm'. On the other hand, an equal number of respondents (40%) voted for 'neutral' and 'slightly cool'. There was a vote for 'cold' and one for 'slightly warm' condition. The rest of (10%) respondents felt 'cool' in this restaurant.

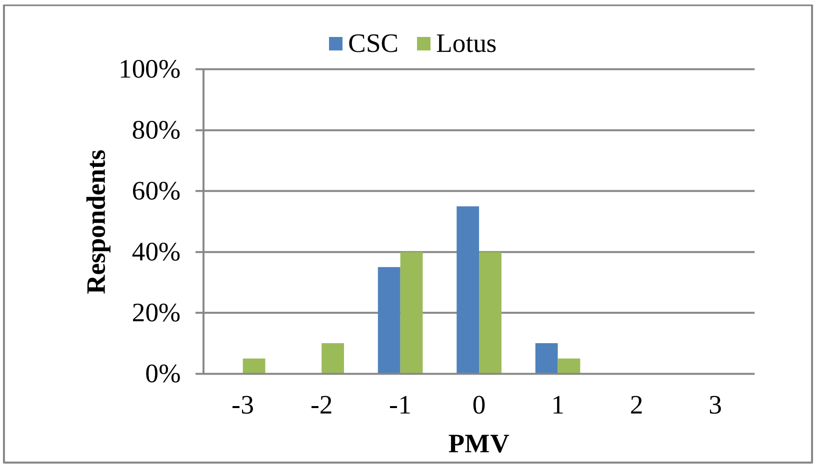

Figure 1: Percentage Customers' PMV in the restaurants

The thermal sensation in these restaurants was found as quite comfortable to the customers' perception. There are 90% of CSC and 70% of Lotus restaurant customers (80% on an average) were voted for 'completely acceptable' thermal conditions in these restaurants. Besides, 10% respondents of CSC and 25% of Lotus restaurant thought the present thermal condition in these restaurants are just acceptable while 5% of Lotus responded as 'slightly unacceptable' environment. Besides, 70% of CSC and 45% of Lotus restaurants' respondents liked the existing air temperature while rest of 30% and 55% recommended for decreasing this level to improve these conditions.

Customers' Perception: Sensation to Humidity

In response to humidity, the study found a mixed response from the customers in both restaurants. Exactly half of the respondents from Lotus and 45% from CSC found the humidity is within their expected level i.e., neutral (Figure 2). Whilst 35% and 30% found the environment as slightly humid, 25% of CSC and 10% Lotus customers thought it is slightly dry where 5% of Lotus respondents found the indoor environment too dry that needs to improve. Furthermore, there are 85% respondents of both restaurants voted for perfect humidity condition where 15% thought it was slightly acceptable. Consequently, 40% customers of CSC deliberated for keeping on this condition where 40% argued to lessen where rest of 20% thought little bit more humidity may increase their comfort level.

Customers' Perception: Wind Sensation

The perception vote for indoor air velocity was found within the scale between slightly windy (-1) to too weak (3). Half of the respondents of CSC voted for neutral, 40% for slightly weak and 10% for slightly windy. On the other hand, 40% of Lotus restaurant's customer responded for neutral, 5% slight windy, 30% slightly windy, 20% weak and the rest of 5% voted for too indoor airflow (Figure 3).

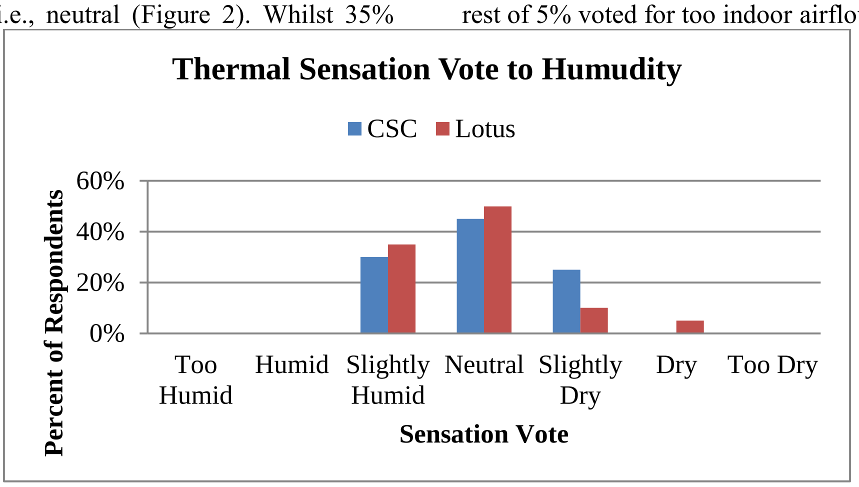

Figure 2: Customers' perception to humidity in the restaurants

The perception vote for indoor air velocity was found within the scale between slightly windy (-1) to too weak (3). Half of the respondents of CSC voted for neutral, 40% for slightly weak and 10% for slightly windy. On the other hand, 40% of Lotus restaurant's customer responded for neutral, 5% slight windy, 30% slightly windy, 20% weak and the

rest of 5% voted for excessive indoor airflow (shown in Figure. 3).

In spite of mixed perception, 95% respondents considered this condition 'acceptable' where 5% assumed for improvement. Besides, 70% respondents of Lotus restaurant considered it as 'acceptable' and 20% recommended for increasing air velocity inside the restaurant. On an average 65% of respondents of both restaurants presumed that the present indoor air velocity is quite sufficient for achieving customers' comfort perception while 27.5% mentioned for increasing and rest of 7.5% argued to decreasing air velocity for achieving the indoor comfort in these restaurants.

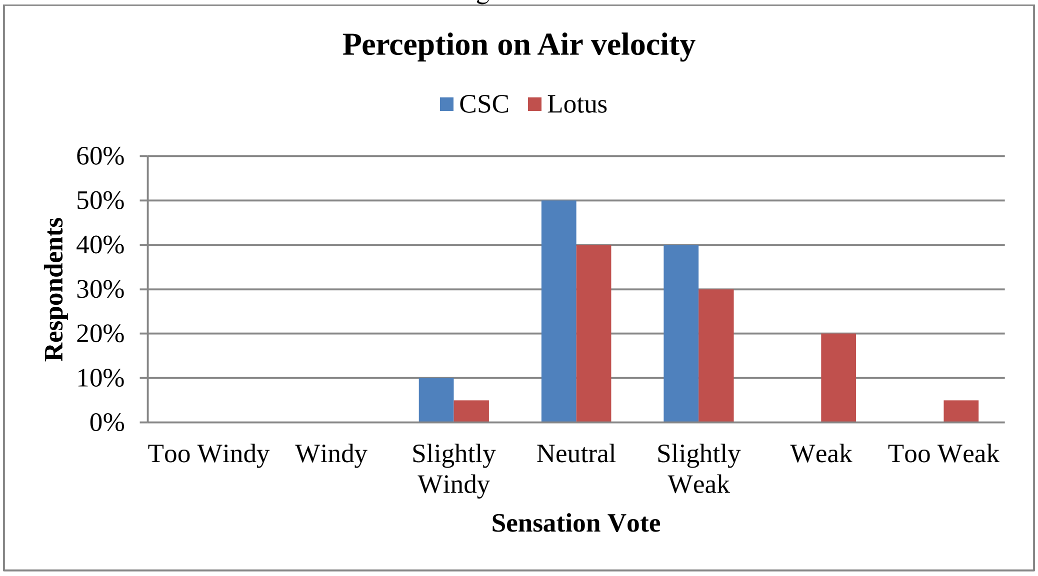

Figure 3: Customers' perception on restaurants' indoor air velocity

4. CONCLUSIONS

Maintaining indoor thermal equilibrium is important for achieving the occupants' comfort in an indoor environment. The obtained customers' PMV and suggestions along the investigated physical parameters were considered for formulating recommendations for improving the indoor thermal comfort of customers' in restaurants. Since, Fanger's PMV model has a limitation (Chen, Wang, & Srebric, 2015) and occupants' comfort is the complex interaction with the buildings (Yao, Liu, & Li, 2010), hence, dynamic thermal sensation model could be applied for more operative conclusions (Chen et al., 2015; Jing, Li, Tan, & Liu, 2012). For the hot humid region of China, (Y. Yang, Li, Liu, Tan, & Yao, 2015) and (Yao et al., 2010) proposed a revised Adaptive Predicted Mean Vote (PMVa) index and adaptive thermal comfort zone can be applied. However, adaptive approach considers real acceptability but responses are dependent on positive, behavioral and dynamic adaptation from occupants. Moreover, historical thermal condition, cultural aspects, technical practices, psychological strain (Liu et al., 2014), behavioral and psychological acclimation in an environment are also important to take into accounts (Yao et al., 2010). Based on physical measurement, customers' perceptions and suggestions, the following important conclusions of this study are noteworthy:

i. The ventilation systems of these restaurants are needed to improve. The kitchen should completely be separated from the common spaces.

ii. The indoor operative temperature can be maintained in relation to the local recommended standards. Most of the respondents suggested for considering the operative temperature (by using any mechanical appliances e.g., AC, heater, fan etc) in consideration of seasonal variations.

iii. The fumes from the kitchen are annoying to customers and interrupt with their overall comfort. The improved ventilation and more exhaust fans can help the conditions.

iv. The humidity can be monitored continuously for maintaining and controlling by using a humidifier or warm air in accordance with the comfort levels.

Although ASHRAE-55 (2013) and ISO-7730 (2005) PMV model describes the occupants' thermal comfort in a steady condition but does not for transient (e.g., occupants' walking or moving) conditions (Chen et al., 2015). Consequently, temperature perception can be overestimated up to 2.1^{0}C and underestimated up to 3.4^{0}C due to declining the occupants' psychological dimensions and socio-cultural aspects (Rupp, Vásquez, & Lamberts, 2015; R. Yang et al., 2015). Therefore this model fails to demonstrate reliable and quite accurate conclusions for indoor thermal comfort (Indraganti, Ooka, Rijal, & Brager, 2014; Y. Yang et al., 2015).

In essence, comfort perception is not uninformed by each human and environmental parameters cannot be able to entirely satisfy all occupants (Yao et al., 2010). Hence, improving indoor environment according to national or local recommended standards with considering occupants' sensitivity might be the best option for maximizing the occupants' perceptions in the restaurants. In that case, this study may help to sustainable building designer as well restaurant owner to consider the occupants' perception for improving the indoor thermal comfort.

5. REFERENCES

1. *ASHRAE-55 (2013). [Thermal Environment Conditions for Human Occupancy].*
2. *Boduch, M., & Fincher, W. (2009). Standards of Human Comfort: Relative and Absolute (pp. 02-04). Meadows Seminar Fall: Center for Sustainable Development (CSD).*
3. *Chen, X., Wang, Q., & Srebric, J. (2015). A data-driven state-space model of indoor thermal sensation using occupant feedback for low-energy buildings. Energy and Buildings, 91, 187-198. doi: 10.1016/j.enbuild.2015.01.038*
4. *Daghigh, R., Adam, N., Sopian, K., & Sahari, B. (2009). Thermal comfort of an air conditioned office through different windows-door opening arrangements. Building Service Engineering Research Technology, 30(1), 49-63. doi: 10.1177/0143624408099448*
5. *Fanger, P. O. (1970). Thermal Comfort. Copenhagen: Danish Technical Press.*
6. *GB/T-50785. (2012). Evaluation standard for indoor thermal environment in civil buildings National Standard of the People's Republic of China. China: Architecture and Building Press.*
7. *He, Y., Li, N., & Huang, Q. (2015). A field study on thermal environment and occupant local thermal sensation in offices with cooling ceiling in Zhuhai, China. Energy and Buildings, 102, 277-283. doi: 10.1016/j.enbuild.2015.05.058*
8. *HMDA. (2010). Environmental Building Guidelines for Greater Hyderabad Comfort, Com Bg 1 (pp. 15). Hyderabad, India: Hyderabad Metropolitan Development Authority.*
9. *Hu, P., Liu, W., & Jiang, Z. (2006). Study on indoor thermal sensation of young college students in the area which is not in hot in summer and cold in winter. International Journal on Architectural Science, 7(2), 47-52.*
10. *Indraganti, M., Ooka, R., Rijal, H. B., & Brager, G. S. (2014). Adaptive model of thermal comfort for offices in hot and humid climates of India. Building and Environment, 74, 39-53. doi: 10.1016/j.buildenv.2014.01.002*
11. *ISO-7730. (2005). Ergonomics of the Thermal Environment – Analytical Determination and Interpretation of Thermal Comfort using Calculation of the PMV and PPD Indices and Local Thermal Comfort Criteria. Switzerland: International Organization for Standardization.*
12. *ISO-10551. (2011). Ergonomics of the thermal environment -Assessment of the influence of the thermal environment using subjective judgement scales. Geneva, Switzerland: International Organization for Standardization (ISO).*
13. *Jing, S., Li, B., Tan, M., & Liu, H. (2012). Impact of Relative Humidity on Thermal Comfort in a Warm Environment. Indoor and Built Environment, 22(4), 598-607. doi: 10.1177/1420326x12447614*
14. *Lawson, F. (2001). Hotels and Resorts-Planning, Design and Refurbishment. UK: Architectural Press.*
15. *Liu, H., Liao, J., Yang, D., Du, X., Hu, P., Yang, Y., & Li, B. (2014). The response of human thermal perception and skin temperature to step-change transient thermal environments. Building and Environment, 73, 232-238. doi: 10.1016/j.buildenv.2013.12.007*
16. *Livchak, A., Schrock, D., & Sun, Z. (2005). The Effect of Supply Air Systems on Kitchen Thermal Environment. ASHRAE Transactions, 111(1), 748. doi: 10.1016/j.enbuild.2015.06.002*
17. *Lstiburek, J. (2002). Relative Humidity Indoor Air (pp. 1-8). Austin, Texas: Building Science Corporation.*
18. *Rupp, R. F., Vásquez, N. G., & Lamberts, R. (2015). A review of human thermal comfort in the built environment. Energy and Buildings, 105, 178-205. doi: 10.1016/j.enbuild.2015.07.047*
19. *Simone, A., & Olesen, B. W. (2009). An experimental study of thermal comfort at different combinations of air and mean radiant temperature. Paper presented at the Proceedings of Healthy Buildings, Syracuse, NY.*
20. *Simone, A., & Olesen, B. W. (2012). Investigation of subject perceptions of the environment in commercial kitchens. Paper presented at the 10th International Conference on Healthy Buildings, Brisbane, Australia.*
21. *Wyon, D. (1996). Individual microclimate control: Required range, probable benefits and current feasibility. Paper presented at the 7th International Conference on Indoor Air Quality and Climate, Nagoya, Japan.*
22. *Yang, R., Liu, L., & Ren, Y. (2015). Thermal environment in the cotton textile workshop. Energy and Buildings, 102, 432-441. doi: 10.1016/j.enbuild.2015.06.024*
23. *Yang, Y., Li, B., Liu, H., Tan, M., & Yao, R. (2015). A study of adaptive thermal comfort in a well-controlled climate chamber. Applied Thermal Engineering, 76, 283-291. doi: 10.1016/j.applthermaleng.2014.11.004*
24. *Yao, R., Liu, J., & Li, B. (2010). Occupants' adaptive responses and perception of thermal environment in naturally conditioned university classrooms. Applied Energy, 87(3), 1015-1022. doi: 10.1016/j.apenergy.2009.09.028*
25. *Yau, Y., Chew, B., & Saifullah, A. (2011). A field study on thermal comfort in lecture halls in Malaysia. Paper presented at the 7th International Symposium on Heating, Ventilation and Air Conditioning, Shanghai, China.*