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ADAPTATION OF THERMAL COMFORT IN NATURALLY VENTILATED STUDENTS RESIDENTIAL COLLEGE IN TROPICAL CLIMATES OF MALAYSIA

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ABSTRACT
The climate in tropical regions was affecting the level of thermal comfort of the individual while accommodating the residential buildings. Residential buildings especially student residential colleges in Malaysia were mainly build depending on natural ventilation systems as a tool to facilitate comfort in their daily life without the consent of the mechanical ventilation system such as air conditioners. This study has been done by distributing a questionnaire to the occupants who live in the naturally ventilated residential college and conducting an interview series with a college management officer to prove and validate the data collected throughout the study. The result of the study shows that students most likely will change their behavior due to the level of heat stress in the dormitory. Statistics from the data collected shown that students were very relying on the support of the mechanical ventilation system and they are also keener towards wearing a thinner and comfortable clothing material as it will help them to reduce the heat discomfort throughout the day. This study also shows a positive correlation analysis between the relationship of low ventilation flow and the level of indoor thermal comfort. This situation is regarded as the environmental factors that play important roles in the level of thermal comfort in a residential building, especially in tropical climates.

Keywords:
Adaptive Behavior, Thermal Comfort, Student Residential

INTRODUCTION

Malaysia is a tropical country that is known for its hot, humid, and rainy climate throughout the year. Climate change in Malaysia is influenced by its strategic location which is intersecting route to the monsoon winds that caused dry climate during the southwest monsoon which is starts from late May till August, and heavy rains during northeast monsoon from November till February all year round. This phenomenon has contributed to the heat stress, wind flow patterns, and humidity level that influenced the comfort level of the locals [1].

Climate indeed was the main factor that affecting the comfort of human life. Humans will strive to adapt to their surrounding environment to reach their standardization of comfort, well-being, health, productivity, and performance. Climate factor has caused the thermal comfort issues in a residential building. Thermal discomfort in student residential buildings will affect the student's learning process and productivity [2]. Thermal discomfort issues in student residential buildings were triggered by the excessive numbers of student enrollment in higher education institutions (HEI) which is recorded from 664,402 students in 2010 to 1,134,134 students in 2012 [3]. However, the increasing rate of registered students was unbalanced with the facilities provided by the university especially in terms of students accommodation centers. This has led to overcrowding issues prompt by the arrangement of a student's placement in one room [4];[5];[6].

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The building trends of multi-story hostels with natural ventilation and ceiling fan for student residential college will lead to negative effects on the comfort level of the occupants [7]. The multi-story building in the tropical climate is known for its capability to manipulate wind sources as an element of natural ventilation. However, the conflict and inconsistency between air velocity and high-temperature pressure throughout the building have created a stack effect problem that disrupts the thermal comfort level of the occupants [8]. This scenario will cause an increased level of heat accumulation in the rooms and will trigger psychological tolerance in response to the heat changes in ambient temperature. The act of opening doors and windows will allow natural ventilation to stimulate the airflow and heat transfer from the building [9].

Thermal discomfort in residential buildings forced the occupants to alter their act of behavior to create a comfortable indoor thermal environment that will help to generate the possible comfort factors available [10];[11]. The stimulating action beyond the occupant's norms was an effort done to reduce the thermal stress experienced by the occupants in their living environment. Occupants adaptive behavior regarding the unsatisfied comfort level will contributing to the massive wastage of natural resources such as energy consumption and increasing rate of financial cost [12];[13].

Each individual reaches a different level of thermal comfort than another individual due to the behavioral adjustment of a person itself in an effort to obtain a balanced and comfortable body temperature for daily living [14]. This behavior adaptation functions in generating individual social interactions that require individuals to train themselves mentally and socially in creating a healthy living environment [15].

[16] stated that high-temperature exposure in natural ventilation residential college will generate a tolerable student in adapting to such environment. Student's acceptance towards the uncomfortable temperature is overcome by conducting a behavioral adjustment by increasing the air velocity in the room by turning on the fan, opening windows and doors to increase the flow into the room, and wearing thin and comfortable clothes of fabrics. The student's dependencies on the natural ventilation due to the absence of the air conditioning system in their dormitory had forced the occupants to accept their living environment. The action of behavioral adjustment involving changes in student behavior helps to increase thermal comfort levels while accommodating the residential college throughout their study years [17].

Thrmal Comfort Model

The thermal comfort model is an important component in the development of the design and operation process of the building. Worldwide research regarding the thermal comfort model was conducted using two methods which are known as a universal model (Predicted Mean Vote (PMV)) and adaptive model [18];[19];[20]. Both methods of approach are used to identify the factors that lead to the level of an individual's thermal satisfaction while living in a building. In this paper, only adaptive model will be discussed as it emphasizes the balance between human behavior towards their living environment [21];[22]. This concept begins when human thermal comfort was not only influenced by the environmental factors itself but also greatly influenced by the individual acceptance and flexibility towards the environmental factors [19,23]. This proved that individuals naturally adapting through behavior changes according to their preference of acceptance [24];[25];[26]. There is three types of adaptive model as shown in Figure 1;

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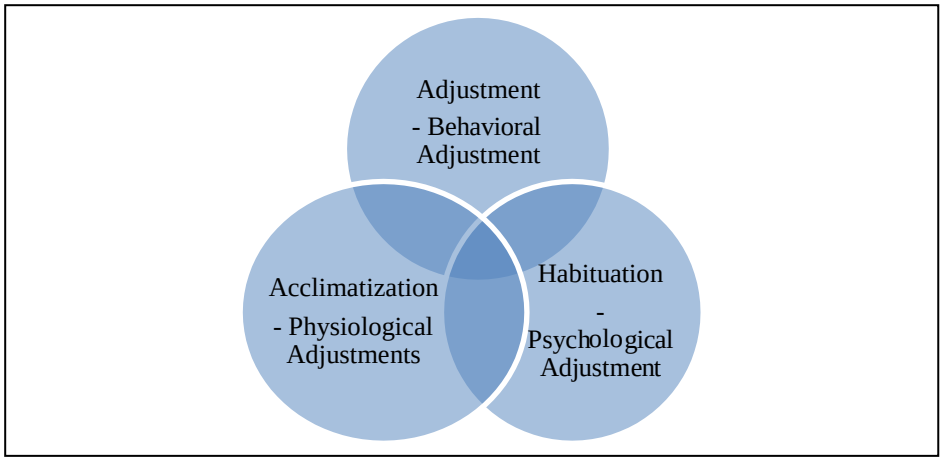

Fig. 1: Adaptive Model [21]

- Behavioral Adjustment

Building efficiency will be achieved once the building system can create a positive interaction among the occupants. The accessibility to control comfort elements such as temperature, solar gain, air velocity and humidity according to the occupant's perspectives and demands will increase their tolerance towards the environmental conditions [27].
Personal response is a result naturally made from human reflex in responses to their bodies. Behavioral adjustment is divided into three categories which is personal response (personal), technological response and cultural response (cultural). These three categories are acts and behaviors performed consciously or unconsciously by each individual to obtain optimal body temperature [21].
Personal response is the willingness of the individual to make controllable behavioral changes to achieve their desired or optimal level of comfort [28]. Environment such as ambient temperature plays important roles regarding the action made by the individuals towards the surrounding atmosphere such as opening window when the air air-flow rate was low, wearing thinner clothing material to stabilize body temperature, avoiding outdoor activities and so on [29].
Modern technology approaches nowadays also contribute to the improvement of human comfort. The improvement of the mechanical ventilation devices such as fans, air conditioners, insulation and many more have become human requirement to be owned and installed in every residential units to maximize the living comfort. Meanwhile, living culture responses are activities performed by individuals according to local weather and climatic conditions such as sunbathing [30];[31].

- Physiological Adjustments

Physiological adaptation is a body response system towards the changes of the ambient temperature and heat. Typically, human body systems require a time to tolerate and adapt to thermal changes until an optimal level of temperature equilibrium can be reached by their bodies. Physiological adaptation is divided into two types, which is genetic modification and adaptation to a new place (acclimatization) [21]. Genetic modification is special genetic traits inherited from familial lineages that contributed to a custom personality or habits that cannot be reoriented by the heat and climate factor around them. Acclimatization is an adaptation in a new place or a process of individual acceptance towards the new environment in terms of temperature and climate differences factors. Typically, each individual needs a certain period to tolerate and adapt to changes in their environment. Poor level of physiological adaptation will lead to several conflicts of human life issues such as low productivity, health problems, fatigue and others.

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- Psychological Adjustment

Psychological adjustment is an individual's perception and response in adapting situations beyond their expectations using thoughts and emotions. Each sensory system will transmit different acceptance and sensitivity in dealing with their environment. Individuals who are exposed to unpredictable temperature beyond their normal norms will tend to develop immunity to thermal stimuli where they can cooperate with local climate change more easily than other individuals. Psychological adjustment is very important for generating positive thinking, increasing individual productivity rate, alertness in emotional control and so on [21].

METHODOLOGY

66 respondents which are the occupants at the residential college were taken as the objects of the questionnaire surveys and the field operative air measurement of the residential colleges at Universiti Tun Hussein Onn Malaysia (UTHM) namely Kolej Kediaman Perwira were conducted from May to August 2019.

Data gained from the questionnaire survey were analyzed thoroughly so that occupant's adaptive behavior can be examined for further investigation. Table 1 shows the selection of daily activities of occupants that occur at the research location. All elements related to mechanical ventilation usage have been recorded with the high status of average mean index among other elements which are Switch on the fan (4.6), Dependent towards fan usage (4.5), and switch on a portable fan and a ceiling fan simultaneously (4.3). This proved that the high dependencies pattern towards mechanical ventilation systems such as ceiling fan and portable fan in the dormitory shows low ventilation flow factor in their rooms. This action mainly due to the occupants' responses that were related to human reflex against their thermal discomfort from the surrounding. Individuals tend to make some changes to gain their optimal level of thermal comfort while in the building. In this case, students' most likely dependent on the mechanical ventilation units to achieved their preferable comfort temperature [32];[16]. The number of fan units in one particular room has been affected the airflow rate in space and this is the factor that causes students to have a high level of dependence towards the mechanical ventilation system during their time accommodating the student residential college. This statement also supported by the Assistant Hostel Manager of Perwira Residential College which stated that:

"One fan unit in each dormitory is not sufficient and will not be able to provide comfort to students. However, this issue is difficult to fix as it involves a huge amount of costs."

The choices of clothing also depend on the climate factors. Clothing and skin are considered body insulators that protect humans and provide heat resistance from environmental elements. Clothing is an element that allows the body to accept the heat and climate changes [33]. Wearing thinner clothes also recorded a high average mean index value (4.4) which is triggered by the high heat stress in the room. The adaptation of an individual's clothing is influence by fashion, gender and activities factor throughout the day. The amount clothes of one person wears in their daily life also depends on the outdoor temperature experienced [19]. However, when the individual was resting in their house/room, they are free to choose the type of clothes they favored. According to [34], building occupants in hot climate regions most likely choose light, loose, brightly color, and sweat-absorbing fabric material clothing to interpret comfort and to allow air movement throughout the body. In this research, students most likely change their attire to wear comfortable clothes that will give them satisfaction and comfort while accommodating the room. This action is controlled by the individual itself, so when they feel uncomfortable, they are free to achieve the desired level of thermal comfort by wearing their preferable clothes.

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Table 1: Student's Adaptive Behavior.

Elements	Comfort Scale					Mean	Status
	1	2	3	4	5		
	Frequency (%)						
Wearing thin clothes	0 (0)	2 (3.0)	6 (9.1)	23 (34.8)	35 (53.0)	4.4	H
Opening a doors and windows	2 (3.0)	5 (7.6)	8 (12.1)	21 (31.8)	30 (45.5)	4.1	H
Switch on the fan	0 (0)	1 (1.5)	6 (9.1)	14 (21.2)	45 (68.2)	4.6	H
Dependent towards fan usage	0 (0)	1 (1.5)	8 (12.1)	13 (19.7)	44 (66.7)	4.5	H
Switch on a portable fan and a ceiling fan simultaneously	1 (1.5)	3 (4.5)	7 (10.6)	16 (24.2)	39 (59.1)	4.3	H
Easily awaken in the middle of the night	6 (9.1)	2 (3.0)	21 (31.8)	13 (19.7)	24 (36.4)	3.7	H
Opening a window or a door while sleeping	7 (10.6)	12 (18.2)	15 (22.7)	16 (24.2)	16 (24.2)	3.3	M
Shower regularly	4 (6.1)	2 (3.0)	17 (25.8)	24 (36.4)	19 (28.8)	3.8	H
Changing the furniture layout of the room	12 (18.2)	5 (7.6)	19 (28.8)	12 (18.2)	18 (27.3)	3.3	M

Opening a door and window also recorded a high average mean index among another element which is 4.1. According to [35], window opening behavior is a consequence of the uncomfortable temperature sensation in the room. Students were frequently most likely to open doors and windows while they were resting in the rooms to enable the airflow existence throughout the room when the indoor temperature is higher than the outdoor temperature [14];[29].

Besides that, shower regularly and easily awakens in the middle of the night also shows a high status of the average mean index which is 3.8 and 3.7 respectively. According to [36], occupants in students' residential college most likely will experienced thermal discomfort at night as a result of the rooms' indoor temperature is higher than the indoor design condition proposed by MS 1525: 2007. This showed that the impractical building design was the factor that leads to the higher heat absorption due to limited opening such as windows, low humidity, and low air movement in the rooms.

Opening a window or a door while sleeping and modified the furniture layout shows a medium status of the average mean index which is 3.3 overall. According to [37], discomfort during the peak hour caused by overheating can be prevented by opening windows at night which will helps to improve indoor air conditions of the rooms. However, this behavioral adjustment not applicable to the occupants that occupy the room on the ground floor due to the security factors and sound pollution issues. The act of moving the furniture from the original position indicates the room's impractical furniture layout was the main factor of the distress and discomfort felt while occupying the rooms. However, this act is prohibited by the management due to the safety factor of accidents or injuries. This statement is linked with a statement made by the Assistant Hostel Manager of Perwira Residential College which stated that:

"The act of moving the furniture in the hostel is one of the actions that violate the rules of the hostel. This is due to the safety factor of the students themselves. Students who are found guilty of moving furniture in the room will be fined so that this does not happen again. "

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- Relationship between low ventilation flow and the level of student's thermal comfort

The correlation analysis results show a medium/average correlation between poor ventilation flow with the level of student's thermal comfort with a coefficient value of .402** (Table 2). The variables of low ventilation flow and the level of student's thermal comfort found a positive correlation and the variance was 16.2% [(0.402 x 0.402) x 100]. This proved that low ventilation flow was the factor influencing the level of discomfort for the residential college occupants.

Table 2 : The Relationship Between Low Ventilation Flow And The Level Of Indoor Thermal Comfort.

Variables		**Low ventilation flow**	**Level of Indoor Thermal Comfort**
Low ventilation flow	Pearson correlation	1	.402**
	Sig. (2-side)		.001
	N	66	66
Level of indoor thermal comfort	Pearson correlation	.402**	1
	Sig. (2-side)	.001	
	N	66	66
**. Correlation is significant 0.01 (2-side).			

CONCLUSION

The optimum indoor temperature standard that has been outlined by ASHRAE Standard for thermal comfort is between 22°C to 25.5°C. However, such standards are not suitable for countries such as Malaysia which have hot and humid climates with temperatures between 20°C to 32°C with relative humidity of around 75% [38]. A large number of housing units in Malaysia including student residential colleges use natural ventilation systems. As such, the issue of thermal comfort often occurs in countries with tropical climates [15];[16]. Thus, the thermal comfort range does not have a perfect fixation when the thermal comfort is different according to individual requirements/acceptance and local climatic factors [39].

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REFERENCES

[1] Suhaila, J., Deni, S. M., Zawiah Zin, W. A. N., & Jemain, A. A. (2010). Trends in Peninsular Malaysia rainfall data during the southwest monsoon and northeast monsoon seasons: 1975-2004. *Sains Malaysiana*, *39*(4), 533–542.

[2] Puangmalee, N., Hussaro, K., Boonyayothin, V., & Khedari, J. (2015). A Field of the Thermal Comfort in University Buildings in Thailand under Air Condition Room. *Energy Procedia*, *79*, 480–485. https://doi.org/10.1016/j.egypro.2015.11.522

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International Journal of Engineering Technology Research & Management

[3] MOHE. (2011). Statistics of Higher Education of Malaysia 2010 (P. a. R. Division, Trans.) (First ed., pp. 118). Putrajaya: Ministry of Higher Education Malaysia.
[4] Adio-Moses, R. O. (2017). Overcrowding a Threat to Environmental Safety and Wellbeing: An Empirical Investigation of Female Undergraduate Halls of Residence in a Nigerian University. *Journal of Modern Education Review*, *6*(7), 490–497. https://doi.org/10.15341/jmer(2155-7993)/07.06.2016/008
[5] Muslim, M. H., Karim, H. A., & Abdullah, I. C. (2012). Satisfaction of Students' Living Environment between On-Campus and Off-Campus Settings: A Conceptual Overview. *Procedia - Social and Behavioral Sciences*, *68*, 601–614. https://doi.org/10.1016/j.sbspro.2012.12.252
[6] Nimako, S. G., & Bondinuba, F. K. (2019). Relative Importance of Student Accommodation Quality in Higher Education. *Current Research Journal of Social Sciences*, *5*(4), 134–142. https://doi.org/10.19026/crjss.5.5548
[7] Dahlan, N. D., Jones, P. J., Alexander, D. K., Salleh, E., & Alias, J. (2009). Evidence base prioritisation of indoor comfort perceptions in Malaysian typical multi-storey hostels. *Building and Environment*, *44*(10), 2158–2165. https://doi.org/10.1016/j.buildenv.2009.03.010
[8] Jamaludin, A. A., & Hussein, H. (2012). Energy Performance of Three Residential College Buildings in University of Malaya Campus, Kuala Lumpur. *Journal of Design and Built Environment*, *Volume 9*(Issue 1).
[9] Sulaiman, S. A., Zakeria, A. F., Ramely, M. F., Zaidi Moni, M. N., & Basrawi, M. F. (2017). Effect of ventilation on thermal comfort in campus hostel bedrooms after sunset. *MATEC Web of Conferences*, *131*, 03005. https://doi.org/10.1051/matecconf/201713103005
[10] Al-Tamimi, N. A., Fadzil, S. F. S., & Harun, W. M. W. (2011). The Effects of Orientation, Ventilation, and Varied WWR on the Thermal Performance of Residential Rooms in the Tropics. *Journal of Sustainable Development*, *4*(2). https://doi.org/10.5539/jsd.v4n2p142
[11] Wafi, S., & Ismail, M. R. (2008). The Relationship between thermal performance, thermal comfort and occupants. *Journal of Sustainable Development*, (Icbedc), 675–690.
[12] Mihlayanlar, E., Öztuna, S., & Büyükakin, K. (2017). Investigation of thermal comfort conditions in higher education facilities: A case study for Engineering Faculty in Edirne. *TEM Journal*, *6*(1), 71–79. https://doi.org/10.18421/TEM61-10
[13] Sapri, M., & Muhammad, S. (2010). Monitoring energy performance in higher education buildings for sustainable caumpus. *Malaysian Journal of Real Estate*, *5*(1), 1–25.
[14] Kumar, P. (2015a). Evaluation of Thermal Comfort of Naturally Ventilated University Students' Accommodation based on Adaptive Thermal Comfort Model and Occupant Survey in Composite Climate. *International Journal of Architecture, Engineering and Construction*, (January 2015). https://doi.org/10.7492/ijaec.2014.024
[15] Azizi, N. S. M., Wilkinson, S., & Fassman, E. (2015). An analysis of occupants response to thermal discomfort in green and conventional buildings in New Zealand. *Energy and Buildings*, *104*(July), 191–198. https://doi.org/10.1016/j.enbuild.2015.07.012
[16] Gou, Z., Gamage, W., Lau, S., & Lau, S. (2018). An Investigation of Thermal Comfort and Adaptive Behaviors in Naturally Ventilated Residential Buildings in Tropical Climates: A Pilot Study. *Buildings*, *8*(1), 5. https://doi.org/10.3390/buildings8010005
[17] Kumar, P. (2015b). Optimizing building performance by integrating experiential thermal comfort in students' accommodation. *14th International Conference of IBPSA - Building Simulation 2015, BS 2015, Conference Proceedings*, 1729–1736.
[18] Frontczak, M., & Wargocki, P. (2011). Literature survey on how different factors influence human comfort in indoor environments. *Building and Environment*, *46*(4), 922–937. https://doi.org/10.1016/j.buildenv.2010.10.021
[19] Hoof, J. van. (2010). Thermal comfort: research and practice. *Frontiers in Bioscience*, *15*(1), 765. https://doi.org/10.2741/3645
[20] Zhang, W., Liu, F., & Fan, R. (2018). Improved thermal comfort modeling for smart buildings: A data analytics study. *International Journal of Electrical Power and Energy Systems*, *103*(February), 634–643. https://doi.org/10.1016/j.ijepes.2018.06.026
[21] Rahman, A. A., & Shafii, H. (2013). *KESELESAAN TERMAL : SATU KAJIAN TEORITIKAL*. 53–60.
[22] Razman, R., & Zaki, A. (2011). Study On Thermal Comfort In University Hostel Building Case Study At Universiti Tun Hussein Onn Malaysia (UTHM), Batu Pahat. *Engineering*, *8*(January), 167–170.
[23] Humphreys, M. A., & Nicol, J. F. (1998). Understanding the adaptive approach to thermal comfort. *ASHRAE Transactions*, *104*(Pt 1B), 991–1004.
[24] Hellwig, R. T., Teli, D., Schweiker, M., Choi, J. H., Lee, M. C. J., Mora, R., … Al-Atrash, F. (2019). A framework for adopting adaptive thermal comfort principles in design and operation of buildings. *Energy and Buildings*, *205*(November), 109476. https://doi.org/10.1016/j.enbuild.2019.109476

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International Journal of Engineering Technology Research & Management

[25] Luo, M., Wang, Z., Brager, G., Cao, B., & Zhu, Y. (2018). Indoor climate experience, migration, and thermal comfort expectation in buildings. *Building and Environment*, *141*(March), 262–272. https://doi.org/10.1016/j.buildenv.2018.05.047

[26] Oliveira, E. A. S. de, Xavier, A. A. de P., Michaloski, A. O., & Pizybski, E. M. (2016). <b>Human thermal comfort and architectural volume. *Acta Scientiarum. Technology*, *38*(2), 129. https://doi.org/10.4025/actascitechnol.v38i2.28308

[27] Szery, K., & Sunindijo, R. Y. (2019). *Occupant Satisfaction in Sustainable and Conventional Higher Education Buildings*. (January), 95–111. https://doi.org/10.1007/978-3-030-18652-4_8

[28] Gou, S., Nik, V. M., Scartezzini, J. L., Zhao, Q., & Li, Z. (2018). Passive design optimization of newly-built residential buildings in Shanghai for improving indoor thermal comfort while reducing building energy demand. *Energy and Buildings*, *169*, 484–506. https://doi.org/10.1016/j.enbuild.2017.09.095

[29] Raja, I. A., Nicol, J. F., Mccartney, K. J., & Humphreys, M. A. (2001). *Thermal comfort: use of controls in naturally ventilated buildings*. *33*, 235–244.

[30] Day, J. K., & Gunderson, D. E. (2015). Understanding high performance buildings: The link between occupant knowledge of passive design systems, corresponding behaviors, occupant comfort and environmental satisfaction. *Building and Environment*, *84*, 114–124. https://doi.org/10.1016/j.buildenv.2014.11.003

[31] Jamaludin, A. A., Inangda, N., Ariffin, A. R. M., & Hussein, H. (2011). Energy performance: A comparison of four different multi-residential building designs and forms in the equatorial region. *2011 IEEE 1st Conference on Clean Energy and Technology, CET 2011*, (June), 253–258. https://doi.org/10.1109/CET.2011.6041492

[32] Kuncheekanna. (2013). A Comparison Of Occupant Thermal Comfort. *Thermal Comfort*.

[33] Alwetaishi, M. S. (2017). Impact of Building Function on Thermal Comfort: A Review Paper. *American Journal of Engineering and Applied Sciences*, *9*(4), 928–945. https://doi.org/10.3844/ajeassp.2016.928.945

[34] Mallick, F. H. (1996). Thermal comfort and building design in the tropical climates. *Energy and Buildings*, *23*(3), 161–167. https://doi.org/10.1016/0378-7788(95)00940-X

[35] Rijal, H. B., Tuohy, P., Humphreys, M. A., Nicol, J. F., Samuel, A., & Clarke, J. (2007). Using results from field surveys to predict the effect of open windows on thermal comfort and energy use in buildings. *Energy and Buildings*, *39*(7), 823–836. https://doi.org/10.1016/j.enbuild.2007.02.003

[36] Ali, N., & Kassim, U. (2018). *Analysis of Thermal Comfort for Student (University Malaysia Perlis)*. 101–108.

[37] Pomfret, L., & Hashemi, A. (2017). Thermal Comfort in Zero Energy Buildings. *Energy Procedia*, *134*, 825–834. https://doi.org/10.1016/j.egypro.2017.09.536

[38] Daud, S. M., Ahmad, S., Hashim, N. M., & Yusoff, Y. M. (2017). Keselesaan terma pelajar dalam bilik darjah: Kajian Kes di Sekolah Agama Menengah Tinggi Sultan Hisamuddin, Klang, Selangor Darul Ehsan (Classroom thermal comfort in Klang, Selangor Darul Ehsan: A case study). *Keselesaan Terma Pelajar Dalam Bilik Darjah: Kajian Kes Di Sekolah Agama Menengah Tinggi Sultan Hisamuddin, Klang, Selangor Darul Ehsan (Classroom Thermal Comfort in Klang, Selangor Darul Ehsan: A Case Study)*, *11*(4), 24–38.

[39] Juangjandee, W. (2017). Analysis Thermal Comfort Condition in Complex Residential Building, Case Study: Chiangmai, Thailand. *IOP Conference Series: Materials Science and Engineering*, *245*(5). https://doi.org/10.1088/1757-899X/245/5/0