© Universiti Tun Hussein Onn Malaysia Publisher's Office

IJIE

Journal homepage: http://penerbit.uthm.edu.my/ojs/index.php/ijie
ISSN: 2229-838X, e-ISSN: 2600-7916

The International Journal of Integrated Engineering

Thermal Comfort and its Relation to Ventilation Approaches in Non-Air-Conditioned Mosque Buildings

Nur Baitul Izati Rasli[1], Nor Azam Ramli[1,*], Mohd Rodzi Ismail[2], Nazatul Syadia Zainordin[3], Syabiha Shith[1], Amni Umirah Mohamad Nazir[1]

[1]Environmental Assessment and Clean Air Research, School of Civil Engineering,
Universiti Sains Malaysia, 14300 Pulau Pinang, MALAYSIA

[2]School of Housing Building and Planning,
Universiti Sains Malaysia, 11800 Pulau Pinang, MALAYSIA

[3]Department of Environmental Management, Faculty of Environmental Studies,
Universiti Putra Malaysia, 43400 Selangor, MALAYSIA

*Corresponding Author

DOI: https://doi.org/10.30880/ijie.2019.11.01.002
Received 28 May 2018; Accepted 29 June 2018; Available online 10 May 2019

Abstract: This paper reports the outcome of a thermal comfort study that assessed the satisfaction of occupants with their surrounding thermal conditions. The study was carried out in 10 mosque buildings around lowland Nibong Tebal, Penang and highland Cameron Highlands, Pahang. It involved determining the compliance level of thermal comfort parameters (i.e. air temperature, relative humidity and air speed) at lowland and highland and establishing relationships between ventilation systems with predicted mean vote and predicted percentage of dissatisfied at lowland and highland according to ASHRAE Standard-55. The study was conducted from 1200h to 1700h/1730h to assess the thermal conditions of the 10 mosques during Zohor/Friday and Asar prayer times. During prayer times, an active ventilation system was in operation, while before and after prayer times, only passive ventilation (windows and doors) was available. Overall, findings indicated that better thermal comfort conditions occurred during prayer time at highland compared with those at the lowland, with the thermal sensation conditions of mosques in the former 'slightly warmer' to 'slightly cool' and in the latter 'slightly warm' to 'hot'. Moreover, most mosques at lowland did not provide good thermal comfort because the percentage of dissatisfied was high compared to that at highland.

Keywords: Mosque, PMV, PPD, thermal comfort, ventilation

1. Introduction

Malaysia, a tropical country, experiences moderately warm ambient temperature all throughout the year. Ventilation is paramount to ensure comfort within an indoor environment. Insufficient ventilation rates and inadequate ventilation strategies coupled with increasing outdoor and indoor pollutants may reduce the indoor air quality (IAQ). High humidity and warm temperatures could also increase the risk of thermal discomfort and moisture problems indoor [1]. Several past IAQ studies in Malaysia reported that IAQ, thermal comfort and sick building syndrome (SBS) have become common concerns in Malaysian buildings [2]-[6].

To create an indoor climate in buildings that occupants would find thermally comfortable, building designers refer to thermal comfort standards to aid in their designs [7]. By referring to Hoyt et al. [8] a comfort zone should be based on six variables, namely, air temperature, air velocity, relative humidity, radiant temperature, occupant's clothing

*Corresponding author: ceazam@usm.my

insulation and occupant's activity level as recommended by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard-55. If temperature and humidity levels in a building are too high or too low, occupants can fall into an uncomfortable zone and feel dissatisfied with the environment, a condition which reduces their productivity.

As Malaysia is located near the equator, buildings may receive greater heat, which increases their thermal loads. In a tropical climate, the high solar and terrestrial radiations that reach building envelopes causes discomfort to the occupants [9]. Mosque, a non-industrial building, is an important building typology for Muslims by serving as a multi-functional space for the community. Its main prayer hall is a place for worshipping, preaching and other religious activities that involve occupancy [10]. Hence, the indoor environment of mosques must be kept as comfortable as possible. IAQ and thermal comfort in public buildings, especially in mosques, may be a concern for tranquility, particularly during prayer times which always receive high attendance; thus, good IAQ is necessary [11]. Poor IAQ could have detrimental health effects on building occupants, such as respiratory and cardiopulmonary pathologies and asthma. Therefore, a poor indoor environment has a negative impact on human health [12]. IAQ and thermal comfort are very important because they can affect public users' health when they are exposed to indoor air pollutants. These issues are not new in Malaysia. However, the lack of study data and local regulations has made IAQ an urgent concern, especially within non-industrial premises [1] like a mosque.

Building conditions or façade design parameters (e.g. dimensions of the building, ventilation, size of doors, type and size of windows) and general activities (e.g. praying) are some of the factors that may interrelate to influence the level of thermal comfort. Moreover, poor thermal comfort or thermal discomfort has a negative impact in its own right. If thermal discomfort continues over prolonged periods, it may contribute to serious adverse health effects for individuals, especially building occupants.

During (Friday) prayer and *Taraweeh* prayer on the nights of the Ramadan month, as well as during other special occasions, such as lecturing and seminar activities where people congregate and tend to stay longer in mosques, mosques often become fully occupied, with occupant density rising up to >1.5 person/m^2 [11]. Despite the importance of IAQ, few studies have been performed to evaluate it in mosque buildings. The attendance of worshippers during Zohor time on Friday increases the number of Jemaah in the mosques and the number of vehicles to transport them.

Therefore, the objectives of this study were to (1) determine the relationship of thermal comfort parameters (air temperature, relative humidity and air speed) at lowland and highland and (2) establish the relationship between ventilation approach and predicted mean value (PMV) and predicted percentage of dissatisfied (PPD) according to their compliance with ASHRAE Standards at lowland and highland. Highlands are expected to have lower ambient temperature than lowlands.

2. Material and Methods

2.1 Sampling Location

Six mosque buildings around the Nibong Tebal area (lowland) and four mosque buildings around the Cameron Highlands area (highland) were selected to determine the physical parameters of thermal comfort (air temperature, relative humidity and air speed). The mosques were selected based on their different microclimate to investigate the thermal comfort characteristics between lowland and highland. From the ten mosques, six mosques were monitored during Zohor and Asar prayers (3 mosques at lowland and 3 mosques at highland), while four mosques were monitored during Friday and Asar prayer (3 mosques at lowland and 1 mosque at highland), times which have high occupancy in the afternoon because of the Friday prayer. Therefore, the data sampling for temperature in mosque buildings on Friday was different from that on normal days. Table 1 shows the coordinates of the studied mosques.

2.2 Selection of Monitoring Instruments

An IAQ monitor (IQ-610) was used to collect air temperature data (range: 10 °C–70 °C; accuracy: ± 0.3 °C) and relative humidity (range: 0–100%), while Air Flow (AS-201) was used for air speed in the mosque buildings. Both instruments are Graywolf models. The instruments were mounted on a tripod 1.3 m above the ground at one sampling point and placed in the main prayer hall.

2.3 Sampling Method

The sampling was divided into four continuous sessions as shown in Table 2. The sampling events in the mosques were conducted for 5/5.5 hours from 1200hrs to 1700h/1730hrs. The discrepancies were due to the late entrance time of Asar and because the congregations finish by 1730hrs. The sampling was carried out for ten (10) days, with 1 day for each mosque with a carpeted floor. All the data was recorded in minutes, then averaged to hourly with no replications. On Friday, during Zohor, praying in congregation is compulsory and is normally called Friday prayer. The two types of ventilation conditions are passive ventilation, in which all fans are switched off when there are no occupants in the mosque, and active ventilation, in which the fans are switched on to cater to praying occupants. The selected sampling locations were more than 0.5 m from the walls, corners and windows but not directly in front of floor fans and not within 2 m of the doors.

Table 1 - Coordinate of the studied mosques

Mosque	Coordinate (N;E)
During Zohor and Asar prayer at lowland	
M01	5.144766, 100.494040
M02	5.174619, 100.541203
M03	5.284583, 100.509856
During Friday and Asar prayer at lowland	
M04	5.168175, 100.477498
M05	5.148779, 100.420434
M06	5.221623, 100.497009
During Zohor and Asar prayer at highland	
M07	4.413980, 101.386603
M08	4.568574, 101.410215
M09	4.492634, 101.388704
During Friday and Asar prayer at highland	
M10	4.470817, 101.382893

Table 2 - Monitoring schedule for all mosques

Session	Time	Descriptions
Before praying	1200 – 1300 hrs.	• No occupants • Passive ventilation
During praying (Zohor/Friday)	1300 – 1400/1430 hrs.	• With occupants • Active ventilation
After/Before praying	1400/1430 – 1600 hrs.	• No occupants • Passive ventilation
During praying (Asar)	1600– 1700/1730 hrs.	• With occupants • Active ventilation

2.4 Clothing Insulation Value and Metabolic Rate

According to ISO 7730 Standard [13] the basic clothing insulation value was based on the activity level determined through observation in the mosque buildings. According to [10], the most common clothes worn by mosque goers (worshippers) in Malaysia are traditional Malay long-sleeved shirt with trousers, traditional Malay long-sleeved shirt paired with *kain sarung*, long-sleeve shirt paired with normal trousers and normal shirt with *kain sarung*. During prayer time, worshippers practice worshipping in the mosque buildings and the movements, such as standing, bowing, prostrating and sitting, are very relax. Table 3 shows the estimated clothing insulation value and metabolic rate for activities used in this study based on ISO 7730 Standard [13] and previous study [10].

Table 3 - Estimated clothing insulation value and metabolic rate

Clothing insulation value (Clo)	Metabolic rate (met)
0.5	1.3

2.5 Thermal Comfort Analysis

The PMV and PPD calculation were carried out using the CBE Thermal Comfort Tool for ASHRAE-55 [8] as shown in Fig 1. With the PMV and PPD methods, five parameters were used as inputs in this tool, namely, air temperature, air speed, humidity, metabolic rate and clothing level. Mean radiant temperature was assumed to be equal to air temperature values because, in most cases, it is negligible in the indoor environment [14]. The calculation of PPD could be strongly affected by the average hourly physical parameters (air temperature, air speed and humidity) recorded in different mosques. Table 4 presents the scale of the PMV index. There are seven (7) thermal sensation scales of PMV which runs from Cold (-3) to Hot (+3) which are from cold to hot. PMV values represent thermal comfort in the mosque's buildings.

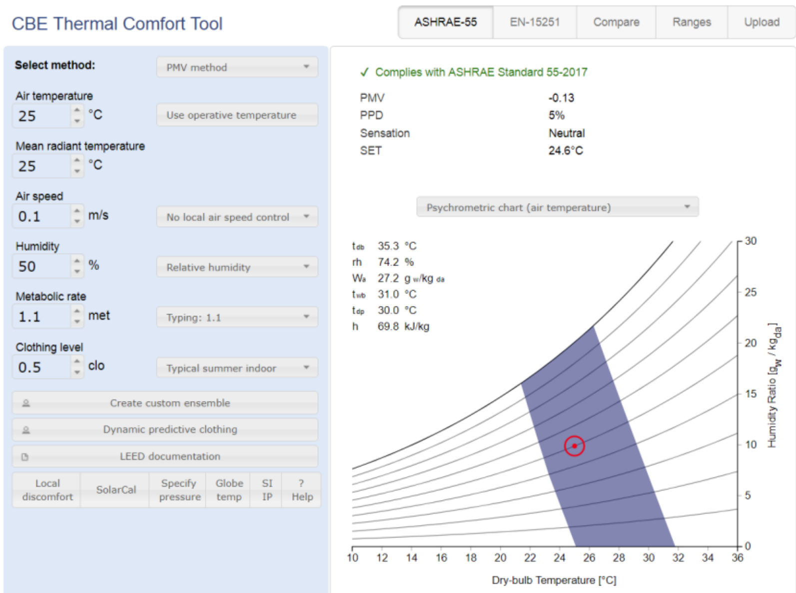


Fig. 1 - CBE thermal comfort tool

Table 4 - PMV and its relation to the thermal sensation scale

Value	Sensation
-3	Cold
-2	Cool
-1	Slightly cool
0	Neutral
1	Slightly warm
2	Warm
3	Hot

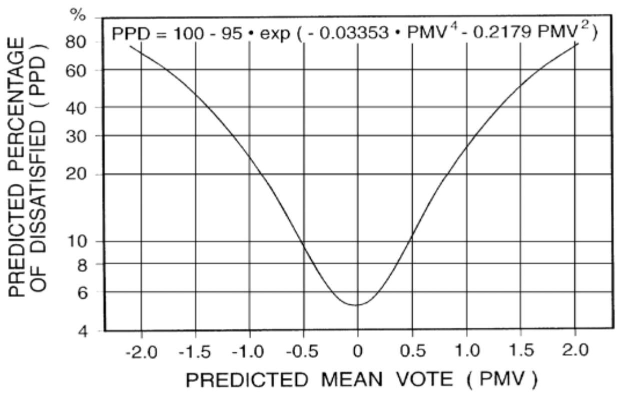


Fig. 2 - PPD as a function of PMV

Fig. 2 shows the relationship between PMV and PPD (PMV–PPD chart) [15]. As PMV changes away from zero in either the positive or negative direction, PPD increases. For general comfort, ASHRAE Standard considers the acceptable range to be a PMV score from –0.5 to +0.5 and a PPD score <10, as shown in Table 5. Both limits are applicable due to physiological variances of occupants. The seven-scale ASHRAE thermal sensations are currently widely accepted for assessment of thermal comfort.

Table 5 - Acceptable thermal environment for general comfort

PPD	PMV Range
<10	-0.5 < PMV < +0.5

3 Results and Discussion

3.1 Relationship Among Air Temperature, Relative Humidity and Air Speed

Fig. 3 shows the relationship among the air temperature, relative humidity and air speed recorded during Zohor and Asar prayers (lowland: M01, M02 and M03; highland: M07, M08 and M09) and Friday and Asar prayers (lowland: M04, M05 and M06; highland: M10). The results obtained suggested that the trends recorded during Zohor and Asar prayers at lowland (M01, M02 and M03) and highland (M07, M08 and M09) were different from the results recorded during Friday and Asar prayers at lowland (M04, M05 and M06) and highland (M10). During Zohor and Asar prayers, the highest temperature (34.5°C) was recorded after Zohor prayer when there was no occupant in the mosque buildings, while the lowest temperature (31.9°C) value was recorded during both Zohor and Asar prayers. Temperature built up rapidly before and after prayer and then dropped steadily during prayer times. Temperature was high before and after prayer because only passive ventilation (windows and doors) was available at that time while active ventilation (fans) was switched off. Temperature dropped during prayer because active ventilation (fans) was switched on at that time.

However, high temperature was also recorded during prayer time at Zohor at MQS01 at lowland and at MQS07 and MQS08 at highland. High temperature was likewise continuously recorded at M02 and M03 during Asar prayer at lowland even though active ventilation was in operation. This result could be due to the thermal load from sunshine from the outdoor environment through building materials into the indoor space of mosques coupled with the inadequate ventilation system. Thermal load consists of solar radiation energy which passes through the outside wall surface and continues on to the inside wall surface via conduction [16].

Façade design is an important parameter that can lower air temperature and ensure adequate ventilation systems in mosque buildings. Façade acts as a boundary between external and internal environments and influences the environmental conditions of indoor spaces, the thermal performance of buildings and the occupants' satisfaction [17].

Façade design can be solved through implementation of passive design such as the opening parameter that allows sufficient air to circulate into indoor space, the orientation of the mosques building, and the shading device that can prevent the heat that direct through the wall of the mosques building [9]. Moreover, ASHRAE 90.1 [18] has suggested that 24 percent of glazing area, such as window of the building's exterior envelope is the ideal percentage to allow optimum indoor daylight and natural ventilation, while more than 30 percent would cause overheating into the building. Larger glazed roof or wall will contributed to poor thermal comfort which caused internal heat gain due to solar, especially in the air-conditioned building because of the cooling load increased [19].

Besides that, Liu et al. [20] found that heat transfer can be reduced from the outside to the inside by the moisture transfer in the buildings. Furthermore, the climatic problem can be solved by the double-shelled dome. The external dome can plays an important role to protect internal dome from the heat of sun's energy, thus can reduce the temperature inside the mosques building [21]. A better natural ventilation can be improved by having proper opening at the right location of a building and a good layout that can regulate the entering air movement throughout the interior spaces of the building [22].

The results obtained during Friday and Asar prayers indicated that the temperature built up from 1200 until 1430 hrs. even when active ventilation was operating, fully. This was because the number of occupant in the mosque buildings at that time was higher as compared to the normal days. This was because Muslim was gathered every Friday in the mosque to perform Friday prayer. The temperature decreased after Friday prayer (1430 hr) when active ventilation was not operating as worshippers left the mosque. According to Guliuzza [23], heat was produced from every cell in the human body as they burnt up energy and to keep the body warm, the heat was formed. The observations suggested that the heat produced from occupants' body affected the result at that time, as the number of worshippers was much higher than during the normal days.

In contrast, relative humidity decreased when temperature was high and increased when temperature dropped and air speeds of the most mosques were increased during prayer time. Relative humidity and air speed are also two of the main indicators that influence the level of thermal comfort for indoors [24].

(a)

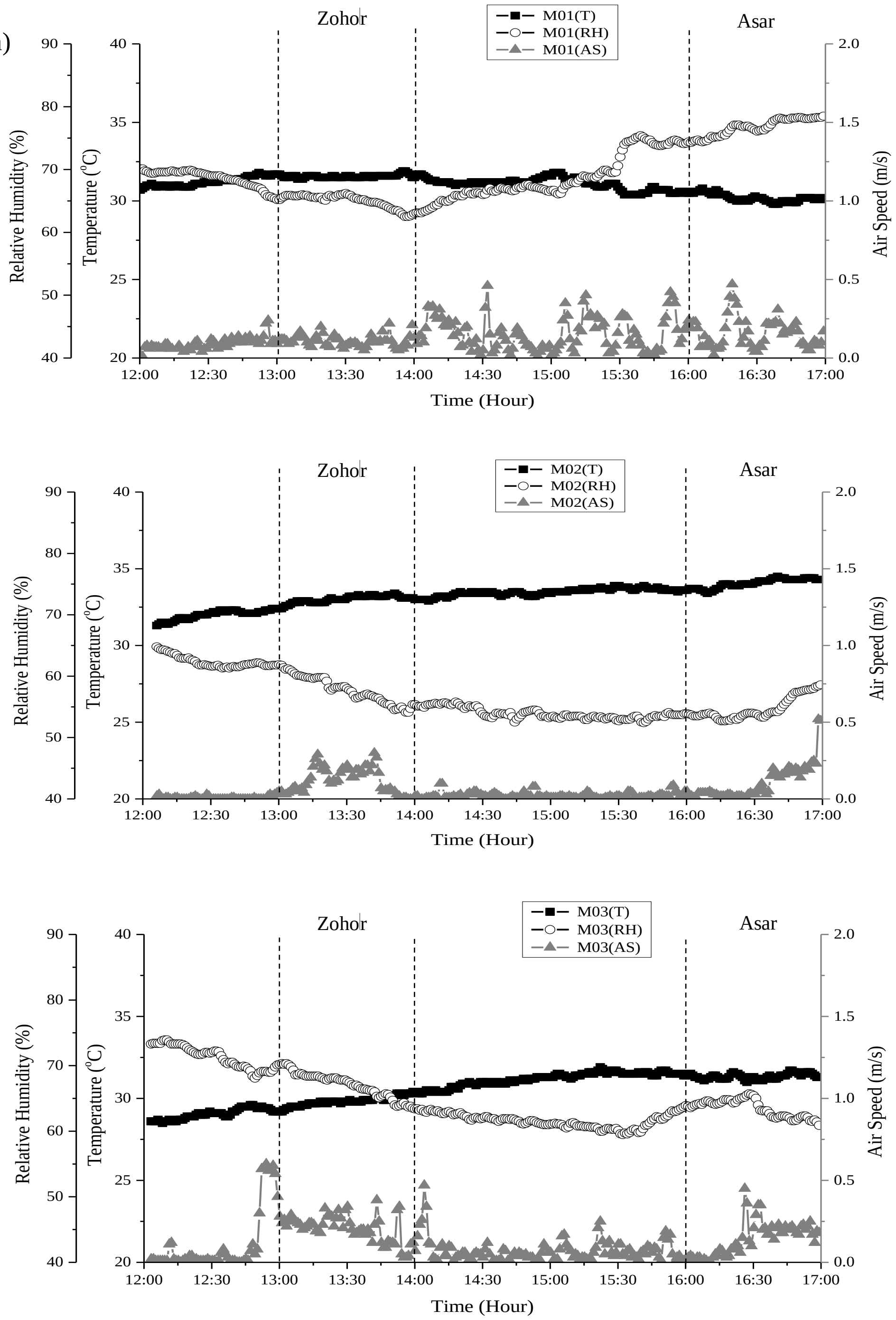


Fig. 3 - (a) Relationship among air temperature, relative humidity and air speed for M01, M02 and M03 during Zohor and Asar prayers at lowland

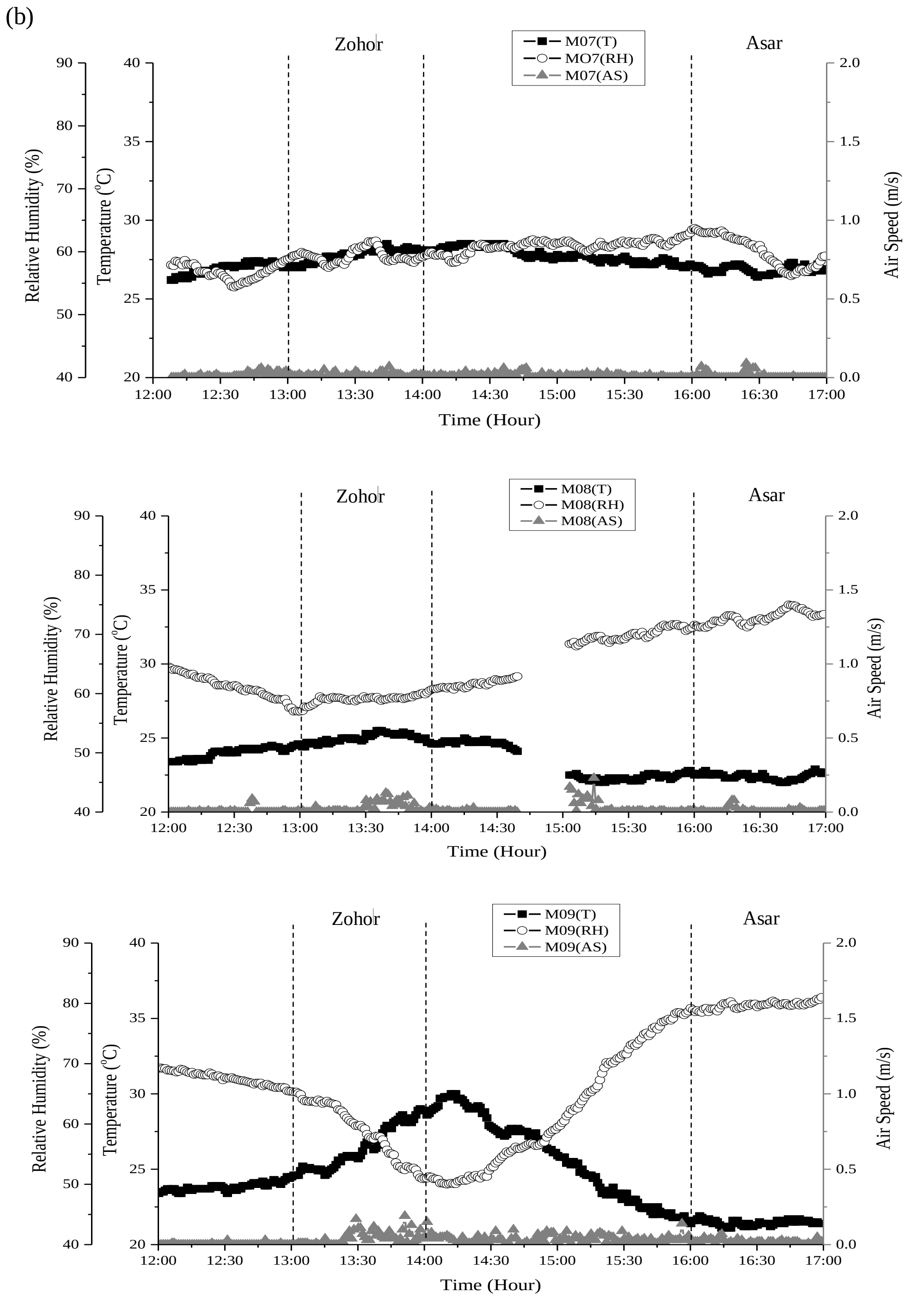


Fig. 3 (b) - Relationship among air temperature, relative humidity and air speed for M07, M08 and M09 during Zohor and Asar prayers at highland

(c)

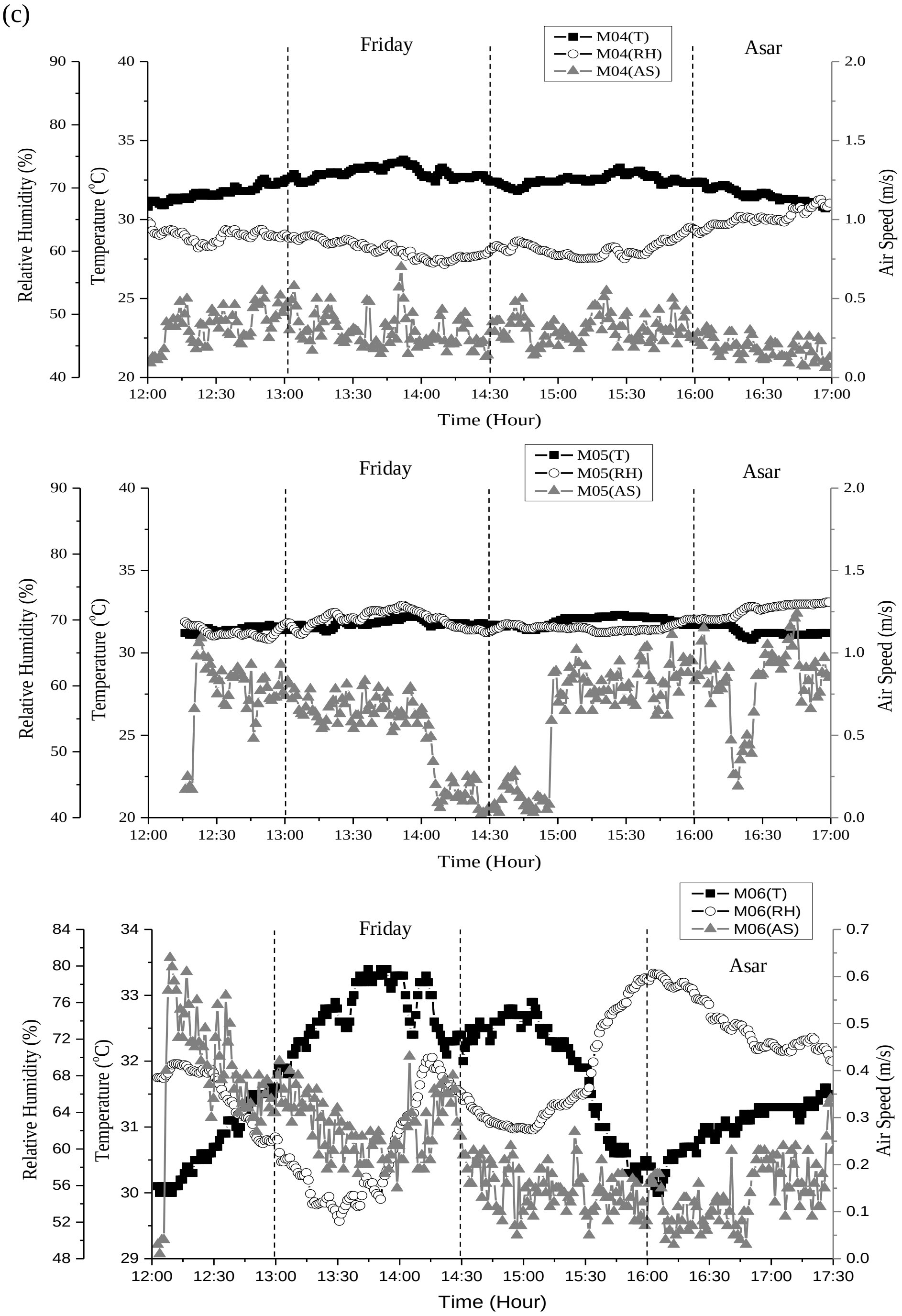


Fig. 3 (c) - Relationship among air temperature, relative humidity and air speed for M04, M05, and M06 during Friday and Asar prayer at lowland

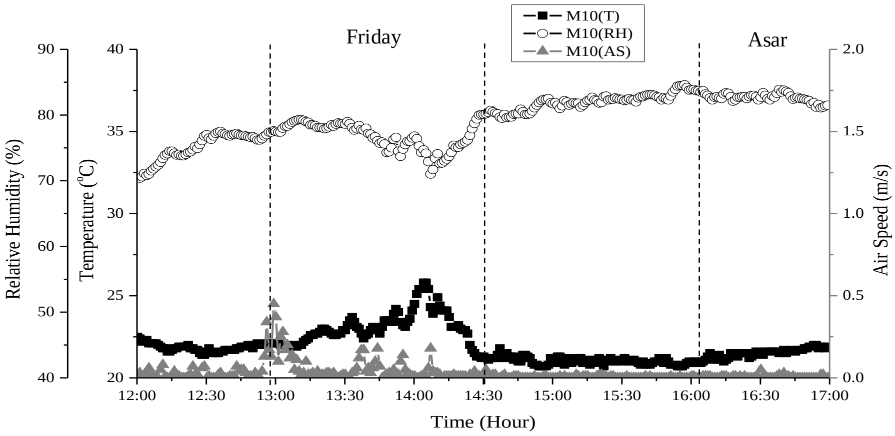
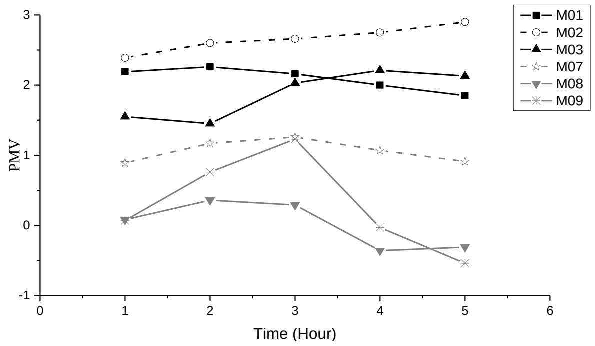
(d)


Fig. 3 (d) - Relationship among air temperature, relative humidity and air speed for M10 during Friday and Asar prayers at highland

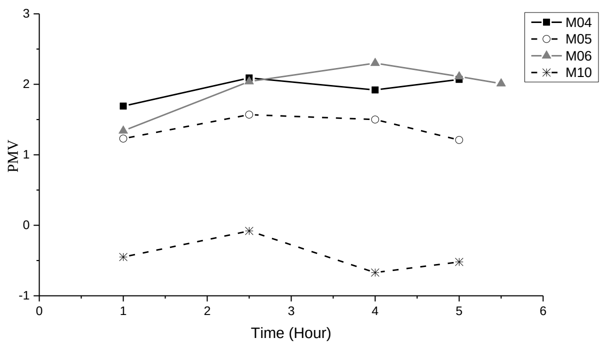
3.2 PMV and PPD

Fig. 4(a) shows the PMV against time during Zohor and Asar prayers at lowland (M01, M02 and M03) and highland (M07, M08 and M09). According to the seven-point ASHRAE scale, the mosques' environment was from 'slightly warm' to 'hot' at lowland and from 'slightly warm' to 'slightly cool' at highland. The plot illustrates that PMV built up rapidly during non-prayer time from hour 2 to hour 4 because no active ventilation was being used at that time.

Fig. 4(b) shows the results of PMV during Friday and Asar prayers at lowland (M04, M05 and M06) and highland (M10). According to the seven-point ASHRAE scale, the environment of mosques' environment was from 'slightly warm' to 'warm' at lowland and from 'neutral' to 'slightly cool' at highland. The plot illustrates that PMV built up rapidly from hour 1 to hour 2.5 because the number of occupants in the mosques during that time on Friday was almost full (700-800 occupants) and higher compared to normal days (10-20 occupants). Thus, the temperature was high even though the active ventilation was in operation.



(a)



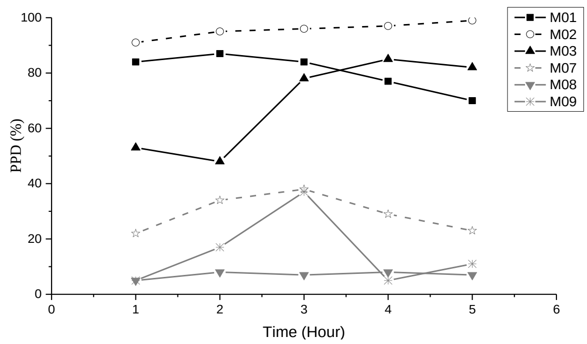
(b)

Fig. 4 - PMV vs. time during (a) Zohor and Asar prayers and (b) Friday and Asar prayer

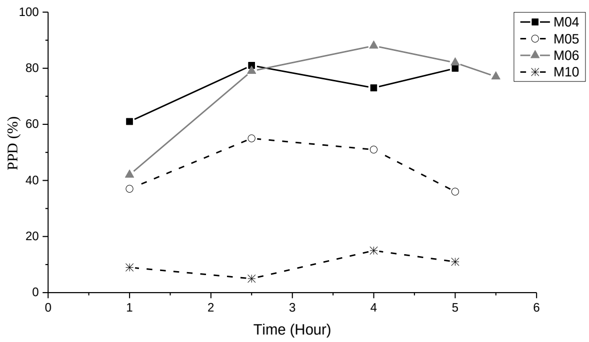
PPD values represent the percentage satisfaction of thermal comfort by occupants regarding the indoor environment; these values are correlated with PMV values [25]. Based on ASHRAE Standard-55, the acceptable limit for PPD value should be less than 10%. Fig. 5(a) shows the PPD results versus time during Zohor and Asar prayers at lowland (M01, M02 and M03) and highland (M07, M08 and M09). This figure shows that most of the occupants were more comfortable when active ventilation was switched on. From hour 2 to hour 4, the number of dissatisfied occupants was very high at lowland compared to that at highland due to the idled active ventilation and the ineffective natural ventilation. In addition, most of the time, natural ventilation such as windows and doors were closed especially during non-prayer time.

Fig. 5(b) shows the PPD during Friday and Asar prayers at lowland (M04, M05 and M06) and highland (M10). The number of people who were dissatisfied when the active ventilation system was switched on from hour 1 to hour 2.5 increased because the temperature at that time was high due to the higher number of occupants compared to normal days. The results also showed that the number of people who were dissatisfied was very high at lowland compared to that at highland.

The results from PMV and PPD showed better thermal comfort and lower number of people dissatisfied at highland compared to those at lowland. However, Hussin et al. [26] reported that most of the *Jemaah* preferred their thermal environment (which felt natural) even though PMV values indicated discomfort (slightly warm) in the air-conditioned mosque buildings. Therefore, further research needs to be conducted to select the appropriate thermal comfort in non-air-conditioned mosque buildings during Zohor/Friday and Asar prayers in hot and humid environments.



(a)



(b)

Fig. 5 - PPD (%) vs. time (hours) for (a) normal day and (b) Friday

4. Conclusion

This study was conducted at 10 mosque buildings from 1200h to 1700h/1730h to assess thermal conditions during Zohor/Friday and Asar prayer times. PMV and PPD were calculated using CBE Thermal Comfort Tools for ASHRAE-55, and the results for passive and active ventilation conditions were captured. Results showed that thermal comfort was poor before and after prayer times because only passive ventilation was available during those periods. However, some of the prayer times (Zohor and Asar prayers) showed high temperature even when active ventilation (fans) was operated. This finding could be caused by the façade design, which influenced by the thermal load from outdoor environment to indoor space, and the inadequate ventilation system. Overall, findings indicated that better thermal comfort occurred during prayer time at highland compared with that at lowland, with the thermal sensation conditions of mosques in the former 'slightly warmer' to 'slightly cool' and in the latter 'slightly warm' to 'hot'. Moreover, based on the obtained results, the mosque buildings did not provide a good thermal comfort at lowland because the percentage of dissatisfied was high compared to that at highland. Therefore, although non-air-conditioned mosques can reduce their energy consumption and cost, poor thermal comfort can negatively influence the users' health. Passive design strategies can be implemented to provide better thermal comfort.

Acknowledgement

This research was supported by the Ministry of Science Technology and Innovation Malaysia under the SCIENCEFUND 1001/PAWAM/6013607 grant.

References

[1] Hamimah, I. S., Baba, D. and Mutalib, L. A. (2010). Indoor air quality issues for non-industrial work place. International Journal of Research and Review in Applied Sciences, 5, 235-244.
[2] Mustapha, A. A., Ayop, S. M., Ahmad, M. K. and Ismail, F. (2008). A thermal comfort study in naturally ventilated school building in Malaysia. Built Environment Journal, 5(2), 66-82.
[3] Syazwan Aizat, I., Juliana, J., Norhafizalina, O., Azman, Z. A. and Kamaruzaman, J. (2009). Indoor air quality and sick building syndrome in Malaysian buildings. Global Journal of Health Science, 1(2), (2009), 126-136.
[4] Makhtar, N. K., Ismail, A. R., Jusoh, N. and Puvanasvaran, A. P. (2010). Thermal comfort in technical school: Physical measurement approach. National Conference in Mechanical Engineering Research and Postgraduate Studies, Pahang, Malaysia, pp 755-761.
[5] Kamaruzzaman, S. N. and Razak, R. A. (2011). Measuring indoor air quality performance in Malaysian government kindergarten. Journal of Building Performance, 2(1), 70-79.
[6] Norhidayah, A., Lee, C. K., Azhar, M. K. and Nurulwahida, S. (2013). Indoor air quality and sick building syndrome in three selected buildings. Procedia Engineering, 53, 93-98.
[7] Nicol, J. F. and Humphreys, M. A. (2002). Adaptive thermal comfort and sustainable thermal standards for buildings. Energy and Buildings, 34(6), 563-572.
[8] Hoyt, T., Schiavon, S., Piccioli, A., Moon, D. and Steinfeld, K. (2017). CBE thermal comfort tool. Center for the Built Environment, University of California Berkeley, http://comfort.cbe.berkeley.edu/.
[9] Abdullah, F. H., Majid, N. H. A. and Othman, R. (2016). Defining issue of thermal comfort control through urban mosque façade design. Proceedings of Social and Behavioral Sciences, 234, 416-423.
[10] Hussin, A., Salleh, E., Chan, H. Y. and Mat, S. (2014). Thermal comfort during daily prayer times in an air-conditioned mosque in Malaysia. Proceedings of 8th Windsor Conference: Counting the Cost of Comfort in a Changing World, London, United Kingdom, pp 1-22.
[11] Ocak, Y., Kılıçvuran, A., Eren, A. B., Sofuoglu, A. and Sofuoglu, S.C. (2012). Exposure to particulate matter in a mosque. Atmospheric Environment, 56, 169-176.
[12] Sundell, J. (2004). On the history of indoor air quality and health. Indoor Air, 14(s7), 51-58.
[13] International Organisation for Standardisation, (2005). Moderate thermal environments. Determination of the PMV and PPD indices and specification of the conditions for thermal comfort. Switzerland: ISO 7730.
[14] Walikewitz, N., Jänicke, B., Langner, M., Meier, F. and Endlicher, W. (2015). The difference between the mean radiant temperature and the air temperature within indoor environments: A case study during summer conditions. Building and Environment, 84, 151-161.
[15] American Society of Heating, Refrigerating and Air-Conditioning Engineers. (2010). Thermal environmental conditions for human occupancy. Atlanta: ASHRAE Standard-55.
[16] Irsyad, M., Pasek, A. D., Indartono, Y. S. and Pratomo, A. W. (2017). Heat transfer characteristics of building walls using phase change material. IOP Conference Series: Earth and Environmental Science, 60(1), 1-6.
[17] Ghaffarian, H., A., Berardi, U., Ghaffarian, H., A. and Makaremi, N. (2012). Intelligent facades in low-energy buildings. British Journal of Environment and Climate Change, 2(4), 437-464.
[18] American Society of Heating, Refrigerating and Air-Conditioning Engineers. (2007). Energy standard for buildings except low-rise residential buildings. Atlanta: ASHRAE Standard-90.
[19] Abdullah, A. H. and Wang, F. (2011). Modelling thermal environmental performance in top-lit Malaysian atrium using computational fluid dynamics (CFD). International Journal of Integrated Engineering, 1(2), 27-42.
[20] Liu, F., Jia, B., Chen, B. and Geng, W. (2017). Moisture transfer in building envelope and influence on heat transfer. Procedia Engineering, Volume 205, 3654-3661.
[21] Varzaneh, E. H., Amini, M. and Bemanian, M. R. (2014). Impact of hot and arid climate on architecture (Case study: Varzaneh Jame Mosque). Procedia Engineering, 94, 25-32.
[22] Wahab, I. A., Ismail, L. H., Abdullah, A. H., Rahmat, M. H., and Salam, N. N. A. (2018). Natural ventilation design attributes application effect on indoor natural ventilation performance of a double storey single unit residential building. International Journal of Integrated Engineering, 10(2), 7-12.
[23] Guliuzza, R. J. (2009). Made in his image: Balancing body temperature. In: Ford, L. E. (Ed), Acts & Facts, Institute for Creation Research, 38 (4), 8 - 9.

[24] Al-Homoud, M. S., Abdou, A. A, and Budaiwi, I. M. (2009). Assessment of monitored energy use and thermal comfort conditions in mosques in hot-humid climates. Energy and Buildings, 41(6), 607-614.
[25] Noman, F. G., Kamsah, N. and Kamar, H. M. (2016). Improvement of thermal comfort inside a mosque building. Jurnal Teknologi, 78, 9-18.
[26] Hussin, A., Salleh, E., Chan, H. Y. and Mat, S. (2015). The reliability of predicted mean vote model predictions in an air-conditioned mosque during daily prayer times in Malaysia. Architectural Science Review, 58(1), 67-76.