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EVALUATION OF THERMAL COMFORT IN JAMIK MOSQUE LHOKSEUMAWE

Muhammad Iqbal[1] *Tjut Nashiha Tsany,* [2], *Eri Saputra*[3], *Effan Fahrizal* [4]
[1]Dosen Program Studi Arsitektur, Fakultas Teknik, Universitas Malikussaleh
[2]Mahasiswa Program Studi Arsitektur, Fakultas Teknik, Universitas Malikussaleh
[3,4]Dosen Program Studi Arsitektur, Fakultas Teknik, Universitas Malikussaleh
Email: miqbal.arch@unimal.ac.id

ABSTRACT

To serve a solemn praying condition for worshippers, most of the mosques currently install Air Conditioning (AC). Jamik Mosque Lhokseumawe, as one of the mosques that have the AC, becomes a research site. The purpose is to see levels of thermal comfort in the mosque based on ASHRAE-55 standards, which mainly studies the main praying area using AC and the mosque porch with no AC. This study applies a quantitative method and calculations with a Predicted Mean Vote (PMV). The results of mean measurements at Dzuhur time showed the highest temperature, in which at the main praying area is 29.5ºC with 52.2% humidity and at the mosque porch is 32.1ºC with 62.0% humidity. Even though the result showed PMV value of 1.67 at the main praying area and 2.18 at the mosque porch, which is categorized as warm, but the survey results showed that respondents still felt comfortable. It is due to some respondents' familiarity with the temperature. The results conclude that the available Air Conditioning has not created the mosque areas as a comfortable place.

KEYWORDS: Evaluation, Mosque, PMV, Thermal comfort,

INTRODUCTION

Nowadays, many mosques use air conditioning (AC) to reach the desired room temperature. One of them is Jamik Mosque located in Lancang Garam, Lhokseumawe City, North Aceh. As human being release residual heat from metabolism burning process, this could result in warmer room temperature when they congregate in one room at the same time.

Although using an AC in closed praying area could decrease room temperature, this does not mean the room is more thermally comfortable than an open area such as the mosque porch. There are moments in which the mosque capacity is full and unable to accommodate many congregations, especially on Friday prayer, Ied prayer, and certain daily prayer time. As a result, the mosque porch is also filled by the congregation.
Since those two areas have a significant difference in temperature, this research was conducted to see the extent of comparison between congregation's comfort who pray at the main praying area and those whom at the mosque porch.

THEORETICAL BASIS

The American Standard ASHRAE-55 defines thermal comfort as a feeling in the human mind that expresses satisfaction with its thermal environment. Factors that influence thermal comfort are air temperature, air humidity, wind velocity, mean radiant temperature, metabolic rate, and clothing insulation

Predicted Mean Vote (PMV) is an index that identifies the cold and warm sensations that humans feel related to comfort parameters, in the form of answers by voting. It is acknowledged that a person feels comfortable when at PMV +1 (slightly warm), 0 (neutral) and -1 (slightly cold). While PMV + 3 (very warm), +2 (warm), -2 (cold), -3 (very cold) is categorized as an uncomfortable area. Predicted Percentage of Dissatisfied (PPD) is a value of discomfort. The greater the percentage of PPD, the more people feel uncomfortable (Fanger, 1970).

To create a comfortable area can use a thermal control that is control of changes in ambient temperature, which is based on the difference between acceptable indoor and outdoor condition. Thermal control strategies can be done by active methods such as installing a heater or an air conditioning, and passive methods such as cross ventilation or thermal insulation.

RESEARCH METHODS

The method used in this research is a quantitative method, which is executed by evaluating values of thermal comfort. The research took 60 days, from March 22-May 20, 2018 at five prayer times, that is Subuh at 04.40-06.15 AM, Dzuhur at 13.00- 13.55 PM, Ashar at 15.40 to 16.25 PM, Maghrib at 18.15-19.20 PM and Isya

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at 20.00-20.30 PM.

Measuring the temperature and air humidity is conducted by applying Krisbow KW0600291 4 IN 1 Environment Meter, and wind velocity measurement with Anemometer. A total of 130 questionnaires were given to the congregation of five different prayer times to find the value of thermal sensations, metabolic rate, and clothing insulation.

Thermal sensation values were measured by using CBE Thermal Comfort Tool of ASHRAE-55 software to generate PMV and PPD values according to the standard. Then the results of the calculation were adjusted to the needs of air conditioning capacity based on Btu/hour using BTU Calculator software in order to achieve thermal comfort.

RESULT AND DISCUSSIONS

The Jamik Mosque area of 600 m^2 wide is capable to accommodate 800 people. The mosque has windows and ventilation but they do not function as air circulation as it had been covered with plastics since the installation of the air conditioning. The total of AC in the main praying area is 19 units, and each has a capacity of 32 PK.

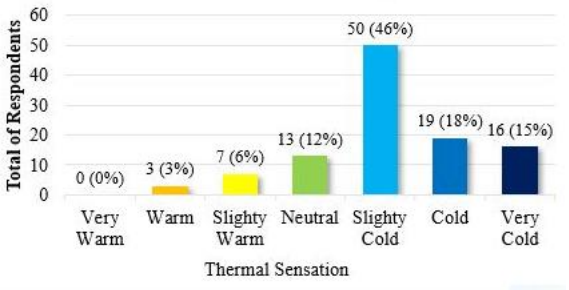
1. The Result of Thermal Sensation Based on Questionnaires

a. *The Thermal sensation in the praying room*

From a total of 108 respondents in five prayer times, 50 respondents felt slightly cold (46%) and there were no respondents who felt very warm. For other thermal sensations, 3 respondents felt warm (3%), 7 respondents felt slightly warm (6%), 13 respondents felt neutral (12%), 19 respondents felt cold (18%), and 16 respondents felt very cold (15%).

Table 1. Total of respondents, average metabolic rate and clothing insulation in the main praying area

Times	Total of Resp.	Met	*Clo*
Subuh	26	1.2	0.64
Dzuhur	17	1.2	0.67
Ashar	26	1.2	0.67
Magrib	18	1.2	0.65
Isya	21	1.2	0.62



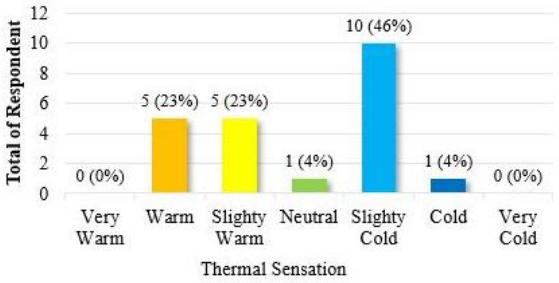
Picture 1. Thermal sensation of respondents in the main praying room

b. *The Thermal sensation in the mosque porch*

From a total of 22 respondents in five prayer time, 10 respondents felt slightly cold (46%) and there was no respondent who felt very hot and very cold. For other thermal sensations 5 respondents felt warm (23%), 5 respondents felt slightly warm (23%), 1 respondent felt neutral (4%), and 1 respondent felt slightly cold (4%).

Table 2. Number of respondents, average metabolic rate and clothing insulation in the mosque porch

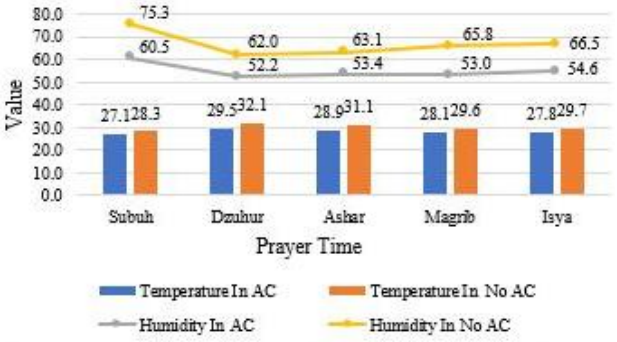
Times	Total of Resp.	Met	*Clo*
Subuh	0	0	0
Dzuhur	9	1.2	0.60
Ashar	0	0	0
Magrib	8	1.2	0.65
Isya	5	1.2	0.59



Picture 2. Thermal sensation of respondents in the mosque porch

2. The Result of Thermal Sensation Based on Measurement

The comparison of average air temperature and humidity between the main praying room area and the mosque porch can be seen in the following graph.



Picture 3. Comparison of air temperature and humidity values in both area

Both areas increase in temperature and decrease in humidity values at Dzuhur prayer time. The main praying area reaches at a temperature of 29,5°C with a humidity of 52,2%, while the mosque porch temperature is 32,1°C and humidity is 62,0%. The difference in colder air temperature is caused by the use of 16 units of

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air conditioning which is turned on every prayer time. It results in absorption of heat from the air in the area which is released to the outside. So that the air temperature inside the room is lower than outside of the area. The use of air conditioning not only reduce air temperature, but also can reduce humidity.

3. The Result of Thermal Sensation Based on PMV and PPD

The closer PMV and PPD values to 0 means a better level of comfort of a room. The main praying area has an average thermal sensation. It was slightly warm at Subuh, Maghrib and Isya prayer time, and there were warm sensations at Dzuhur and Ashar prayer time. Meanwhile, the mosque porch has a slightly warm sensation at Subuh and Isya prayer time, and warm sensation at Dzuhur, Ashar and Maghrib prayer times.

Table 3. Comparative values of PMV and PPD between the main praying area with AC and the mosque porch with no AC

Prayer Room with AC		**Prayer Time**	**Mosque Porch with No AC**	
PMV	**PPD**		**PMV**	**PPD**
1,04	28	Subuh	0,94	24
1,67	60	Dzuhur	2,18	84
1,52	52	Ashar	1,89	71
1,27	39	Magrib	1,51	52
1,17	34	Isya	1,49	50

4. Correlation of Air Conditioning Use to Thermal Comfort

According to the respondents, air conditioning turning on at Dzuhur, Ashar, Maghrib and Isya prayer time, setting at 16ºC, which consumes 288,000 BTU/hour has made the main praying area of 520 m^2 in a thermally comfortable condition. Even with the highest average number of the congregation of 347 people at Dzuhur prayer time, the highest air temperature recorded was around 29,5ºC. However, the PMV and PPD calculations show a different result. The main praying area has an average sensation of warmth at prayer time, which shows that Jamik Mosque does not comply standards of comfort.

Different results obtained through questionnaires and software occurred due to differences in the sensation of respondent assessment of thermal, while the results through software are based on measurement results with thermal comfort parameters. Thermal sensations felt by respondents are relative and cannot be standardized, because respondents in the main praying area or in the mosque porch could feel different thermal sensations even though they were in the different place at the same time. This could happen due to various factors such as variations in the human body, age, gender, type of clothing, or activities before coming into the mosque.

Table 4. The Average air conditioning value, temperature and congregation

Prayer Time	AC On	PK AC	Temp.	Total of conger-gation
Subuh	7	14	27.1	46
Dzuhur	16	32	29.5	347
Ashar	16	32	28.9	197
Magrib	16	32	28.1	270
Isya	16	32	27.8	136

5. Analysis of Thermal Control

a. *The Praying room*

A comfortable temperature of around 25ºC is achieved by turning on the available air conditioning.

Table 5. Amount of energy (BTU/hour) based on comfortable temperature

Prayer Time	Ac On	Temp.	Comf. Temp.	Btu/Hour
Subuh	7	27,1	25,2	17.022
Dzuhur	16	29,5	25,2	38.523
Ashar	16	28,9	25,2	33.148
Magrib	16	28,1	25,2	25.981
Isya	16	27,8	25,3	22.397

b. The *Mosque Porch*

A comfortable temperature of around 26oC can be achieved by means of thermal control through the surrounding environment, such as adding a shading, making a roof to block direct solar radiation or by adding vegetation in the mosque yard.

Table 6. Air temperature at mosque porch

Prayer Time	Temp.	Comf. Temp.
Subuh	27,1	25,2
Dzuhur	29,5	25,2
Ashar	28,9	25,2
Magrib	28,1	25,2
Isya	27,8	25,3

CONCLUSIONS

PMV and PPD in both spaces are unable to create comfortable space for congregation since the thermal sensations obtained are mostly warm. Subuh prayer time had a slightly different thermal sensation since it was slightly warm. This fell under +1 category, therefore it can be said to be thermally comfortable.

Dzuhur prayer time at the mosque porch area was very warm due to the lack of thermal control. The main

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praying room needs to have a decrease of 38,523 BTU/hour energy consumption to reach a comfortable temperature. To reach desirable thermal comfort, all available air conditioning should be turned on. 1 more unit of air conditioning with a minimum capacity of ½ PK also need to be added in the area.

REFERENCES

ASHRAE Standard 55. (2003). *ASHRAE Standard Thermal Environmental Conditions for Human Occupancy*. American Society of Heating Refrigerating and Air Conditioning Engineers Inc, Atlanta.

Frick, Heinz., Ardiyanto, Antonius., and Darmawan AMS. (2008). *Ilmu Fisika Bangunan*. Book from PT Kanisius, Yogyakarta.

Hermawan., Prianto, Eddy., and Setyowati, Erni. (2014). *Prediksi Kenyamanan Termal Dengan PMV di SMK 1 Wonosobo*. Jurnal PPKM UNSIQ I, 13-20, Januari 2014, Universitas Diponegoro, Semarang, pp 13-14.

Idham, Noor Cholis. (2016). *Arsitektur dan Kenyamanan Termal*. Andi, Yogyakarta.

Istiningrum, Demi Tria., W.S, Rr Leidy Arumintia., and Mukhlisin, Muhammad. (2017). *Kajian Kenyamanan Termal Ruang Kuliah Pada Gedung Sekolah C Lantai 2 Politeknik Negeri Semarang*. Wahana Teknik Sipil, Vol 22, No 1, Juni 2017, Politeknik Negeri Semarang, pp 2-5.

Karyono, Tri Harso. (2001). *Penelitian Kenyamanan Termis di Jakarta Sebagai Acuan Suhu Nyaman Manusia Indonesia*. Dimensi Teknik Arsitektur, Vol 29, No 1, Juli 2001, Universitas Kristen Petra, pp 25-26.

Kotta, M.Husni. (2008). *Suhu Netral dan Rentang Suhu Nyaman Manusia Indonesia (Studi Kasus Penelitian Pada Bangunan Kantor di Makassar).* Metropilar, Vol 6, No 1, 24 pp.

Latifah, Nur Laela. (2015). *Fisika Bangunan 1*. Griya Kreasi, Jakarta Timur.

Satwiko, Prasasto. (2009). *Fisika Bangunan*. Andi, Yogyakarta.