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THERMAL COMFORT STUDY OF OUTDOOR SPACE FOR FACE-TO-FACE LEARNING SYSTEM

Study of Outdoor Thermal Comfort for Face-to-face Learning Systems

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Abstract. The transmission covid-19 virus is through droplets are splashed by people who have the virus. Therefore, activities that make crowding especially in closed rooms with poor air circulation are very avoided, because the rate of transmission in the inner room with poor air circulation has a higher presentation compared to transmission in the outside room. With new protocol to use maximum room capacity limit of 50%, using outdoor space can be good alternative solution to increase space for face to face learning system. But there is needed a study of thermal comfort for outdoor space. The object taken as a sample in this study was sitting area of the Undip Architect campus. This paper present measurements of dry temperature, humidity, and air movement with quantitative method. From the examine of effective temperature show that the object research have cozy thermal comfort according by Mom dan Wiesebron standards. This examination of effective temperature can also be exam for other outdoor environments.

Keywords: thermal, comfort, covid-19, mom and wiesebron

1. INTRODUCTION

In early 2020 covid-19 virus began to spread in Indonesia. This virus is very easily transmitted between humans. Transmission of the covid-19 virus is through droplets that are splashed by people who have the virus, and if inhaled by others then the virus will enter the lungs and live on the walls of the respiratory tract [1]. Therefore, activities that make crowding especially in closed rooms with poor air circulation are very avoided, because the rate of transmission in a room with poor air circulation has a higher presentation compared to transmission in outdoor spaces [2].

Semarang City Government has released information referring to the Semarang City Regulation No. 49 of 2021, the Minister of Home Affairs of the Republic of Indonesia 53 of 2021 and Inwal 7 of 2021 that PPKM in the city of Semarang entered into level-1, where for areas that have been categorized as level 1, in terms of teaching and learning activities can be implemented with face-to-face learning system with a maximum capacity of 50% and maintain the closest distance of 1.5 meters. In line with this, the spokesman for handling Covid-19 Wiko Adisasmito in Kompas News and The Ministry of Education said that the government encourages universities in areas with the predicate level-1 to level-3 to carry out face-to-face learning.[3][4]. In carrying out the advice from the government, Diponegoro University Semarang began preparing face-to-face learning system. To reveal this, Undip needs to prepare a safe space and remain comfortable for the implementation of the mining system during the covid-19 pandemic. With a maximum room capacity limit of 50%, the use of outdoor space can be used as an alternative good solution to increase the capacity of lecture capacity. But previously, there needed to be a study on the thermal comfort. This is necessary because from existing research uncomfortable air temperatures can reduce productivity by more than 80% [5].

The study took the outdoor sitting area as a sample of the object of the study. This outdoor space was chosen because it already has facilities that are able to support teaching and learning activities, such as roof coverings, chairs, tables and electrical terminals. This outdoor sitting area has a capacity of 72 people with 12 round tables, and each table is equipped with an electric terminal.

Figure 1. Object research

The purpose of this study is to examine the thermal comfort of outdoor spaces for teaching and learning activities. The object of the research taken is the outdoor sitting area of campus Diponegoro University Architects Semarang.

Comfort is a result of physiological and mental factors, but there is no objective benchmark for measuring comfort [6][7]. Thermal comfort is a state of mind that expresses satisfaction with the thermal environment and is usually subjectively assessed[8] [9][10]. Changes in heat on the surface of the body are influenced by environmental factors. There are four factors that affect thermal comfort: air temperature; humidity; Air movement and radiation. Of the four factors, air temperature is the most important factor for determining thermal comfort [11].

The thermal index used in Indonesia refers to effective temperature. Effective temperature will provide sensation that is then defined as comfort or discomfort [12]. Effective temperature can be determined by linking dry temperature and humidity in a Psychometric calculator to get wet temperature, which is then connected to the air movement on a nomogram chart [13][11]. Thermal comfort limits in equatorial areas range from 22.5ºC to 29.5ºC with relative humidity between 20%-50% [13]. Air humidity according to SNI 03-6572-2001 is a comparison between the amount of water vapor contained by the air compared to the amount of water vapor content in a saturated state at the air temperature of the room. For the tropics, the recommended relative humidity is between 40%~50%, but for rooms with a crowded of people such as meeting rooms, relative humidity is still allowed to range from 55%~60% [6].

The study will refer to Mom and Wes Brom standards with effective temperature comfort limits between 20ºC to 29ºC [14]. The selection of Mom and Wes Brom standards because MOM standard conducts a research area in Jakarta (6º LS) with the research subjects of Indonesian groups so that this standard is most appropriately applied as a reference in research objects located in the city of Semarang. The effective temperature criteria according to Mom and Wiesebron are as follows[14]:

a. Cool - Comfortable 20.5 º C - 22.8 º C ET
b. Comfortable – Optimal 22.8ºC – 25.8ºC ET
c. Heat – Comfortable 25.8ºC – 27.1ºC ET

Comfortable air humidity according to Mom and Wiesebron is 40%-70% with air movements of 0.1 m / s to 0.5 m / s [14], if it exceeds the limit (above / below) then the sensation is said to be uncomfortable.[15]

2. METHODS

Data collection methods

Data collection taken from primary empirical sources, obtained through observations into the object research, taking measurements, interviews, and documentation. The measurement methods of primary data is temperature, humidity and air movement speed carried out are as follows:

1. Measuring instruments are placed in the centre of the outer space,

2. The distance of measurement every 30 minutes from 08:00 WIB to 16:00 WIB. The time of taking measurements follows the working hours that have been determined by Diponegoro University.

This research uses several tools to help:

1. Thermometer to measure dry air temperature.
2. Hygrometer to measure humidity.
3. Digital anemometer to measure air movement.
4. Camera, to document activities.

Table 1. Parameters and Tools

Parameters	Tools
Dry Temperature	Thermometer
Humidity	Hygrometer
Air Movement	Anemometer digital
Wet Temperature	Psychometric Calculator
Effective Temperature	Nomogram
Thermal Comfort Standard	Mom dan Wiesebron

Research Methods In this study, using quantitative research methods. The stages of data analysis are carried out, dry temperature and humidity data that has been obtained from object research then processed with a psychometric calculator to get wet temperatures. The wet temperature figures that have been obtained are then connected to air movement speed by using a nomogram temperature to get the effective temperature. The effective temperature that has been obtained is then processed with excel to get graphs and diagrams to facilitate the process of data analysis.

3. RESULTS AND DISCUSSION

There are four data studies related to thermal comfort, there is: dry temperature, humidity, air movement and effective temperature. Measurements of temperature, humidity and air movement are carried out at the same time from 08:00 WIB to 16:00 WIB with the distance of each measurement each 30 minutes. With the following measurements:

Table 2. Measurement Result of Temperature, Humidity and Air Movement

No	Time	Temperature (°C)	Humidity (%)	Air Movement (m/s)
1	08:00	29,6	68	0,7
2	08:30	29,7	66	1,1
3	09:00	29,7	65	0,5
4	09:30	29,6	64	0,8
5	10:00	29,6	62	1,5
6	10:30	29,6	62	0,4
7	11:00	30	62	1,4
8	11:30	30,6	58	0,7
9	12:00	30,6	56	1,3
10	12:30	30,7	55	0,5
11	13:00	30,8	54	1,1
12	13:30	30,8	55	1,3
13	14:00	30,6	58	0,7
14	14:30	29,7	66	1,1
15	15:00	29,3	67	0,4
16	15:30	28,8	67	1,3
17	15:37	28,8	68	0,7
18	16:00	28,7	68	0,4

Remark : Highest result of Measurement

The measurement results in table 2 show that each parameter has the highest peak of the measurement value at different times. Dry temperatures are at their highest during the day, as opposed to humidity at the highest presentation in the morning and evening, while air movements tend to be more volatile.

3.1 Dry Themperature

Figure 2 shows the time series of dry temperatures. Dry temperatures tend to increase from 10:30 pm to 14:00 pm. It tends to continue to decline into the afternoon. The highest temperature is at 13:00 WIB to 13:30 pm which is 30.8^{o}C and the lowest temperature is 28.7 ^{o}C which is 16:00 WIB with an average temperature of 29.84^{o}C.

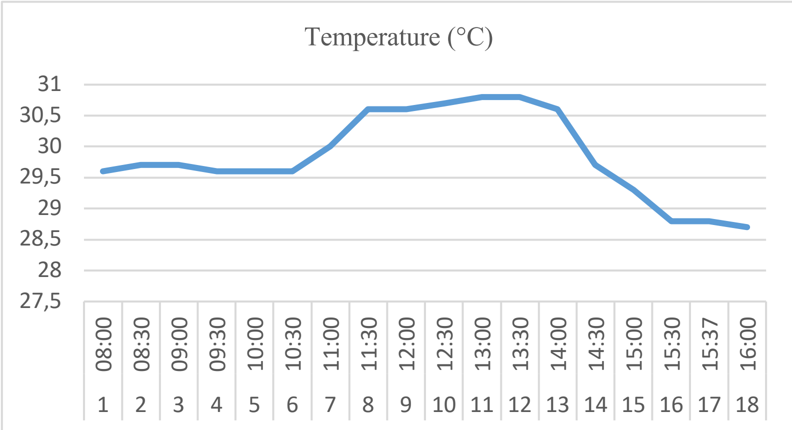

Figure 3. Time series of dry temperature

Dry temperatures are at a high level during the day, which is between 11:00 WIB to 14:30 WIB and the increase in temperature tends to be sharp, which is 1^{o}C at 10:30 WIB to 11:30 WIB. Dry temperature is not the only parameter of thermal comfort, it should include humidity and air movement in it. So that the air temperature above 29^{o}C does not mean uncomfortable, because it can not be included in the category of thermal comfort.

3.2 Humidity

The percentage of humidity tends to decrease from morning to noon at 1:00 WIB. With the lowest humidity reaching 54%. Then continue to increase until the afternoon. This is in appropriate with a statement from Lippsmeier which states, the higher the temperature, the higher the ability of air to absorb water, so that the percentage of moisture in the air becomes reduced.[13]

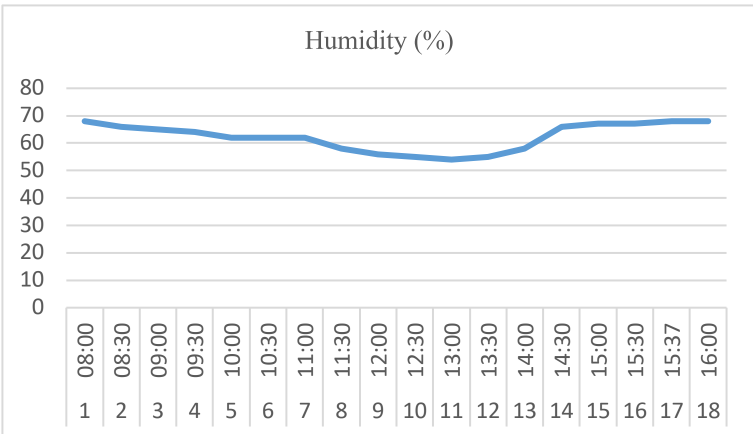

Figure 4. Time series of humidity

The highest humidity occurred at 08:00 WIB which is 68%, with an average value of 62.27%. According to Mom and Wiesebron standards, the humidity in this outdoor sitting area falls into the category of comfortable.

3.3 Air Movement

Time series of air movement measurements are shown in figure 5. Where the pattern of changes in air movement is much different from the pattern of temperature changes and humidity. As noted early paper, changes in temperature and humidity are greatly influenced by time, with the results of numbers between measurements that are not far adrift. While the pattern of changes in air movement tends not to be influenced by time, with a fluctuating pattern.

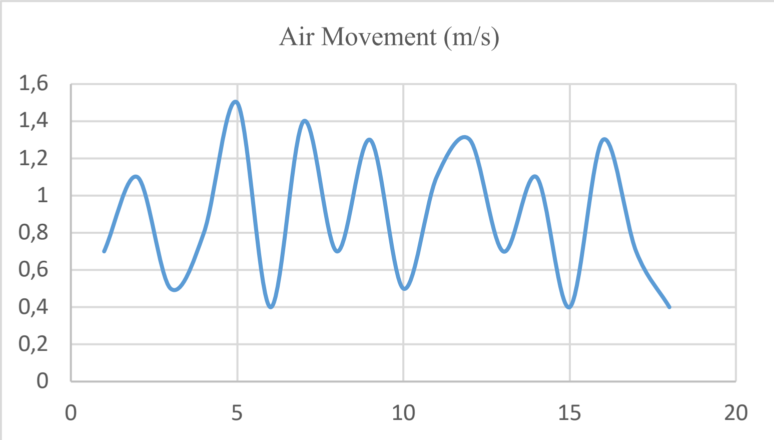

Figure 5. Time series of air movement

Highest air movement raise to 1.5 m/s at 10.00 WIB and the lowest being 0.4 m/s with an average of 0.883 m/s. Average air movement is above Mom and Wiesebron comfort standards, but air movement parameters cannot stand alone to be summed up into comfortable and uncomfortable criteria.

3.4 Effective Temperature

Effective temperature is obtained from the combination of measurements of dry temperature, humidity and air movement processed in psychometric calculators and nanograms, calculation results show at table 3.

Table 3. Calculation Result of Effective Temperature

No	Waktu	Effective Temperature (^{O}C)
1	08:00	24,3
2	08:30	24
3	09:00	23,9
4	09:30	23,6
5	10:00	23,3
6	10:30	23,3
7	11:00	23,6
8	11:30	23,5
9	12:00	23,1
10	12:30	23
11	13:00	22,9
12	13:30	23,1
13	14:00	23,5
14	14:30	24
15	15:00	23,9
16	15:30	23,4
17	15:37	23,6
18	16:00	23,5

The lowest effective temperature was 13:00 WIB at 22.9ºC ET, and the highest temperature in the morning was 24.3ºC ET, with an average effective temperature of 23.57ºC ET. The movement of effective temperature changes can be seen in figure 6.

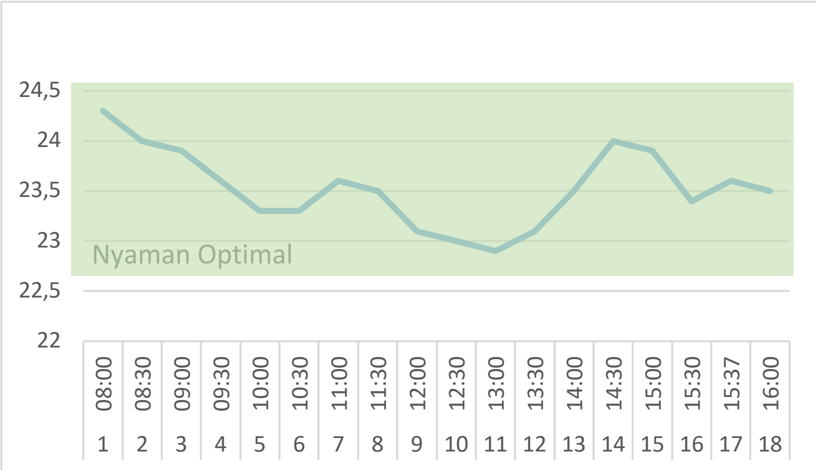

Figure 6. Effective temperature

Effective temperature change patterns tend to be volatile, where there are three decreases and two increases. But overall it falls into the criteria of optimal comfortable temperature, based on the comfortable criteria of Mom and Wiesebron with a range of 22.9 ºC ET to 24.3 ºC ET.

4. CONCLUSION

Based on the results of temperature, humidity and air movement measurements in the outdoor sitting area Campus Architects of Diponegoro University Semarang from 08:00 WIB to 16:00 WIB which is then processed to get effective temperatures according to the criteria of Mom and Wiesebron as a whole (100%) belong to optimal comfortable conditions. So this outdoor sitting area can be used to teaching and learning activities with comfortable thermal and can be a solution to increase the capacity of face-to-face learning system.

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