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Analysis of Thermal Comfort of Office Buildings (Case Study: Hasanuddin University Rectorate Building)

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Abstract

Thermal comfort is one of the fundamental aspects of indoor environmental quality, and it is closely related to occupant satisfaction and energy use in buildings. The purpose of this research was to analyze the thermal conditions of the student affairs rooms (Interest & Talent Room and Student Meeting room) at the second floor and the academic and education rooms (Academic Meeting room, Academic Registration room, and Head of Education and Evaluation room) at the seventh floor of Hasanuddin University rectorate building. This study used a quantitative method using a survey where the researcher asked several respondents about the level of thermal comfort of the room occupants when the volume of air conditioner (AC) is increased gradually every day at 18ºC, 22ºC, and 27ºC. In addition, measurements were conducted using HOBO from 08.00 – 17.00 to obtain data in the form of air temperature, humidity, and air velocity in the room. At the same time, respondents were asked to fill out a questionnaire asking the level of comfort felt by the room occupants at that time. The results showed that the average air temperature at 18º C is 24.62ºC, humidity is 63.108%, and air velocity is 0.144 m/s. At a temperature of 22º C, the average air temperature is 24.78ºC, humidity is 60.684%, and the air velocity is 0.142 m/s. At a temperature of 27º C, the average air temperature is 25.97ºC, humidity is 64.022%, and the air velocity is 0.127 m/s. The results showed that the respondents felt ‚cold‘ when the volume was at 18ºC, felt 'comfortable' when the volume was at 22ºC, and felt neutral when the volume was at 27ºC. In the end, temperatures of 22ºC and 27ºC can be used as a reference in the use of air conditioning temperatures in the room.

Keywords: Thermal comfort, rectorate building, temperature, humidity, air velocity

1. Introduction

Thermal comfort is one of the fundamental aspects of indoor environmental quality, and it is closely related to occupant satisfaction and energy use in buildings. Maintaining thermal comfort for building occupants is the main goal of HVAC (Heating, Ventilation, and Air Conditioning), design engineers, architects, and buildings because humans need comfortable room air (thermal comfort) to perform activities optimally [1]. Generally, the comfort of a room depends on two factors. They are an environmental factor and individual factors caused by the user itself [2]. Thermal comfort is defined as a feeling in the human mind that expresses satisfaction with its thermal environment [3].

The requirement for a 'comfortable temperature' is a thermal condition of the air in the space, which 'does not disturb' the body [4]. The terms of thermal comfort range from cold/cool/slightly cool/neutral/ slightly warm/warm/hot [5]. Thermal comfort is needed by humans so that they can carry out activities smoothly, whether at home, school, or office. A comfortable work environment is needed by workers to be able to work optimally and productively. Therefore, the work environment must be handled or designed in such a way that it becomes conducive for workers to carry out activities in a safe and comfortable atmosphere [6].

According to Szokolay in [7] comfort depends on climatic variables (sun or radiation, air temperature, humidity, and wind speed) and several individual factors such as clothing, acclimatization, age, gender, level of obesity, health level, type of food and drinks consumed, and skin color. Typically, an office was designed to be a room that should be filled by working people. These workers certainly have positions and roles. The Office grew even more along with the needs that came from a formal human profession. Then, people started to build spaces and facilities in it [8]. Therefore, thermal comfort in office space needs to be considered properly.

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Two approaches can be taken to meet room thermal comfort standards; through the use of active devices and passive designs [9]. AC is an active device that can be used to provide comfort and benefits during activities. In fact, air conditioners can make a room more airtight [10]. The function of the air conditioner is as a regulator (coolant/heater) of the desired room temperature to create comfortable air conditions. In the workplace, AC is also a way to increase work productivity [11]. However, using too much air conditioner will consume much energy [12]. This research was conducted to analyze the thermal conditions of the room. This research was conducted in the rectorate building of Hasanuddin University on the second and seventh floors, representing the Hasanuddin University rectorate. The second floor represents the bottom four floors, and the seventh floor represents the top four floors.

According to standard [13], buildings must provide the following thermal environment.

- Cool and comfortable, between effective temperature 20.5° C – 22.8° C
- Optimal comfort, between the effective temperature of 22.8° C – 25.8° C
- Warm and comfortable, between the effective temperature of 25.8° C – 27.1° C

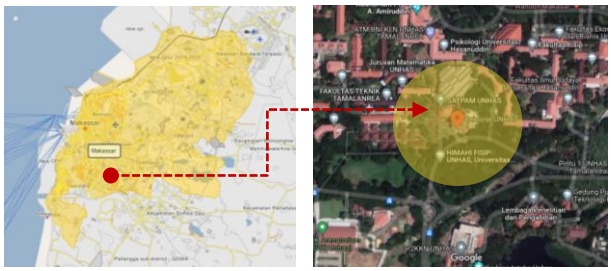
For tropical areas, the recommended relative humidity is between 40% ~ 50%, but for a room with a dense number of people such as a meeting room, the relative humidity is still allowed in the range of 55% ~ 60%. In order to maintain comfortable conditions, the velocity of the air over the head should not be greater than 0.25 m/s and preferably less than 0.15 m/s.

2. Research Method

The research method used was quantitative research with survey methods. This method was used to find detailed information on the thermal conditions of the Hasanuddin University rectorate building so that the data obtained are accurate and reliable. The informants were 37 rectorate employees working in the room.

2.1. Research sites

The research location was in the rectorate of Hasanuddin University on Jl. Perintis Kemerdekaan No. KM 10, Tamalanrea Indah, Tamalanrea district, Makassar City, as shown in Fig. 1. The Hasanuddin University Rectorate, as shown in Fig. 2, consists of 8 floors, and the top floor is the floor occupied by the UNHAS Chancellor. The rectorate building area is 10,208.66 m^2. The sample location of the study was on the second floor, which has a floor area of 1,376.24 m^2, and the seventh floor (academic and educational) with an area of 1,020.96 m^2.



(a) (b)

Figure 1. (a) Makassar City Map (b) Location Map of Hasanuddin University Rectorate Building

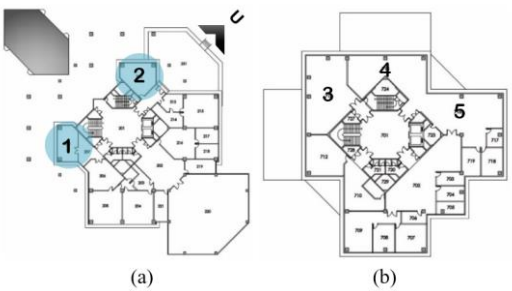
Figure 2. Rectorate building facade

2.2. Population and sample

The population in this study were employees of the rectorate building, especially employees in the second-floor fields (student affairs) and seventh-floor (academic and education), head of interest and talent room, student Meeting room, Academic Meeting room, registration (academic) room and Head of Education and Evaluation room. The four rooms represent the rectorate. The population was the generalization area consisting of objects/subjects that have certain quantities and characteristics determined by the researcher to be studied and then draw conclusions [14]. While the samples taken include questionnaires of respondents about air temperature, humidity, and air velocity in the room.

2.3. Data collection

Data collection was conducted in the form of primary data and secondary data. Primary data is a source of direct data obtained by researchers. While secondary data is data obtained by researchers from existing sources, such as through books, research journals, and articles related to



(a) (b)

Figure 3. (a) The floor plan of the student affairs on the second floor (1) head of interest and talent room (2) student meeting room (b) The floor plan of academics and education on the seventh floor (3) academic meeting room (4) registration (academic) room (5) Head of Education and Evaluation room

research. In this research, data collection was conducted using research instruments such as the Hobo thermal measuring instrument to obtain statistical data in the form of temperature, humidity, and air velocity measurements which were carried out every Monday to Friday from 08.00 - 17.00 WITA. This study measures the value of several variables using a Likert scale to find out about the thermal conditions, behavior, and activities of room occupants.

a. Data Analysis

The data analysis technique was descriptive analysis. This analysis is used to describe the characteristics of respondents and research variables. After the data in the form of air temperature, humidity, and air velocity were obtained, the data were tabulated, and a table or graph was made. Data analysis was performed using MS Excel spreadsheet software and the Statistical Package for Social Sciences (SPSS). Spreadsheets were used to calculate the average values of the thermal environment variables and to produce tables showing microclimatic conditions [15]. SPSS version 22 was used to analyze the validity and reliability of the questionnaire.

The measurement data were analyzed statistically to determine differences in air temperature, humidity, and wind flow speed at each measurement point. In addition, statistical tests were carried out to ensure the validity and consistency of the questionnaire.

3. Discussion and Results

3.1. General description of respondents

The number of respondents in the study were 17 people on the 2nd floor and 20 people on the 7th floor, making it 37 respondents in total. The respondents consist of 17 men (45.9%) and 20 women (54.1%). The age of the respondents started with 7 people (18.9%) aged 21-34 years, 25 people (67.6%) aged 35-54 years, and 5 people (13.5%) aged > 55 years. In the room occupancy variable, from a total of 37 respondents, 33 respondents (89.2%) answered 5x a week, 1 respondent (2.7%) answered 1-4x a week, and 3 respondents (8.1%) answered 1-4x in 4 weeks. In the type of clothing variable, 30 respondents (81.1%) answered "long-sleeved shirt, long pants", 6 respondents (16.2%) chose "long-sleeved light shirt, long pants" and 1 respondent (2.7%) answered “sweater/jacket”.

Table 1. Respondent data and measurement time at Hasanuddin University rectorate

No	Room	Total of Respondents	Measuring Time
1	Head of Interest and Talent room	5	08:00 – 17:00
2	Student Meeting room	12	08:00 – 17:00
3	Academic Meeting room	6	08:00 – 17:00
4	Registration (academic) room	7	08:00 – 17:00
5	Head of Education & Evaluation room	7	08:00 – 17:00
	TOTAL	37	

3.2. Student affairs

The room measured using HOBO is a room in the student affairs area on the second floor of the rectorate. It consists of the Head of Interest & Talent room and the Student Meeting room.

The room for the Head of Interest and Talent (a) has an area of 39.6 m^2 witha length of 8.25 m and a width of 4.80 m. While Student Meeting room (b) has an area of 52.58 m^2 with a length of 8.40 m and a width of 6.26 m. This room is in the form of a pentagon because it has five sides to the room. In addition, these two rooms are heading towards the west of the building.

3.3. Academics and education

The room measured using HOBO is a room located in the academic & education on the seventh floor of the rectorate. It consists of Academic Meeting room, Registration (Academic) room and Head of Education & Evaluation room.

(a) (b)

Figure 4. (a) Head of interest and talent room (b) Student meeting room

(a) (b)

(c)

Figure 5. (a) Academic meeting room (b) registration (academic) room (c) Head of Education and Evaluation room

The academic Meeting room has an area of 119.52 m^2, while The Academic Registration room has an area of 100.26 m^2 and has openings to the north and west of the building. The Head of Education & Evaluation room division has an area of 126.36 m^2 and has an opening or window to the north of the building. The type of opening or window in this room is a glass window that can be opened by sliding the glass.

3.4. Result of average thermal condition at temperatures 18ºC, 22 C, and 27 C

3.4.1. Temperature (ºC)

The average value of air temperature in the study room can be seen in Fig. 6. As shown in Fig. 6, the average air temperature at 18º C is 24.62ºC with the following description. The Head of Interest & Talent room is 25.9ºC, the Student Meeting room is 24.1ºC, the Academic Meeting room is 23.24ºC, the Registration (academic) room is 25.25ºC, and the Education & Evaluation room is 24.61ºC. The average temperature at 22ºC is 24.78ºC, where the Head of Interest & Talent room is 25.08ºC, the Student Meeting room is 24.65ºC, the Academic Meeting room is 26.17ºC, the Registration (academic) room is 24.26ºC, the Education & evaluation room is 23.74ºC. The temperature of 27ºC is 25.97ºC, where the Head of Interest & Talent room is 25.81ºC, the Student Meeting room is 25.04ºC, the Academic Meeting room is 26.59ºC, Registration (academic) room is 26.3ºC, and the Education & evaluation room is 26.11ºC.

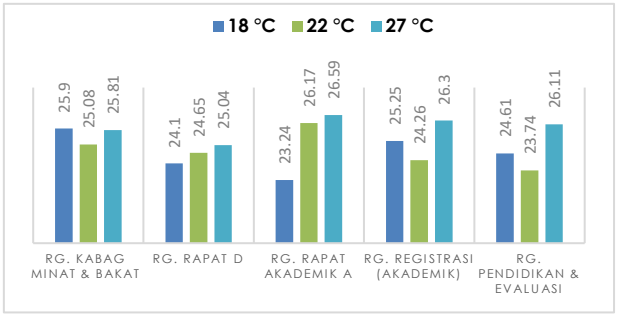


Figure 6. The average value of air temperature in the study room

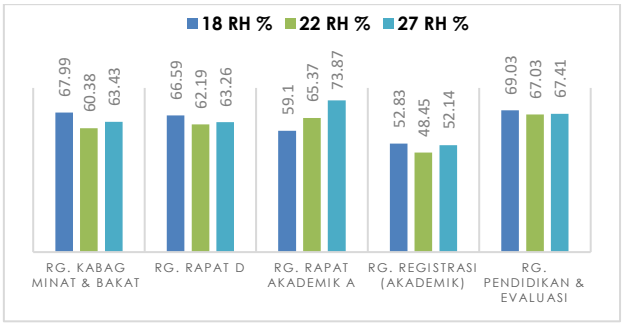


Figure 7. The average value of air humidity in the study room

3.4.2. Humidity (RH %)

The average value of air humidity in the research room can be seen in Fig. 7. As shown in Fig. 7, the average humidity at 18ºC is 63.108% with the following description; the Head of Interest & Talent room is 67.99%, the Student Meeting room is 66.59%, the Academic Meeting room is 59.1%, the Registration (academic) room is 52.83%, and the Education & Evaluation room is 69.03%. The average temperature at 22ºC is 60.684 %, where the Head of Interest & Talent room is 60.38 %, the Student Meeting room is 62.19%, the Academic Meeting room is 65.37%, the Registration (academic) room is 48.45 %, the Education & Evaluation room is 67.03%. While, the temperature of 27º C is 64.022%, consisting of the Head of Interest & Talent room is 63.43%, the Student Meeting room is 63.26%, the Academic Meeting room is 73.87%, the Registration (academic) room is 52.14%, and the Education & Evaluation room is 67.41%.

3.4.3. Air velocity (m/s)

The average air velocity value in the research room can be seen in Fig. 8. As shown in Fig. 8, the average air velocity at 18ºC is 0.144 m/s with the following description: the Head of Interest & Talent room is 0.099 m/s, the Student Meeting room is 0.077 m/s, the Academic Meeting room is 0.191 m/s, the Registration (academic) room is 0.141 m/s, and the Education & Evaluation room is 0.214 m/s. The average temperature at 22ºC is 0.142 m/s, where the Head of Interest & Talent room is 0.130 m/s, the Student Meeting room is 0.078 m/s, the Academic Meeting room is 0.195 m/s, the Registration (academic) room is 0.160 m/s, the Education & Evaluation room is 0.147 m/s. While the average temperature at 27ºC is 0.127 m/s, consisting of the Head of Interest & Talent room is 0.109 m/s, the Student Meeting room is 0.081 m/s, the Academic Meeting room is 0.220 m/s, the Registration (academic) room is 0.109 m/s, and the Education & Evaluation room IS 0.117 m/s.

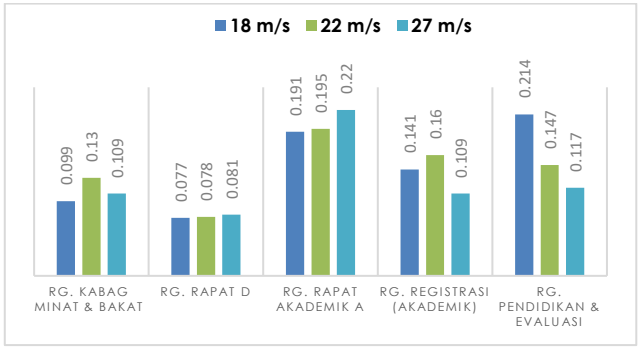


Figure 8. The average value of air velocity in the research room

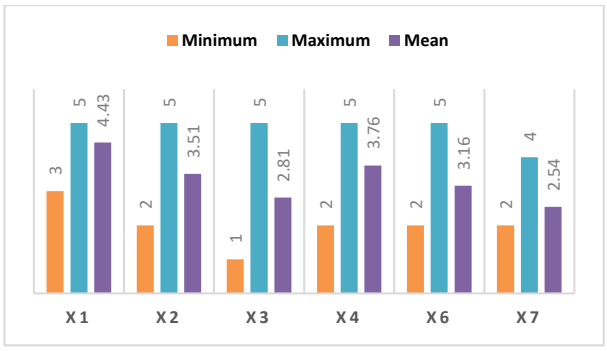


Figure 9. The average results of respondents' answers at a temperature of 18ºC

3.5. Average results of perceptions on temperature 18ºC, 22ºC, and 27ºC

3.5.1. Temperature of 18º C

From Fig. 9, the results of the average respondents at a temperature of 18ºC state that the room felt (X1) "Very cold" and respondents felt (X2) "Uncomfortable" so they wanted a change in the temperature to be (X3) "warmer" in the room. The thermal conditions at that room temperature were also (X4) "Neutral – Unacceptable" for the respondents.

3.5.2. Temperature of 22ºC

From Fig. 10, the results of the average respondents at a temperature of 22ºC stated that the room felt (X1) "Cold", respondents felt (X2) "Comfortable" so they were (X3) "Neutral" to temperature change. When it was 22ºC, the thermal condition at that room temperature was also (X4) "Acceptable" for the respondents.

3.5.3. Temperature of 27ºC

From Fig. 11, the results of the average respondents at a temperature of 27ºC stated that respondents felt (X1) "Neutral" to changes in temperature. When the temperature is at 27ºC, the thermal condition of the room was still (X4) "acceptable".

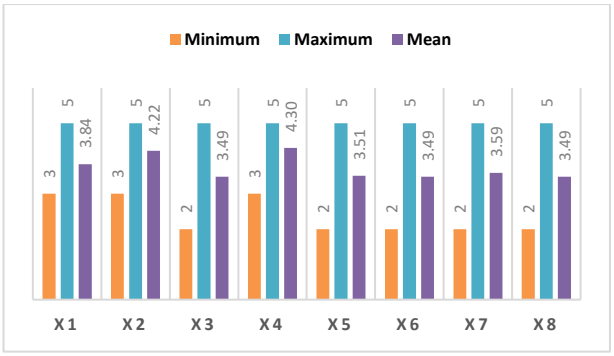


Figure 10. The average results of respondents' answers at a temperature of 22ºC

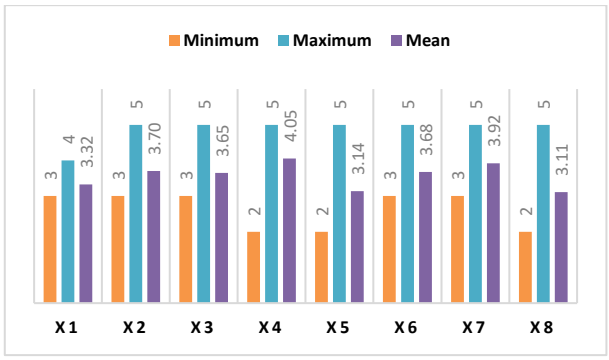


Figure 11. The average results of respondents' answers at a temperature of 27ºC

4. Conclusion

Based on the results of data measurements, the natural thermal conditions of the room using HOBO-Temp/RH/Light/External conducted from 08.00 - 16.00 Central Indonesia Time, the highest average temperature in all measured rooms is in the range of 27 C - 30ºC. From these results, it can be concluded that the room does not meet the categories in the ASHRAE and SNI thermal comfort standards in the building. Using air conditioning in the room is a good solution to help create a room so that it can be cooler and more comfortable when used by room occupants, who were the rectorate staff of Hasanuddin University.

Based on the results of research conducted by the author by measuring five rooms using HOBO-Temp/RH/Light/External, when the temperature is at 18ºC, the average value of the room temperature is 24.62ºC, the humidity is 63,108, and the air velocity is 0.144 m/s. When the temperature is at 22º C, the average value of the room is 24.78ºC, the humidity is 60.684, and the air velocity is 0.142 m/s. While the temperature is at 27ºC, the room temperature is 25.97ºC, the humidity is 64.022, and the air velocity is 0.127 m/s. Although the temperatures of 18º C and 22ºC are not much different, room occupants feel more "comfortable" in the room if the AC temperature is set at 22ºC.

Based on the results of the questionnaire, the perception of room occupants towards the room when the temperature is at 18ºC is that the average respondent's answer felt very cold in the room. Besides, they felt a dry sensation which made them uncomfortable. At a temperature of 22ºC, the respondents said that they were comfortable or could accept the current thermal conditions with a damp sensation that was still tolerable. Meanwhile, for a temperature of 27ºC, the respondents answered neutral, so the temperatures of 22ºC and 27ºC can be used as a reference in the use of air conditioning temperatures in the room.

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