



Analysis of Indoor Thermal Comfort in Achmad Sanusi UPI Building Using CBE Thermal Comfort Tool

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ABSTRACT

Indonesians generally rely on multipurpose buildings as infrastructure for activities such as seminars, weddings, competitions, art performances, and others. An example is the Achmad Sanusi Building located at the Indonesian University of Education. These activities certainly involve many users in it who require good thermal conditions for the health, comfort, and satisfaction of users. The analysis of the thermal comfort of the space in the Achmad Sanusi Building uses a field observation method by collecting data directly using the Elitech Temperature and Humidity Data Logger measuring instrument and an anemometer. Furthermore, the data obtained will be accumulated using the CBE Thermal Comfort Tool software. The results of the CBE Thermal Comfort Tool data will show the thermal comfort value of the building. The results of the thermal comfort analysis are used as an evaluation of the Achmad Sanusi Building design and a reference for designing multipurpose buildings.

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1. INTRODUCTION

Thermal comfort is a person's state of mind that expresses their satisfaction with their thermal environment (Szokolay, 1973, *Manual of Tropical Housing and Building*). Thermal comfort is defined as a sensation closely related to one's thermal environment, ranging from feelings of being very cold, cold, or warm, to experiencing an environment that feels very hot (Hamdy et.al, 2021). The thermal comfort of a room can be influenced by several factors, including air temperature, humidity, wind speed, activity, and occupant clothing (Ratnasari & Asharhani, 2021). The thermal comfort standard measured in this study is operating temperature comfort. Operating temperature is the temperature directly perceived by humans. Operating temperature itself is the body temperature in thermal equilibrium with the environment without metabolic heating or evaporative cooling. This operating temperature can also be defined as the temperature directly perceived by the human body.

The Achmad Sanusi Building is a multi-purpose building located on the campus of the Indonesian University of Education, Bandung, Indonesia. The Achmad Sanusi Building is frequently used by the general public and UPI students for various activities. As a building that supports various community interests, the Achmad Sanusi Building must have good indoor thermal comfort. The Achmad Sanusi Building is frequently used for large-scale events involving numerous parties. Therefore, understanding the thermal comfort of the interior of the Achmad Sanusi Building is crucial for evaluating multi-purpose building design, ensuring user health, comfort, and satisfaction, and as a design reference for multi-purpose building design.

1.1. Literature Review

CBE Thermal Comfort Tool is a thermal comfort calculation software that uses the ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) standard 55. ASHRAE standard 55 is an American national standard that focuses on environmental thermal conditions for human habitation established in 2020. According to this standard, to achieve thermal comfort in a room, a PMV value between -0.5 and +0.5 is required. Meanwhile, the PDD value needed to achieve this thermal comfort is between 5% -10%.

The CBE Thermal Comfort Tool is a thermal comfort calculation software that uses ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Standard 55. ASHRAE Standard 55 is an American national standard that focuses on environmental thermal conditions for human habitation, established in 2020. According to this standard, to achieve thermal comfort in a room, a PMV value between -0.5 and +0.5 is required. Meanwhile, the PDD value required to achieve this thermal comfort is between 5% and 10%.

ASHRAE Standard 55 also defines factors that can influence a room's thermal comfort. These factors are air temperature, air humidity, wind speed, radiant heat, clothing insulation, and metabolic rate. Air temperature is the degree of hotness or coldness of the air around us. Differences in air temperature in each location are influenced by several factors, including sunlight, location, humidity, altitude, and weather. Air temperature conditions are closely related to health. Unsuitable air temperatures can have various adverse health effects. Furthermore, air humidity is the amount of water vapor contained in the air at a given time. Air humidity can affect changes in human body temperature. Extreme changes in body temperature can threaten human health. Wind or air speed is the speed at which wind flows past a specific point. Differences in wind intensity passing through each point affect thermal comfort in different locations. The wind speed of a room affects the body temperature of its

occupants because stagnant air in a room creates a stuffy atmosphere, making occupants sweat more easily (Istiningrum et al. 2017).

Radiation temperature is the temperature associated with electromagnetic radiation emitted by objects or surfaces. Examples include thermal radiation emitted by the human body and solar radiation. Solar radiation significantly influences the temperature at the Earth's surface. Research conducted by Parson (2003) showed that environments with high radiation temperatures, such as urban areas, can increase human body temperature and cause illnesses such as heat stroke and heat exhaustion. Furthermore, clothing insulation affects the flow of heat from the body. Clothing is classified according to its insulation value. The unit used for clothing insulation is the Clo. The total Clo value can be calculated by adding up the Clo values of each item of clothing worn. Slenajutny is the metabolic rate. According to W. T. Hersey (1941), metabolism is a series of chemical reactions that occur in the body to break down food substances into energy and body components needed for growth, maintenance, and regulation of body functions. The more physical activity, the more heat is produced by the metabolic process. Metabolism is measured in METs (1 MET = 58.2 W/m² of body surface).

2. METHODOLOGY

The analysis of indoor thermal comfort in the Achmad Sanusi Building was conducted through direct field observations of the building. Data was collected using an Elitech Temperature and Humidity Data Logger and an anemometer, then inputted through the ElitechLogWin data logger application, which was then calculated using the CBE Thermal Comfort Tool software.

The Elitech Temperature and Humidity Data Logger is a measuring instrument manufactured by the company Elitech that records temperature and humidity. Data was collected from the Elitech Temperature and Humidity Data Logger every hour from 10:00 AM to 2:00 PM for 10 minutes on each of the four sides of the building. This instrument can record minimum, maximum, and average temperature and humidity. This study used the average temperature on each side of the building, which was then accumulated to create the average indoor temperature for the Achmad Sanusi Building each hour.

The CBE Thermal Comfort Tool is software developed by the Center for the Built Environment. This website calculates thermal comfort predictions according to ASHRAE Standard 55. The data analyzed by the software are PMV and PDD values. PMV is the predicted mean vote, defined as an index that aims to predict the average value of a balanced or good thermal sensation for a user group. Thermal equilibrium in humans is said to be achieved when the amount of heat production is equal to the amount of heat loss. Meanwhile, PDD is an index that determines user dissatisfaction with the thermal sensation they feel (too cold or too hot).

2.1. Analysis

The indoor thermal comfort research object is the Achmad Sanusi Building, located at the Indonesian University of Education, Jalan Doktor Setiabudhi No. 229, Gegerkalong, Sukasari, Isola, Sukasari District, Bandung City, West Java 40153. The Achmad Sanusi Building covers an area of approximately 390,000 m². Measurements were taken from four sides of the building, with varying orientations to ensure the data collected encompasses the building's overall thermal characteristics.

The Achmad Sanusi Building is located on the Indonesian University of Education campus, at an elevation of 902 meters above sea level. It is situated in a highland area. The warm

season lasts for 2.4 months, from September 1 to November 15, with an average daily high temperature above 29°C. The hottest month of the year in Bandung is November, with an average low temperature of 20°C and a high of 29°C. The winter season lasts for 1.8 months, from December 31 to February 23, with an average daily high temperature below 27°C. The coldest month of the year in Bandung is July, with an average low of 18°C and a high of 28°C.

The rainy season lasts for 6.7 months, from October 20 to May 11, with a greater than 44% chance of a rainy day. The month with the wettest days in Bandung is January, with an average of 22.0 days with at least 1 millimeter of rainfall. The dry season lasts for 5.3 months, from May 11 to October 20. The month with the fewest wet days in Bandung is August, with an average of 4.9 days with at least 1 millimeter of rainfall. The prevailing wind direction passing through the Achmad Sanusi Building comes from the northwest at a speed of 5.5 km/h.

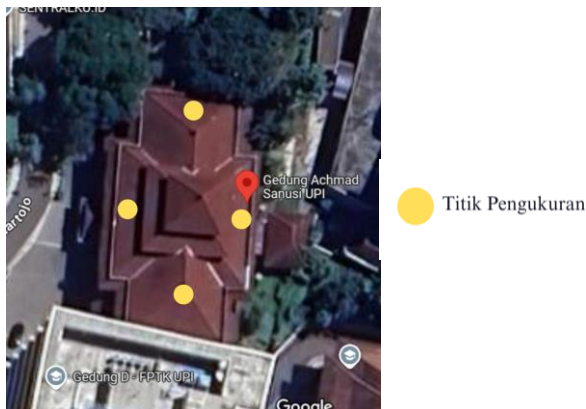


Figure 1. Nazifa, Achamd Sanusi, 2025
Source : Personal Document

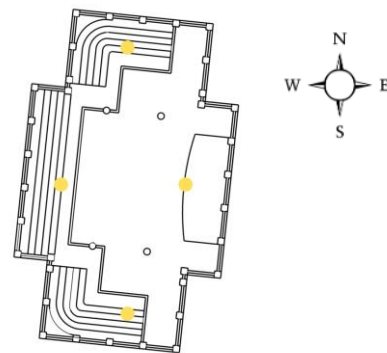


Figure 2. Nazifa, Building Layout , 2025
Source : Personal Document

The Achmad Sanusi Building utilizes wood for its walls, ceiling, stage, and additional furniture. Ceramic tiles are used throughout the floor. The ceilings are quite high, approximately 6-7 meters. The building also utilizes open spaces, as evidenced by the minimal partitions between rooms. Openings for light and air are distributed along the north, south, and west sides. These openings generally consist of vents attached to the windows and doors, as well as openings from living windows. These openings vary in size, including 15x100cm, 40x100cm, 70x15cm, and 50x170cm.



Figure 3. Nazifa, North Side of Achamd Sanusi, 2025
Source : Personal Document



Figure 4. Nazifa, East Side of Achamd Sanusi, 2025
Source : Personal Document



Figure 5. Nazifa, South Side of Achmad Sanusi, 2025
Source : Personal Document



Figure 6. Nazifa, West Side of Achmad Sanusi, 2025
Source : Personal Document

3. RESULTS AND DISCUSSIONS

Average temperature measurements were taken for the first 10 minutes on the west side, followed by another 10 minutes on the other sides, in the order of north, east, and then south. The average temperatures for each side were then accumulated to create an average temperature for the hour. The following data shows the average room temperature measurements in the Achmad Sanusi Building.

Table 1: Measurement results and Average Temperature Accumulation per Hour

Time	Avarage Temperature (°C)	Avarage Temperature/Hour (°C)
10.00-10.10	27	25.6
10.12-10.22	24.7	
10.24-10.34	25.8	
10.36-10.46	24.8	
11.00-11.10	25.58	25.6
11.12-11.22	24.7	
11.24-11.34	26.6	
11.36-11.46	24.9	
12.00-12.10	24.9	24.8
12.12-12.22	24.8	
12.24-12.34	24.7	
12.36-12.46	24.8	
13.00-13.10	25.2	25
13.12-13.22	24.6	
13.24-13.34	25.1	
13.36-13.46	25.4	
14.00-14.10	26.3	25.8
14.12-14.22	25.7	
14.24-14.34	25.5	
14.36-14.46	25.9	

Based on the data above, the average room temperature from 10:00 AM to 2:00 PM was 25:36°C. According to Indonesian National Standard 03-6572-2001, this temperature is classified as optimally comfortable. The air temperature dropped at 12:00 PM and rose again at 1:00 PM. This could be due to changing weather conditions.

Wind speed and relative humidity measurements were performed exactly as temperature measurements: the first 10 minutes on the west side, then another 10 minutes on the other sides, in the order of north, east, then south. The following are the results of wind speed and relative humidity measurements using an anemometer.

Table 2. Measurement results and accumulation of average hourly wind speed and relative humidity.

Time	Wind Speed	Relative Humidity Average (%)	Average Temperature/Hour (°C)
10.00-10.10	0	65	68
10.12-10.22	0	66	
10.24-10.34	0	70.5	
10.36-10.46	0	70.5	
11.00-11.10	0	69	70.9
11.12-11.22	0	70	
11.24-11.34	0	73.5	
11.36-11.46	0	71	
12.00-12.10	0	71.5	71.6
12.12-12.22	0	72.5	
12.24-12.34	0	71.5	
12.36-12.46	0	71	
13.00-13.10	0	70	70.5
13.12-13.22	0	71	
13.24-13.34	0	71	
13.36-13.46	0	70	
14.00-14.10	0	71	67
14.12-14.22	0	60	
14.24-14.34	0	67	
14.36-14.46	0	70	

On all sides of the building, the measured wind speed was 0 m/s. This could be due to the lack of air openings in the building. Meanwhile, the building's average relative humidity was 69.5, a level not recommended by health experts as healthy.

The Achmad Sanusi Building is a multipurpose building commonly used for large and small scale activities. The activities inside are varied, from formal activities that do not involve much movement to informal activities where users generally do more body movement. To analyze thermal comfort with different body activities, the accumulated metabolic rate is divided into two types. Namely a metabolic rate of 1.0 (seated, quiet) which represents formal activities and a metabolic rate of 1.2 (standing, relaxed) which represents activities with informal activities. The following are the accumulated results from the CBE Thermal Comfort Tool software. The clothing level used in this measurement is 0.61 clo (trousers, long-sleeve shirt) because the clothing of this building's users generally wear formal to semi-formal clothing considering the type of activities usually carried out in this building.

Table 3. Accumulated Results of CBE Thermal Comfort Tool (Metabolic Rate 1)

Time	Temperature (°C)	Relative Humidity (%)	Air Speed (m/s)	Metabolic Rate (met)	Clothing Level (clo)	PMV	PDD (%)
10.00	25.6	68	0	1	0.61	0.27	6
11.00	25.6	70.9	0	1	0.61	0.29	7
12.00	24.8	71.6	0	1	0.61	0.00	5
13.00	25	70.5	0	1	0.61	0.07	5
14.00	25.8	67	0	1	0.61	0.33	7

The accumulated results of the CBE Thermal Comfort Tool above are the results of the thermal comfort of the space in the Achmad Sanusi Building with user activities that do not involve much body movement such as seminars or the like. All PMV values at each hour show numbers in the interval -0.5 - +0.5 and PDD values at all times show numbers in the interval

5% - 10%. According to the ASHRAE 55 standard, this shows that the Achmad Sanusi Building which is used for formal activities or activities with minimal activity has a good level of thermal comfort.

Table 4. Accumulated Results of CBE Thermal Comfort Tool (Metabolic Rate 1.2)

Time	Temperature (°C)	Relative Humidity (%)	Air Speed (m/s)	Metabolic Rate (met)	Clothing Level (clo)	PMV	PDD (%)
10.00	25.6	68	0	1.2	0.61	0.62	13
11.00	25.6	70.9	0	1.2	0.61	0.29	14
12.00	24.8	71.6	0	1.2	0.61	0.41	9
13.00	25	70.5	0	1.2	0.61	0.46	10
14.00	25.8	67	0	1.2	0.61	0.68	15

The second CBE Thermal Comfort Tool accumulation was performed by changing the metabolic rate to 1.2 to observe differences in thermal comfort with different activity intensities. The accumulated results showed that at certain times, namely 10:00, 11:00, and 14:00, PMV and PDD values did not meet the ASHRAE 55 thermal comfort standard, with PMV outside the -0.5-+0.5 interval and PDD outside the 5%-10% interval. This second accumulation of data differed from the thermal comfort results for lower activity intensities. This means that the Achmad Sanusi Building has good indoor thermal comfort when activity intensity is low. When users engage in high-intensity activities such as walking, running, dancing, and so on, the Achmad Sanusi Building does not meet the indoor thermal comfort standard. Users with high activity intensity may feel hot, stuffy, sweaty, and uncomfortable while in the Achmad Sanusi Building.

The Achmad Sanusi Building's 10-20 window openings on the west, north, and south sides, with window sizes ranging from 15x100cm to 40x100cm, high ceilings, and ample open space provide adequate ventilation and air circulation, resulting in good indoor thermal comfort. The predominant wood material used in the building also contributes to heat absorption. Wood helps absorb and trap heat indoors. However, this only occurs when building occupants are not engaged in intense activity. Increased activity causes their metabolism to produce more heat. This impacts other thermal comfort factors, so according to the CBE Thermal Comfort Tool standards and calculations, the Achmad Sanusi Building does not yet achieve optimal indoor thermal comfort.

According to ASHRAE, the ventilation requirement per person in a room is approximately 10 L/s (liters per second). This means each person requires their own air supply. Looking at the size and number of openings in the Achmad Sanusi Building, the openings for air circulation in the room are considered less than optimal with a room area of 390,00m². This could be the cause of the Achmad Sanusi Building not having optimal thermal comfort, especially for high activity. Considering that a multi-purpose building is a building that can accommodate various kinds of community activities from low to high intensity activities. To be able to fulfill good indoor thermal comfort at all levels of community activity, a multi-purpose building must have a good design to achieve such thermal comfort. Looking at the results of the thermal comfort research of the Achmad Sanusi Building, a multi-purpose building should have good air circulation paths such as high ceilings, minimal partitions between rooms, materials that can absorb heat well, and sufficient air openings. Air openings for a multi-purpose building can use windows or vents with standard opening sizes accompanied by a sufficient number. Considering that the number of openings in the Achmad Sanusi Building which is around 20% of the building's side area is still considered insufficient, a multi-purpose building should be able to have air openings of more than 20% of the building's side area.

4. CONCLUSIONS

The Achmad Sanusi Building is a multi-purpose building that accommodates various community activities from low to high levels. The thermal comfort of the space in a multi-purpose building must be able to meet all levels of activity. The design of the Achmad Sanusi Building, such as materials, ceilings, room sizes, and air openings, is sufficient to help this building have good thermal comfort for low-intensity activities. However, with a fairly high activity and more users, the resulting metabolic rate will have a higher value and the need for greater air circulation. Insufficient air circulation or air openings in this building cause the Achmad Sanusi Building to not have optimal thermal comfort. The results of this study recommend the design of a multi-purpose building to have optimal air openings, which is not less than 20% of the building's side area. Thermal comfort in a multi-purpose building is an important thing that must be considered to achieve the health and comfort of all users inside.

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