Thermal Comfort Analysis of Design Element in El's Coffee Roastery Building Bandar Lampung: A Case Study of the Use of Glass Facades in a Tropical Climate

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Abstract

Indonesia's tropical climate, characterized by high humidity, hot temperatures, and intense solar radiation year-round, demands a more adaptive and thoughtful architectural design approach. In this context, building designers need to consider the balance between aesthetics and thermal comfort for space users. The use of glass, for example, can provide abundant natural lighting and enhance a building's visual character, but it can also increase the heat load of interior spaces if not equipped with appropriate mitigation strategies. Therefore, implementing effective air circulation, such as air conditioning devices, shading devices, and reflective protective coatings, is crucial to reducing excess heat. Facade design that is responsive to tropical climates is key to achieving optimal building performance. This study examines the thermal comfort analysis and application of architectural design elements to the El's Coffee Roastery building in Bandar Lampung, with a particular focus on the function and quality of the glass facade as a key element influencing the building's appearance and performance in a tropical climate.

Keywords: *Climate, Thermal Comfort, Glass Facade*

I. INTRODUCTION

The use of glass in modern architecture is increasingly widespread and has become one of the most popular facade elements. This material is chosen for its transparency, aesthetics, and modernity, in line with contemporary design trends. Furthermore, glass supports the creation of a visual connection between indoor and outdoor spaces, thus enhancing the user's spatial experience. In the context of commercial buildings, the use of glass is often a strategy to strengthen a professional image and attract public attention.

However, the application of glass is not without its challenges, especially in tropical regions like Indonesia. High solar radiation intensity throughout the year causes significant heat gain inside glass-clad buildings. When solar heat is absorbed and transmitted to the interior, room temperatures can rise dramatically, affecting occupants' thermal comfort. This situation encourages the excessive use of mechanical cooling, ultimately leading to higher building energy consumption.

Bandar Lampung, a city with a strong tropical climate, is a relevant location to study the use of glass in buildings. One example is El's Coffee Roastery, a commercial building that uses a glass facade to emphasize its modern appearance and professional image. While the use of glass in this building provides high aesthetic value, it also raises issues related to indoor heat management, particularly during periods of intense solar radiation.

Therefore, it is crucial to understand the performance of glass in tropical buildings and the design strategies used to control overheating. Factors such as building orientation, glazing type, shading system, and the use of reflective protective coatings play a crucial role in

improving a building's thermal performance. Evaluation of these elements can provide insight into the extent to which glass facade designs can function optimally in challenging tropical climates.

Furthermore, examining the effectiveness of glass facade design in this context can help formulate a more adaptive and sustainable architectural approach. By understanding the relationship between glass materials, tropical climates, and thermal comfort, designers can create design solutions that not only meet aesthetic demands but are also energy-efficient. This approach is becoming increasingly important given the increasing demand for high-performance, energy-efficient buildings.

This research is expected to yield a more comprehensive understanding of the application of glass in tropical buildings, particularly in the case of El's Coffee Roastery in Bandar Lampung. The findings not only contribute to the development of modern tropical architectural concepts but also offer design recommendations that support energy efficiency and occupant comfort. Thus, the use of glass can be optimized as an aesthetically pleasing and sustainable architectural element.

II. Materials and Methods

Comfort can be defined as a human response and relationship to an environment that is free from negative influences, where the assessment is subjective. In this case, thermal comfort includes various conditions ranging from feeling stuffy, comfortable, hot, fresh, cold, to cool or stuffy, all of which are important parts of the concept of comfort (Sugini, 2004).

Climate is a description of the average weather conditions in a region over a long period of time. Meanwhile, weather describes the state of the atmosphere over a short period of time and can change from hour to hour, day to day, or even month to month. Climate can also be considered as the average weather conditions measured over a long period of time and has relatively constant characteristics (Kartasapoetra, 2012).

1. Factors Affecting Thermal In Buildings

There are several factors that influence thermal comfort in buildings, both positive and negative, namely:

a. Temperature

Air temperature is one of the most dominant influencing factors and has a significant effect on determining human thermal comfort. The following are standards for thermal comfort for acceptable warmth levels, according to SNI 03-6572-2001, ranging from 25.8°C to 27.1°C.

b. Humidity

Humidity is the amount of water vapor in the air. Humidity is a crucial factor in thermal comfort when the air temperature approaches or exceeds the comfort threshold, and humidity is greater than 70% or less than 40%. Indoors, humidity affects the rate of heat loss from the human body. High humidity makes it difficult for the body to release heat, creating discomfort.

c. Wind Velocity

The wind speed around people is a crucial factor influencing comfort levels within a room, particularly through the presence of openings such as windows or vents. Good air circulation helps maintain air quality and provides comfort for occupants.

According to SNI 03-6572-2001, the ideal wind speed range for supporting indoor thermal comfort is around 0.25 m/s. However, this value is not absolute; airflow speed can be increased beyond 0.25 m/s if the indoor air temperature tends to be higher. Therefore, adjusting wind speed is crucial to achieve a balance between thermal comfort and efficient air circulation within a space.

d. Radiation Temperature

Radiant temperature refers to the heat emitted by an object through radiation. One of the main sources is solar radiation, which not only produces light but also carries heat energy that can increase air temperature. When a building is exposed to direct sunlight, this heat can be absorbed, causing an increase in indoor temperatures, resulting in discomfort for occupants.

2. Material Characteristics Against Heat

a. Glass

According to the book entitled Introduction to Glass Science and Technology by Shelby (2005), glass has a low heat capacity, so its temperature changes easily and cannot store heat for too long. Glass has excellent thermal insulation properties and is often used in windows and doors. However, due to its high coefficient of expansion, glass can crack if subjected to sudden temperature changes. Its low thermal conductivity makes it difficult for heat to transfer through the material. Care must be taken when using glass in extreme temperature conditions, and thicker glass is usually required to withstand temperature changes more safely.

b. Plastic

According to Strong (2006) in his book Plastics Materials and Processing, plastics have several important characteristics related to their response to

heat. In general, plastics have low thermal conductivity, so heat is not easily absorbed or transferred through them. Plastics, both thermoplastics and thermosets, can soften at high temperatures, although thermosets are more heat-resistant up to around 200–300°C. These materials have a high coefficient of thermal expansion, making them prone to deformation or cracking when subjected to sudden temperature changes. However, plastics remain widely used due to their lightweight and excellent thermal insulation properties, for example in food packaging and coolers.

c. Wood

According to the Wood Handbook: Wood as an Engineering Material by Forest Products Laboratory (2010), wood has lower thermal conductivity compared to other building materials such as metal or concrete. Wood has excellent thermal insulation properties because it conducts heat slowly and has a low coefficient of thermal expansion. This makes it stable against temperature changes and suitable for use as a construction material requiring effective heat insulation.

3. Thermal Comfort Standards

According to Lippsmeier (1994), the comfortable temperature range for humans in equatorial regions is between 19°C TE as the lower limit and 26°C TE as the upper limit. At around 26°C TE, humans generally begin to sweat, while work capacity and endurance tend to decrease as the temperature increases from 26°C TE to 30°C TE. The environment begins to feel uncomfortable at temperatures between 33.5°C TE and 35.5°C TE, and becomes intolerable at 35°C TE and 36°C TE.

The standard procedures for technical planning of energy conservation in buildings published by the Public Works Cultural Problems Study Foundation (LPMB-PU) divides comfortable temperatures for Indonesians into three categories, as shown in Table 1.

Table 1. Thermal Comfort Standards

CATEGORY	EFFECTIVE TEMPERATURE
COOL COMFORT THRESHOLD	20.5°C-22.8°C (24°C)
OPTIMAL COMFORT THRESHOLD	22.8°C-25.8°C (28°C)
WARM COMFORT THRESHOLD	25.8°C-27.1°C (31°C)

Source: (ASHRAE, 2009)

4. Research Method

This research uses quantitative and qualitative methods with a case study approach. This approach was chosen because it provides a deeper and more comprehensive understanding of phenomena in real-world settings.

a. Observation

Observation in this study refers to the researcher's activities in directly observing the behavior and social phenomena that are the object of study. According to Simamora (2023), observation involves the process of seeing, feeling, and recording data relevant to the research. In the context of this study, the researcher conducted direct observations of design elements at El's Coffee Roastery in Bandar Lampung.

b. Questionnaire

According to Sugiyono (2017:142), a questionnaire is a data collection method carried out by providing a set of written questions or statements to respondents to answer. This study used a closed-ended questionnaire as an instrument to measure the phenomenon under study. Respondents were simply asked to select the most appropriate answer. The questionnaire, as shown in Table 2, was distributed online to users of the El's Coffee Roastery building in Bandar Lampung to obtain the necessary data.

Table 2. Questionnaire List

LIST OF QUESTIONS	VERY UNCOM-FORTABLE	UNCOM-FORTABLE	COMFOR-TABLE	VERY COMFOR-TABLE
DOES THE GLASS FACADE ELEMENT AFFECT THE COMFORT OF ACTIVITIES IN PUBLIC SPACES FOR USERS?				
DOES LAMINATED GLASS HELP REDUCE HEAT FROM OUTSIDE THE BUILDING?				
IN YOUR OPINION, IS THE INTENSITY OF SUNLIGHT ENTERING THE PUBLIC SPACE GLARING DURING THE DAY?				
IS THE VENTILATION YOU EXPERIENCE IN THIS PUBLIC SPACE FUNCTIONING WELL?				
IN YOUR OPINION, WHAT IS THE ROLE OF NATURAL VENTILATION ELEMENTS IN CREATING AIR COMFORT IN THIS BUILDING?				
ARE YOU COMFORTABLE WITH THE TEMPERATURE IN THE PUBLIC SPACE?				
DO YOU FEEL STUFFY WHEN YOU ARE IN THE PUBLIC SPACE?				
IN YOUR OPINION, DOES THE OVERALL BUILDING DESIGN CREATE A COMFORTABLE ATMOSPHERE FOR ACTIVITIES?				

c. Measurement

Measurement is an activity aimed at determining the size or extent of an object or phenomenon (Hadi, 1995). Measurement results can be numerical or descriptive, and both are crucial for assisting decision-making. Therefore, the quality and accuracy of the information are crucial. In this study, researchers measured the temperature at 3 areas in the El's Coffee roastery building, ensuring that the measuring tools used were appropriate and following the correct measurement

steps to ensure accurate results.

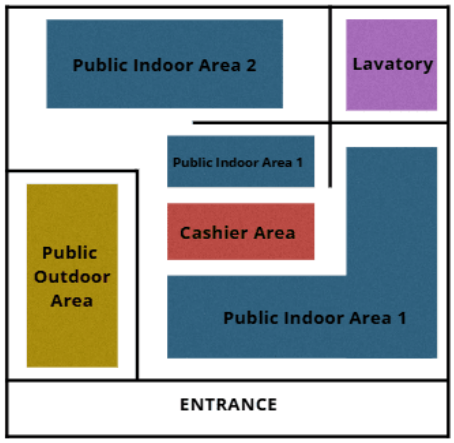

Figure 1. Schematic of the El's Coffee Roastery Building Space.
Source: (Personal Analysis, 2025)

Figure 2. Public Indoor Area 1

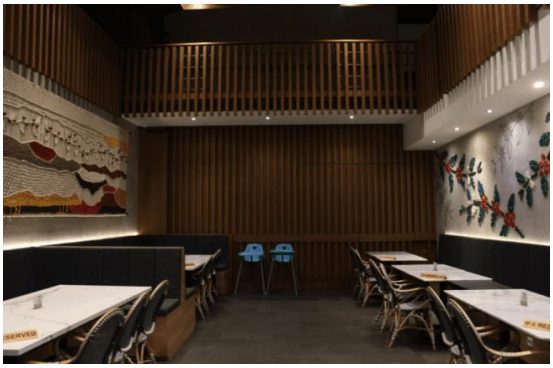

Figure 3. Public Indoor Area 2

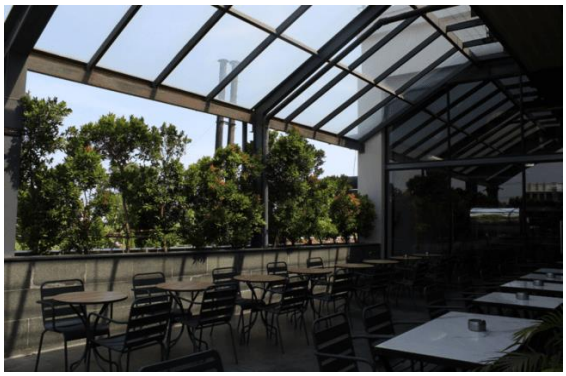

Figure 4. Public Outdoor Area

Figure 5. Cashier Area

III. Results and Discussions

A. El's Coffe Roastery Analysis

El's Coffee Roastery is classified as a public building, generally facing east. Architecturally, it exhibits modern architectural features, evident in its shape and dimensions, which include large windows and doors, as well as an additional terrace. El's Coffee Roastery is generally divided into spaces used as public spaces for users, as well as several supporting spaces for user infrastructure.

B. El's Coffe Roastery Observation Result

Direct observation or review of the research location was conducted to understand the actual condition of the El's Coffee Roastery building on the ground. To obtain accurate data, researchers collected various pieces of information deemed most relevant and able to provide in-depth explanations of the topics to be discussed in the study.

Figure 6. Facade of El's Coffee Roastery Building

The El's Coffee Roastery building in Bandar Lampung is a concrete example of the application of laminated glass facades in a tropical climate.

Arranging trees around a building at a certain distance allows the vegetation to function optimally. However, on the sides of the building adjacent to other structures, there are empty areas without vegetation, allowing direct sunlight to enter the building and

reducing air circulation. The spacing between trees and the building must be considered to create sufficient space for air flow, as the greater the distance, the stronger the wind that can move through it.

The El's Coffee Roastery building in Bandar Lampung faces east. The sun passes from east to west, from dawn to sunset, around 5:00 AM to 6:00 PM WIB. At El's Coffee Roastery, the sun is directly overhead from 12:00 PM to 2:00 PM WIB, with the sun's strongest rays occurring around 10:00 AM to 3:00 PM WIB.

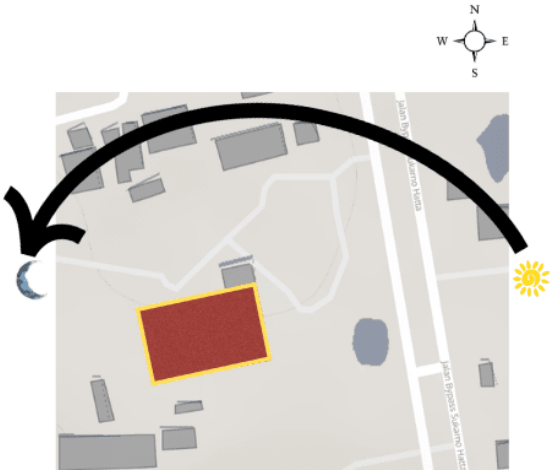

Figure 7. Schematic Illustration of the Environmental Conditions of El's Coffee Roastery
Source: (Personal Analysis, 2025)

The El's Coffee Roastery building in Bandar Lampung does not have any ventilation ornaments that utilize natural ventilation. The building uses an artificial ventilation system located in the ceiling, as shown in Figure 8, with the aid of mechanical energy such as air conditioning (AC), so that temperature and air circulation can be regulated to create comfortable thermal conditions for its occupants.

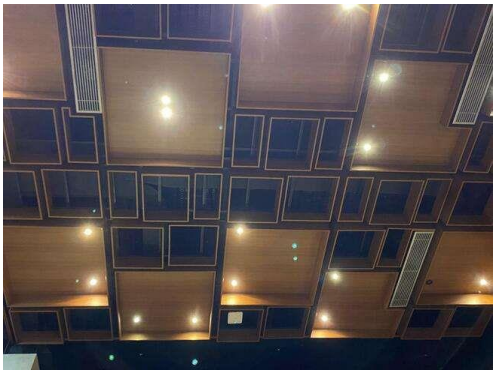

Figure 8. El's Coffee Roastery Building Ceiling.

Several elements that support this thermal comfort include the use of a modern, energy-efficient air conditioning system and a building design that prioritizes natural air circulation. Large windows are equipped with heat-rejecting film to minimize direct sunlight, while automatic blinds regulate lighting levels. The presence of plants in the surrounding area also helps maintain a cool ambient temperature. Overall, the various steps taken by El's Coffee Roastery Bandar Lampung to provide thermal comfort have yielded positive results. The cool and comfortable atmosphere not only supports increased productivity within the building but also positively impacts the comfort of all its users. This success is expected to inspire other public buildings to create more optimal and conducive activity environments.

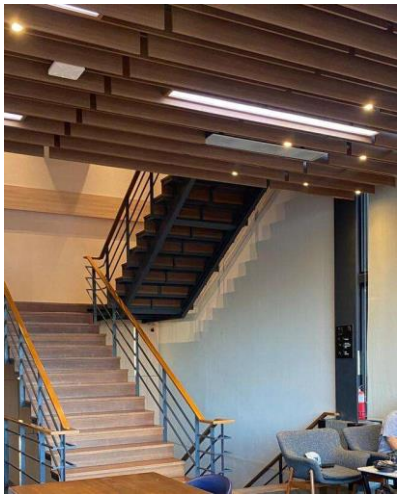

Figure 9. Room Ventilation.

Figure 10. Automatic Curtain System in Buildings.

C. Thermal Comfort Survey Responses

Responses to temperature conditions in the study room at El's Coffee Roastery Bandar Lampung were carried out by distributing online questionnaires on October 31, 2025 - November 1, 2025.

When conducting the research, 20 respondents were taken, of which 70% were men and 30% were women who came from users who were considered to frequently visit the El's Coffee Roastery Bandar Lampung building, aged between 17 and 30 years.

Respondents also shared their feedback on the room design and amenities provided. The majority of users positively assessed the presence of large windows, which allow natural light in and promote airflow. Features like automatic blinds and heat-retaining window film were also appreciated, as they help reduce direct sunlight exposure, maintaining a stable room temperature throughout the day.

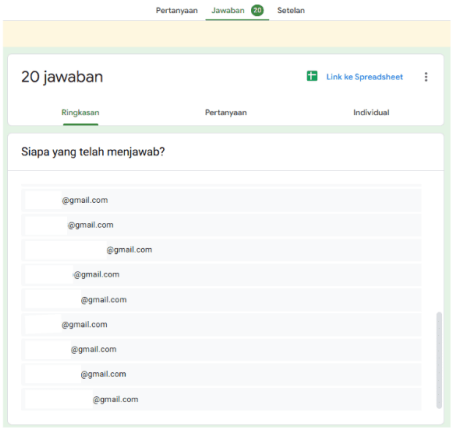

Figure 11. Online Questionnaire Filling for Users.

The results of the questionnaire showed that at most 58.75% chose 3 (comfortable), 31.875% chose 4 (very comfortable), 6.875% chose 2 (less comfortable), and 2.5% chose 1 (very uncomfortable).

Based on the questionnaire results, 90.625% of respondents considered the room temperature to be within a comfortable range, between 19.1°C and 27.6°C. This temperature range is considered appropriate for supporting activities and providing thermal comfort. Building users felt that the conditions, which were neither too hot nor too cold, allowed them to feel at home and enjoy the available facilities without being disturbed by their surroundings.

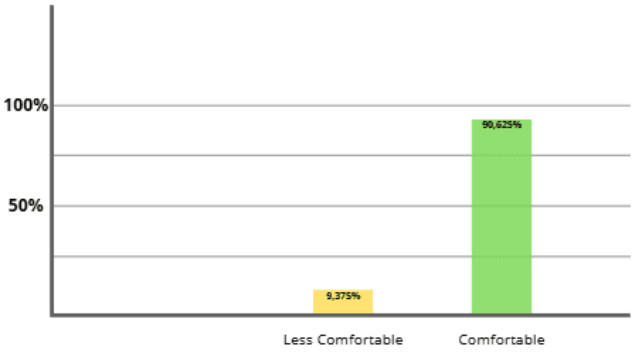

Figure 12. Average Respondents' Answers Results Diagram.
Source: (Personal Analysis, 2025)

D. Measurement results

Air temperature measurements were conducted over four days, obtaining data in the form of air temperature. They were taken at three times: 10:00 AM - 12:00 PM WIB, 12:30 PM - 2:30 PM WIB, and 3:00 PM - 5:00 PM WIB. Each indoor area had the same air conditioning (AC) system. To obtain valid air temperature data, measurements were taken at three different points within the location.

In research on thermal comfort, various tools are needed to collect data during the research process, namely the XH-W3001 Temperature controller, this tool is used to measure the temperature in a room.

Figure 13. *Temperature controller* XH-W3001.

After conducting physical measurements using standardized tools, the average room temperature at El's Coffee Roastery Bandar Lampung was recorded to be in the range of 19.1°C to 27.6°C in the indoor public area, and 27.8°C to 29°C in the outdoor public area. According to ASHRAE standards, the temperature range is in the optimal comfort category with a maximum temperature range of 28°C for indoor public areas and a comfortable warm category with a maximum temperature range of 31°C for outdoor public areas. These standards can be seen in Table 1.

Table 3. Table of results of air temperature measurement data.

Day/Date	Time	Temperature (°C)		
		location 1	location 2	location 3
Sunday, October 19, 2025	10:00-12:00 WIB	27.7	23.5	29
Sunday, October 19, 2025	12:30-14:30 WIB	28.6	22.0	30.2
Sunday, October 19, 2025	15:00-17:00 WIB	27.2	19.1	29.4
Monday, October 20, 2025	10:00-12:00 WIB	26.3	21.8	28.2
Monday, October 20, 2025	12:30-14:30 WIB	26.8	23.0	28.7
Monday, October 20, 2025	15:00-17:00 WIB	23.9	18.9	27.2
Sunday, October 26, 2025	10:00-12:00 WIB	27.4	22.4	28.6
Sunday, October 26, 2025	12:30-14:30 WIB	28.0	23.1	29.2
Sunday, October 26, 2025	15:00-17:00 WIB	27.1	20.3	28.4
Monday, October 27, 2025	10:00-12:00 WIB	26.8	21.1	27.5
Monday, October 27, 2025	12:30-14:30 WIB	27.0	21.8	28.1
Monday, October 27, 2025	15:00-17:00 WIB	25.8	18.2	26.2

Table 4. Table of average air temperature measurement results.

Parameter	Rata-rata	min	max
Temperature(℃)	Pagi(25,8)	21,1	29
	Siang(26,3)	21,8	30,2
	Sore(24,3)	18,2	29,4

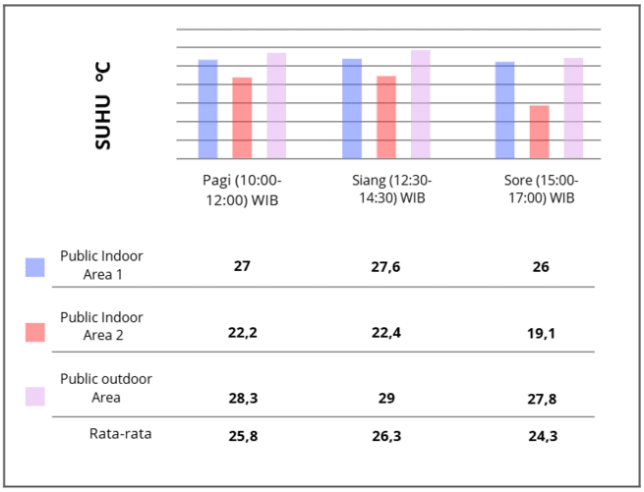

Figure 14. *Average temperature results diagram*

Thermal comfort is an important aspect in supporting the productivity and well-being of users in public building areas. El's Coffee Roastery Bandar Lampung, as a place where public activities take place, must be able to provide an environment that supports thermal comfort for all building users. Thermal comfort is a state of mind that expresses satisfaction with the thermal environment. According to ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers), thermal comfort is achieved when the thermal conditions around a person are within an acceptable range.

IV. CONCLUSIONS

From the results of the research that has been conducted, it was found that the level of thermal comfort at El's Coffee Roastery Bandar Lampung. Thermal comfort at El's Coffee Roastery in Bandar Lampung is considered to meet general standards, but observations, questionnaires, and measurements are still required to ensure its quality. These measurements cover several important aspects, such as air temperature, air circulation, the use of building materials, and other environmental factors that can affect thermal conditions. The ventilation system within the building plays a significant role, as air inflow and outflow are not fully balanced. Indoor activities, including the use of lights and various machines, also generate internal heat that can become trapped if there is inadequate air circulation.

The results of thermal comfort measurements in the El's Coffee Roastery room studied showed that the morning air temperature was at 25.8°C. During the day, the temperature increased to 26.3°C, while in the afternoon it dropped back to 24.3°C. Meanwhile, the questionnaire results showed that 58.75% chose 3 (comfortable), 31.875% chose 4 (very comfortable), 6.875% chose 2 (less comfortable), and 2.5% chose 1 (very uncomfortable). Thus, the majority of respondents considered the thermal conditions in the room to be at a comfortable level. Referring to ASHRAE standards, thermal comfort is a psychological condition when a person feels satisfied with their thermal environment.

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