Passive Architectural Design Solution to Enhance Thermal Comfort using Building Information Modelling (BIM) on Cafe building in Bandung

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Received 1*Maret 2023* **|** *Revised* 15 *Maret 2023* **|** *Accepted* 25 *Maret 2023*

ABSTRAK

Saat ini café menjadi tempat yang digemari oleh masyarakat untuk melakukan pertemuan formal maupun informal. Kenyamanan termal merupakan suatu kondisi dimana seseorang merasa nyaman untuk melakukan suatu kegiatan terutama di dalam ruangan. Penelitian ini bertujuan untuk menganalisis kenyamanan termal pada bangunan kafe "Beda Stories" di Bandung dan dilakukan dengan menganalisis temperatur udara, kelembaban udara, kecepatan udara, serta mengeksplorasi kemungkinan alternatif desain pasif untuk mencapai kenyamanan yang diinginkan. Analisis ini menekankan pada proses penelitian dengan teori-teori yang sudah ada dengan menggunakan identifikasi dan alat ukur independen dengan menggunakan analisis statis. Penelitian ini menggunakan pendekatan penelitian kuantitatif dengan menggunakan data numerik. Hasil penelitian menunjukkan bahwa lingkungan dalam ruangan di kafe Beda Cerita Bandung memiliki kondisi kenyamanan termal yang rendah pada siang hari, karena memiliki situasi kepuasan termal yang berbeda, oleh karena itu dari hasil yang diperoleh, penelitian ini telah melakukan alternatif desain pasif dengan menggunakan Building Information Modelling (BIM) untuk mencapai kondisi kenyamanan dalam ruangan.

Kata kunci: *Cafe, Building Information Modelling (BIM), Kenyamanan Termal*

ABSTRACT

Currently the café is a place favored by the public for both formal and informal meetings. Thermal comfort is a condition where a person feels comfortable to carry out an activity, especially indoors. This study aims to analyze the thermal comfort of "Beda Stories" Cafe Building in Bandung and conducted to analyze air temperature, humidity, air speed.The study also has explored the possibility of designing the passive design alternative to achieved comfort. This analysis emphasizes the research process with already-existing theories using identification and independent measuring tools utilizing static analysis. It applies quantitative research approaches employing numerical data. The results showed that the indoor environment in cafe Beda Cerita Bandung had low thermal comfort conditions during the day, as it also had different thermal satisfactory situations.Therefore, from the results obtained, the study has conducted alternative passive design using Building Information Modeling (BIM) to achieve indoor comfort condition.

Cafe, Building Information Modelling (BIM), Kenyamanan Termal

Keyword: *Cafe, Building Information Modelling (BIM), Thermal Comfort*

1. INTRODUCTION

The culinary sector like cafes in Indonesia especially in Bandung City is developing very fast and popular. Originally, cafés were places to eat and meet, but recently they have come to be chosen as places for socializing and doing homework. As consumers take time to settle into cafes, cafe owners compete for cafes that not only excel in food but also building comfort. Nowadays, many coffee shops are good enough for many consumers, but they don't think about the convenience of these consumers. A cafe or coffee shop is usually a self-service place that offers indoor and outdoor seating for visitors to relax. The cafe does not serve heavy meals as it focuses on light menu items such as cakes, breads, and soups [1].

Thermal comfort has been the subject of research and interest for over a century. This observational data can also be used for further investigation of the environmental factors that affect the thermal comfort of café buildings. Thermal comfort in a building is the state in which people can comfortably work in the space. Thermal comfort is also the state in which occupants feel comfortable with their environment. According to ASHRAE (American Society of Heating Refrigerating and Air Conditioning), thermal comfort is a state of mind that describes satisfaction with a thermal environment [2]. Supported by Fanger that thermal comfort refers to the human metabolic rate which is affected by activity, clothing insulation, air temperature, humidity, wind speed, and light intensity [3]. As a result, important advances have been made that have led to the setting of standards and guidelines for the thermal environment in buildings. Defining a building's acceptable indoor climate is critical to its success, not only for building comfort but also for determining energy usage and ensuring sustainability.

Additionally, thermal comfort has a great influence on the quality of the indoor environment. Many environmental factors affect the health and performance of cafe building residents, including natural and artificial light, ventilation, air quality, noise, temperature and humidity. Design strategies to improve the thermal comfort of buildings vary greatly by climate region. The thermal performance of a building is primarily determined by the strategic design of the building envelope, building orientation, and glazing. These affect the possibilities of daylighting and natural ventilation for cooling or heating the interior spaces of the building. Learning environments should therefore be designed to be more self-sufficient or climate-friendly to promote indoor comfort [4].

Moreover, there is currently not a significant amount of research on the time-varying effectiveness of passive design solutions in responding to future climate change in hot and humid climates. The adoption of passive design solutions might be particularly difficult in hot and humid areas because of the high temperatures and humidity levels. In order to achieve a high building performance, architects might include appropriate passive designs at an early design stage [5].

On the other hand, to improve thermal comfort for building occupants and reduce energy consumption and building temperatures without the use of energy, the passive design adapts to the local climate. It provides a variety of passive design techniques, including choosing the best building material, choosing the best orientation, and planning the building form. Additionally, it draws attention to the necessity of implementing passive cooling design strategies and control principles that can improve a building's thermal efficiency and lower cooling loads [6].

In addition to building form, passive cooling design strategies and control principles can improve a building's thermal efficiency and reduce cooling loads. These strategies include the use of shading devices, such as overhangs and louvers, to block direct sunlight; the use of natural ventilation, such as cross ventilation and stack ventilation, to cool the building; and the use of thermal mass to store heat during the day and release it at night.

Moreover, passive design is a building design approach that utilizes natural energy sources to create comfortable indoor environments without the use of energy-consuming mechanical systems. It involves choosing the right building materials, orientation, and building form to optimize thermal comfort and energy efficiency. Additionally, the use of passive cooling design strategies and control principles can further improve a building's thermal efficiency and reduce cooling loads.

Furthermore, in the construction sector, passive building design is a relatively specialized concept. However, if properly planned, it can benefit the occupant in many aspects, especially their health, financial, and level of comfort inside the residence. The architect's role is made more fascinating by the architectural passive design since aesthetic components are less important than those that affect the building's appropriate level of energy performance [7].

Supported by Chang (2022), passive design should consider the energy-saving effect, evaluation method and economic factors. By optimizing a building's orientation, form, and fenestration, and incorporating other passive design strategies, such as natural ventilation, insulation, and shading, architects and designers can create buildings that are highly energy-efficient and sustainable, while also being cost-effective [8].

In passive building design, the architect's role is focused on maximizing energy efficiency and reducing environmental impact. Aesthetics are important, but they are secondary to the building's energy performance. This means that architects need to be knowledgeable about energy-efficient building design and have a good understanding of building science. They need to consider factors such as site orientation, insulation, windows, and ventilation when designing passive buildings.

Overall, passive building design is an important concept in the construction sector that can benefit occupants in many ways. By reducing energy consumption and improving indoor comfort and air quality, passive buildings can provide a healthier, more affordable, and more comfortable living space for occupants.

Building Information Modeling (BIM) in 2002, was first used to describe the design, construction, and management of virtual facilities. In 1986 Graphisoft introduced the new ArchiCad software as his solution for virtual buildings. It also enables the creation of three-dimensional (3D) project models. At the time, most design work was done using traditional 2D drawings, which had limitations in terms of visualizing the final product and communicating design ideas.

ArchiCAD was one of the first computer-aided design (CAD) software packages to allow architects to create 3D models of their designs. The software made it possible to create a virtual building model with all of the design elements, including walls, floors, roofs, doors, and windows. The model could be viewed and navigated in 3D, giving designers and clients a much clearer understanding of what the building would look like in reality [9].

Building Information Modeling (BIM) has been one of the most important technological advances of the last few years and has been adopted by the design and construction industry. BIM refers to a 3D digital model that contains information about a building's design, construction, and operation. The technology has been adopted across the industry and is now widely used by architects, engineers, contractors, and building owners. BIM has transformed the design and construction industry by improving collaboration, increasing efficiency, enhancing accuracy, promoting sustainability, and improving facility management. The adoption of BIM is expected to continue to grow, and the technology is likely to become an essential part of the design and construction process in the future.[10].

Furthermore, suitable for large and more complex buildings, BIM is used in commercial, residential, educational, healthcare, and many other building types. BIM is a versatile tool that can be used in a wide variety of building types, providing benefits such as collaboration, efficiency, cost-effectiveness, and the ability to manage complex projects. By providing a comprehensive view of the building's design and construction process, BIM enables collaboration, efficiency, and cost-effectiveness, making it an essential tool for modern building design and construction.[11].

This study was conducted on Beda Cerite cafe buildings in the Bandung area. The main purpose of the current research is to evaluate the thermal comfort of the occupants of a naturally ventilated cafe building in Bandung and develop passive design solutions to overcome thermal discomfort in hot weather.

2. METHODOLOGY

The research methodology includes two main phases. The first stage is the evaluation of the thermal comfort of the built environment by investigating external and internal environmental factors. External factors were evaluated through field studies of building geometry, and open space external climate data. The second phase of research explores viable passive design solutions to achieve desired indoor comfort conditions. There are three standards of thermal comfort for temperatures in Indonesia, namely:

1) SNI-14-1993-03 [12] Determining the basic temperature or reference temperature, this study refers to the Indonesian thermal comfort standards, there are three:
    1. Comfortable cool, 20.5°C – 22.8°C, relative humidity 50%-80%.
    2. Optimum comfort 22.8°C – 25.8°C, relative humidity 70%-80%
    3. Almost comfortable 25.8°C – 27.1°C, relative humidity 60%-70%.
2) Lippsmeier (1994) [13] stated that at a temperature of 26°C TE (generally the occupants have started to sweat), a temperature of 26°C TE–30°C TE (the endurance and workability of the occupants begins to decrease), the temperature is 30.5° C TE–35,5°C TE (environmental conditions are starting to become difficult), and temperature 35°C TE–36°C TE (environmental conditions are no longer possible).
3) MENKES NO. 261/MENKES/SK/II/1998 [14] states that a healthy room temperature ranges from 18°C-26°C.

Due to the lack of controls and the unawareness regarding the requirement of minimum comfort levels for buildings, these standards are not normally applied and very few projects include energy and comfort studies during the design and operation stages.

2.1 Study Area

Bandung city is the capital city of the Indonesian province of West Java and located at a distance of approximately 140 kilometers (87 miles) southeast of Jakarta, the capital of Indonesia. Bandung is one of the largest cities in Indonesia which is located at an altitude of ± 768 meters above sea level, with the highest point in the North being above sea level. With a height of 1,060 meters and 675 meters above sea level, the southern part of Bandung city is its lowest point. [15]. The city covers an area of 167,3 km2 and an overall population of 2,444,160. The unique topography of Bandung has both advantages and challenges, shaping the city's climate, culture, and economy.

2.2 Climate of Bandung

The study compared climate data with data from official weather stations owned by the Meteorological, Climate and Geophysical Agency (BMKG) Bandung. As meteoblue web data were still used in this study, the results of the comparison continued to show a good fit [16]. Specific climatic sample data were also collected in the autumn region to ensure accuracy. climate data were obtained in a specific region at 6.93° south latitude and 107.63° east longitude. External data on extreme climatic conditions within a year were also collected. Extreme conditions were taken into account and September and October was the month chosen to provide images of more tricky thermal conditions (Figure 1).

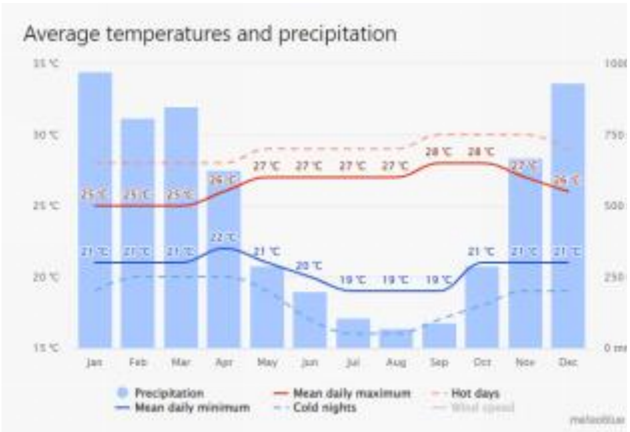


Figure 1. Temperature and precipitation

2.3 An overview of the case study building

Cafe Beda Cerita is located on Jl. Jatihandap No. 138, Mandalamekar, Cimenyan, Bandung Regency, province of Jawa Barat, Indonesia. Indonesia The building area are 440m2, ."Beda Story" Cafe Building consists of 4 floors, namely the 1st floor which functions as a parking area, the 2nd floor serves as a dining and bar area, the 3rd-floor functions as a dining area and there is a prayer room, and the rooftop serves as an area to see the scenery. This building is divided into 3 zoning areas, namely the public zone, the service zone and the private zone. The public zone is divided into a parking area, entrance area, indoor dining area, outdoor dining area, and prayer room. The service zone is the toilet and warehouse, while the private zone is the kitchen area.

Figure 2. Location of Beda Cerita Cafe

Figure 2 shows the cafe area, this cafe is located in a residential area, but some of the residences in this area have changed their function. In some cases, cafes in residential areas can benefit from a sense of community and regular customer base, particularly if they are located in an area with a high population density. However, residential areas can also present unique challenges for cafes. One of these challenges is the fact that the surrounding environment may not be conducive to a commercial business. For example, the area may lack parking spaces, or there may be noise restrictions that limit the cafe's ability to play music or host events.

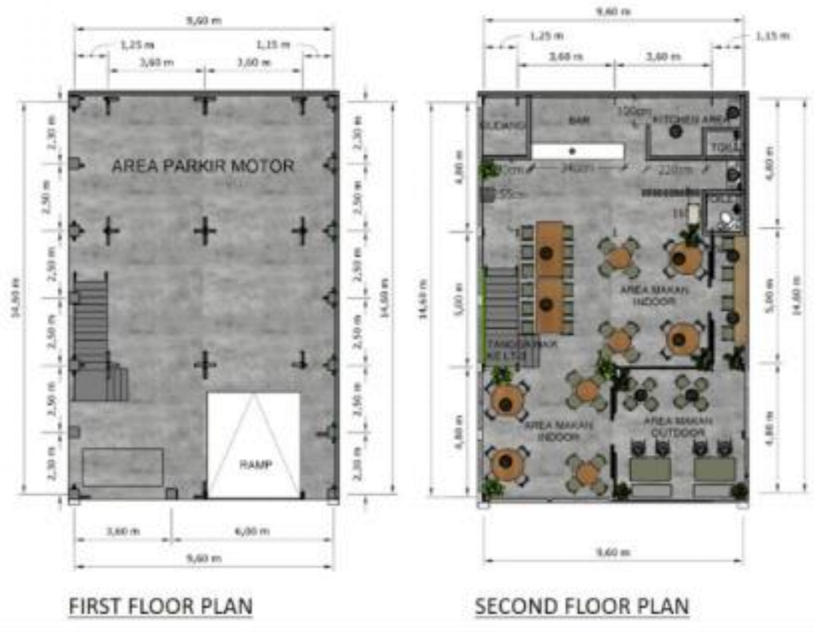


Figure 3. (left) first-floor and (right) second-floor of Beda Cerita Cafe

Figure 3 shows the first floor area is used as a vehicle parking space, while the second floor area is used as the main cafe room. Based on the arrangement of furniture made by the owner, visible on the back side are the warehouse, kitchen, bartender, toilet. The dining area is divided into two types of customers who come, including: group type consisting of 4 chairs and a couple. Meanwhile, based on the zone, that is, the indoor sitting zone and the outdoor sitting zone.

Figure 4. (left) Third floor and (right) roof floor of Beda Cerita Cafe

Figure 4 shows the third floor and the roof floor are floors that are in great demand by visitors. This cafe is a hangout place with a modern minimalist industrial concept, which is Instagramable so it is suitable for visitors who like to take pictures because this place has an interesting spot. At night, it is the right moment with the view of City Light Bandung giving a typical atmosphere of a highland cafe in the city of Bandung.

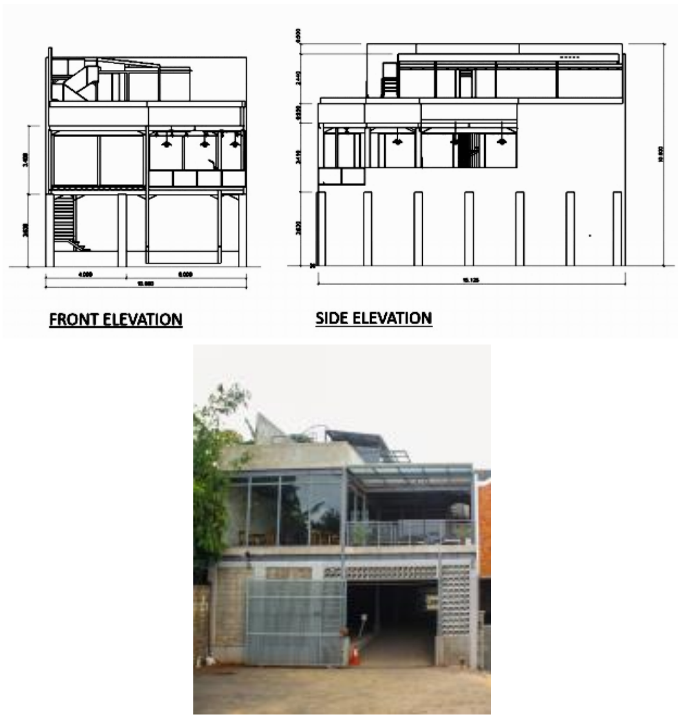


Figure 5. (Up) Front and side elevation (down) facade Cafe Beda Cerita

Figure 5 shows the facade design of the front of this building does not use fins in its openings because there is a terrace area that can guide air movement in the building. This terrace on roof top is part of the Café Beda Cerita building which functions as an outdoor dining area (Figure 6). A terrace area on the rooftop can function as an outdoor dining area, and it can also provide a natural means of ventilation.

The open-air space allows for the circulation of fresh air, which can help to cool the building during hot weather. This can reduce the need for air conditioning and lower the overall energy consumption of the building.

The architects of Café Beda Cerita avoided installing fins in the facade openings by integrating the terrace into the building's ventilation plan. Fins are often used to regulate the amount of sunlight that enters a building and to prevent solar heat gain. However, they can also obstruct airflow and limit natural ventilation. The absence of fins in the openings of the Café Beda Cerita building also allows for more natural light to enter the space. This can improve the overall comfort of the indoor environment and reduce the need for artificial lighting, which can further reduce the building's energy consumption.

The design of the Café Beda Cerita building's facade demonstrates the importance of considering natural ventilation strategies and outdoor spaces in building design. By using the rooftop terrace to guide air movement in the building, the designers were able to create a comfortable and energy-efficient space that also serves as an attractive outdoor dining area.

Figure 6. Roof top floor of Beda Cerita Cafe

3. RESULT AND DISCUSSION

This chapter discussed the results of the research, which were related to the data interpretation, obtained from the measurement outcomes. The Location of the measuring point observed in this study is the space in the Beda Cerita cafe building. Dots are done throughout the room. The following is a table of measurement points for external factors related to thermal comfort.

Figure 7 shows that the measurement points carried out cover the entire space. It is intended that the value of the measurement results can be validated.

Table 1. Zone and Number of measurement points on first floor

Room	Colours	Zone	Number of point
Park		A	10
Enterance		B	2
Pool		C	1
Ramp		D	2

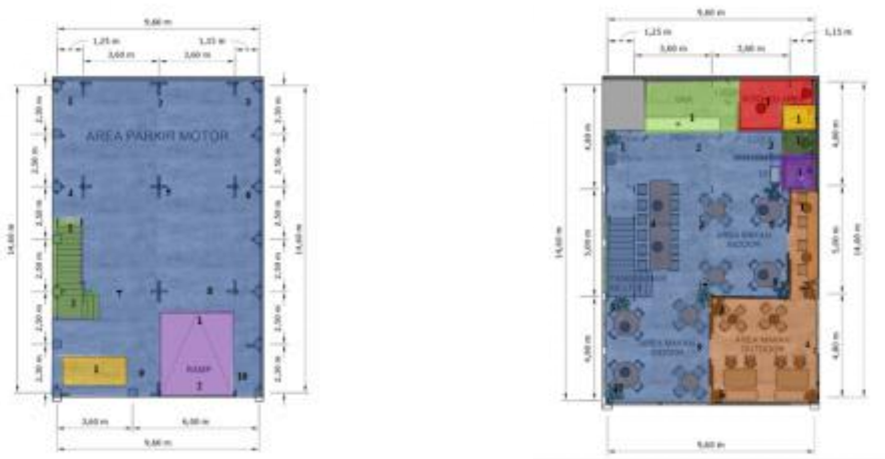


Figure 7.(left) Location of measurement point in first floor and (right) Location of measurement point in second floor

The number of measurement points on the first floor is 15 observation points, while the observation points on the second floor have 20 observation points

Table 2. Zone and Number of measurement points on second floor

Room	Colours	Zone	Number of point
Indoor		A	10
Outdoor		B	5
Man Toilet		C	1
Womern Toilet		D	1
Walkin kloset		E	1
Bar		F	1
Kitchen area		G	1

While the observation points on the second floor have 20 observation points

Table 3. Zone and Number of measurement points on third floor

Room	Colours	Zone	Number of point
Indoor		A	5
Outdoor		B	6
Toilet		C	1
Stair to roof top		D	2
Walkin kloset		E	1
Void Stair		F	1
Pray room		G	1

Table 4. Zone and Number of measurement points on roof top floor

Room	Colours	Zone	Number of point
Roof top		A	4

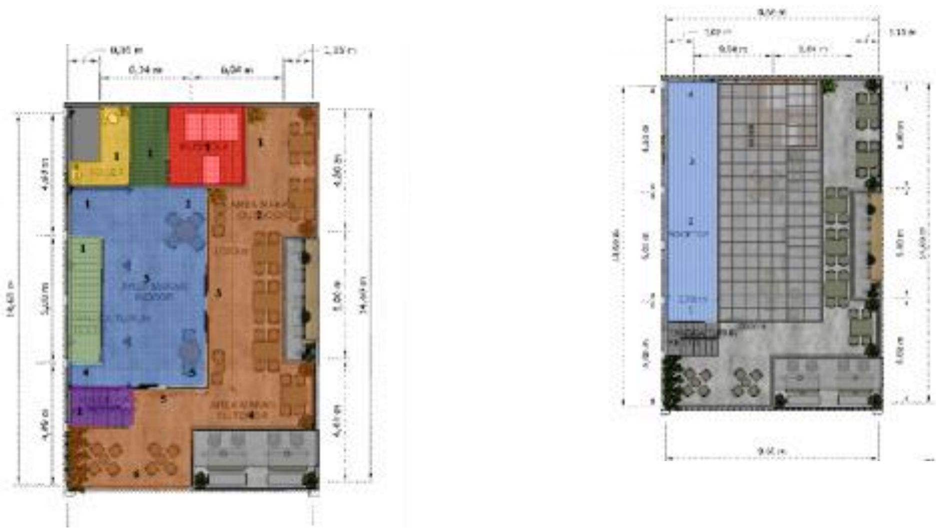


Figure 8.(left) Location of measurement point in third floor and (right) Location of measurement point in roof top floor

Measurement data includes the location of the measuring point, measurement time, and measurement data related to thermal comfort. Figure 9 shows measurements tools to measure wind speed (anemometer), and to measure air temperature and humidity. The measurement time was carried out on 3 days, and carried out at 10.00 –15.00 WIB. This building has quite the same type of opening. Most of the window openings are of the fixed type. Therefore, natural light, ventilation, and air enter the building only through the door. The building has mostly fixed window openings, this can have some implications for the building's comfort and energy efficiency. Fixed window openings do not allow for the same level of natural ventilation as operable windows, which can be opened to allow fresh air to flow into the building. Without operable windows, the only means of ventilation is through the door, which can limit the amount of fresh air that enters the building.

Additionally, the fixed windows may limit the amount of natural light that enters the building. Natural light is important for creating a comfortable and healthy indoor environment, and can also reduce the need for artificial lighting, which can increase energy consumption. However, there are some advantages to using fixed windows in a building as well. They are often more energy-efficient than operable windows, as they do not allow for air leaks and can provide a more secure barrier against the outside elements. Fixed windows can also be less expensive to install and maintain, as they do not require the hardware and mechanisms needed for operable windows.

It can conclude that the use of fixed window openings in the building you mentioned may have some implications for the building's natural ventilation and lighting, as well as its overall energy efficiency. However, there may be other strategies in place to address these issues, such as the use of mechanical ventilation systems or artificial lighting. It is important for designers and building owners to carefully consider the trade-offs of different window and door types in order to create a comfortable and sustainable indoor environment.

Figure 9.(left) Anemometer (right) Air Temperature & Humidity Meter

3.1 Analysis of External Factors Related to Thermal Comfort

Air temperature

The air temperature within comfortable limits (20.8°C < T < 27.1°C). For uncomfortable air temperature (T < 20.8°C or T > 27.1°C). It can conclude that the most uncomfortable areo of air temperature is on the 3rd floor (indoor and outdoor café area) because on the 3rd floor solar heat radiation directly shines into the building and there is no shade in that area, so the air temperature on the 3rd floor is always low, it can be concluded that in three days measurement have uncomfortable temperature.

Humidity

The recommended relative humidity is between 55% – 60%. The humidity is at a comfortable level (40% < RH < 50%) and for public/meeting areas (55% < RH < 60%), while uncomfortable air humidity (RH < 40%, RH > 60%). It can conclude that the most uncomfortable humidity is the 1st floor (parking area) is uncomfortable, due to the lack of air entering the area causing the humidity in that area to be quite high, so it can be concluded from the data we have processed that the humidity

Wind velocity

This wind speed analysis uses data from the processed measurement results and then the data that has been obtained is correlated with the wind speed theory from chapter 2 theory, namely the comfortable limit of (0.6 m/s-1.5 m/s) with a comfortable limit and the air is not comfortable (v<0.6 m/s or v.>1.5 m/s). It can conclude that the most uncomfortable wind velocity is 3rd floor (indoor and outdoor café area).

Table 5. summary of measurement of thermal conditions

Zone	Day	The average of thermal conditions (10 am - 3 pm)		
		Air Temperature (C)	Humidity (%)	Wind Velocity (m/s)
1st Floor	Day 1	26,37 °C	62.5%	2,487m/s
	Day 2	26,88 °C	59,43%.	2,44m/s
	Day 3	28,5°C	60,7%	1,333m/s
2nd Floor	Day 1	27.72	56.25	2,555m/s
	Day 2	28.30	56,15%	2,528m/s
	Day 3	28.89	56,25%	1,773m/s
3rd Floor	Day 1	29.82	53.56	4,175m/s
	Day 2	29.86	48,03%	3,928m/s
	Day 3	30.1	52,78%	3,006 m/s

Zone	Day	The average of thermal conditions (10 am - 3 pm)		
		Air Temperature (C)	Humidity (%)	Wind Velocity (m/s)
Roof Top	Day 1	29.22	45	7,188m/s
	Day 2	29.95	41,5%	7,00m/s
	Day 3	30.52	43,87%	4,5m/s

3.2 Design Recommendations

3.2.1 First Floor (Parking Area)

Air Temperature:

The design recommendation that we got from the survey results and field data measurements is that the 1st floor parking area can be added to a roster of air holes or ventilation on the right and left sides of the wall so that air flow will enter the building evenly and reduce unwanted air temperatures. comfortable when the air temperature at that time increased and also the use of plant barriers in the form of plants or trees outdoors is also a way to reduce solar radiation that enters the building.

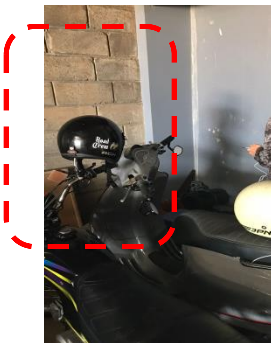
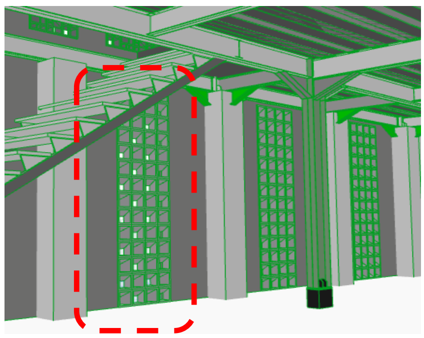
Air Humidity:

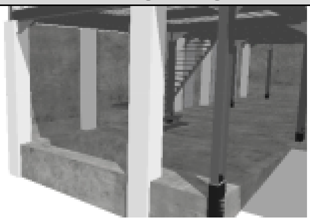
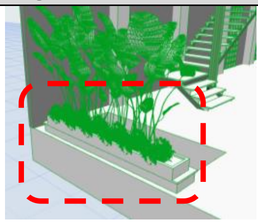
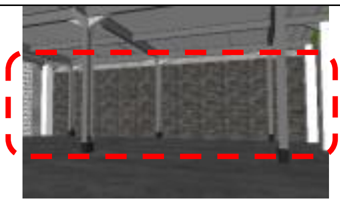
In this parking area the air humidity is too high because in this area the walls are damp due to rain, you can use a layer with a "wall coat" construction consisting of layers with additional waterproof construction, such as aluminum, eternity , or metallic materials. The use of river stone or natural stone on the walls of the 1st floor parking area can be used to reduce the humidity that occurs.

Wind Speed:

Design recommendations that can be made to reduce wind entering this area by adding vegetation to the front of the building because the front area of this building is a contoured vacant land area and there is no vegetation that blocks/reduces incoming wind.

Table 6. Recommended floor plan design 1 (parking area) café "beda cerita"

No	Existing Design	Design Recommendations
1.	 Existing parking area	 Design recommendations in the parking area by adding a roster on the right and left walls, serves to stabilize the air circulation in the parking area thereby reducing uncomfortable air temperatures.

No	Existing Design	Design Recommendations
2.	 Existing parking area (3D modeling image)	 Design recommendations in the parking area to reduce other hot air by using a plant barrier as a barrier to sunlight, apart from an effort to reduce sunlight entering the plant barrier, it can also be used to block or reduce the wind speed that enters the café parking area. This is done to achieve thermal comfort in the building.
3.	 Area parkir eksisting (gambar 3D modeling)	 The design recommendation of the parking area to reduce air humidity is to add natural stone to the rear wall of the parking area.

3.2.2 Second Floor

Air Temperature:

The design recommendation that we got based on the results of the survey and data measurement in the field is that the 2nd floor indoor area can be added with ventilation holes such as the use of a roster in the north in order to make the air flow flowing, because in the indoor area there are only massive openings that facing west. As for the outdoor area on the 2nd floor, you can use roofing materials that can reduce heat such as Polyester or Polyurethane Foam and you can also use ornamental plants with the function of cooling the room, such as rubber plants or types such as mother-in-law's tongue which has a high water content.

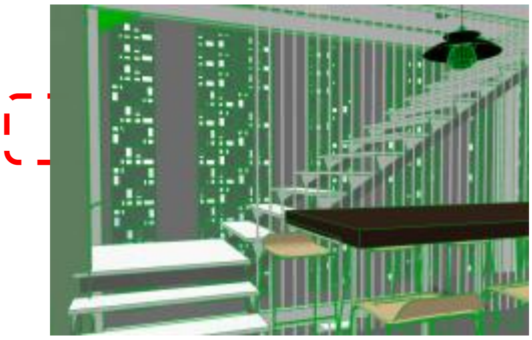
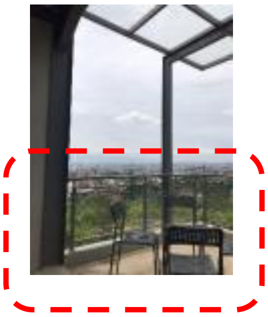
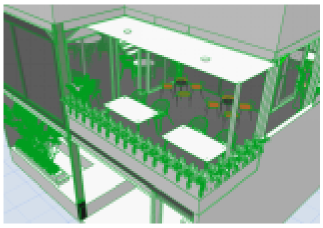
Air Humidity:

Air humidity on the 2nd floor is quite low in the outdoor area because it is an open area that is quite exposed to direct sunlight. As for the indoor area, the humidity level is quite high due to the lack of openings that can reach all indoor areas, so the design recommendations that can be given are the addition of ventilation that can reach areas that were previously not exposed to direct sunlight or only allow air to enter and circulate properly.

Wind Speed:

In the indoor and outdoor areas on the 2nd floor, according to the measurement data, it can be counted up and down because the climate at that time has entered a rainy climate so that design recommendations that can be made to minimize the incoming wind speed are by adding vegetation to filter the incoming air such as spider plant, aglaonema, or bamboo palm.

Table 7. Recommended 2nd-floor plan design (Indoor and Outdoor) café "beda cerita"

No	Existing Design	Design Recommendations
1.	 Existing 2nd floor	 The design recommendation for the indoor area on the 2nd floor by adding a roster to the north of the building, serves to stabilize the air circulation in this area so as to reduce uncomfortable air temperatures.
2.	 Existing outdoor area	 Design recommendations in outdoor areas to reduce other hot air by using plant barriers as a barrier to sunlight, besides that plant barriers can also be used to block or reduce the wind speed that enters the outdoor cafe area is a different story. This effort is made to achieve thermal comfort in the building.

3.2.3.Third 3rd floor

Air Temperature:

The openings on the 3rd floor are adequate, only when it is hot, the sun directly enters the glass of the indoor dining area because the glass is not provided with protection or fins to ward off the sun. Changing the material used as a building cover to a material that can ward off heat and maintain the air temperature in the room.

In the prayer room area, a design recommendation that can be put forward is to replace the prayer room covering material in the form of glass into a brick wall or roster. Because the glass material is translucent and does not block the sun's rays, so people who do worship become less comfortable.

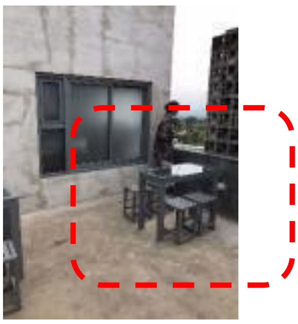
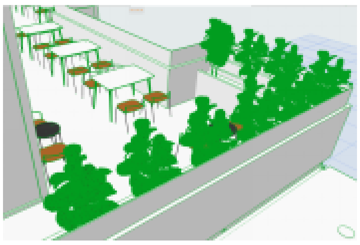
Air Humidity:

The air humidity on the 3rd floor is relatively low so no design changes are needed. The dining area is an open area that is very exposed to direct sunlight. As for the service area, the humidity level is quite high because it is located behind and is closed but this is not a problem.

Wind Speed:

The design recommendation for the wind that blows to the 3rd floor is that adding vegetation to the outdoor areas of a third-floor windy environment is a great way to make it more comfortable for those who visit. Not only can vegetation act as a natural barrier to protect visitors from dust, vehicle fumes, and construction projects that are nearby, but it can also help minimize the wind's intensity. Plants and trees can be especially useful in this regard - they can act as a windbreak, reducing the wind's force and providing a pleasant, shaded environment. Additionally, vegetation can also help to reduce sound pollution and absorb pollutants in the air, making the air quality much better. As a result, visitors will be able to enjoy the wind without having to worry about any of these unpleasant elements. In short, adding vegetation to a third-floor windy environment is an excellent way to make it more comfortable and enjoyable for those who visit. Not only can it provide a windbreak, but it can also help to improve air quality and make the environment much more aesthetically pleasing.

Table 8. Recommended 3rd-floor plan design (Indoor and Outdoor) café "beda cerita"

No	Existing Design	Design Recommendations
1.	 Existing 3rd floor	 The design recommendation is to replace the glass wall with an exposed brick wall so that it still feels industrial.
2.	 Existing prayer room design	 Isometry of the prayer room design. The glass walls of the mosque were replaced by using brick walls that do not absorb heat.
3.	 Existing outdoor dining area design	 Recommended outdoor dining area

CONCLUSION

This paper is a section of a research study conducted in Bandung cafe buildings. This study's primary goal is to investigate and evaluate the effects of building design on the thermal performance of Beda Cerita café buildings in Bandung. It can be concluded that there were several location points in the Beda Cerita café building that do not support thermal comfort in the building. The Beda Cerita café building has a function as a trading building and currently the café is a place that is very popular with the community, especially in the city of Bandung. This refers to the design of the building and the thermal comfort in the building. The design of the new building prioritizes visual aesthetics but does not give a functional meaning. Café visitors generally stay more than 30 minutes to spend their time in the café, so it is necessary to pay attention to the thermal comfort in the building so that visitors can stop comfortably. Therefore, thermal control is needed by paying attention to building materials and types of air openings so that air movement in the room can occur optimally so as to create thermal comfort.

The Beda Cerita café building is an example of a structure that faces challenges in achieving thermal comfort due to its location and design. In this case, the environmental factors of air temperature, humidity, and wind speed have a significant impact on the building's thermal performance. Observations of the building show that there are several areas within the structure where thermal comfort is not optimal, which can negatively impact visitors' experience in the cafe. The designers should have considered the importance of functional requirements, in addition to visual aesthetics, in the building design. This could have resulted in better strategies for managing the internal temperature and air movement within the space.

The use of suitable building materials and types of air openings are important for creating optimal air movement and temperature control. In this case, some of the materials and types of openings in the Beda Cerita café building are not sufficient to handle the weather conditions, which contributes to the challenges of achieving thermal comfort. To improve thermal comfort in the building, design recommendations should be implemented to address the observed issues. These could include using more efficient building materials, implementing better ventilation systems, and optimizing the types of air openings in the building. Further research on environmental and external factors that affect thermal comfort can also help improve the design of future café buildings in similar contexts. Moreover, prioritizing thermal comfort in building design is crucial for ensuring a positive experience for visitors and users of the space.

Observations on thermal comfort in Beda Cerita café building have been based on environmental/external factors that influence it such as air temperature, humidity, and wind speed. From the observations it can be concluded that the air temperature in the cafe environment is quite high, exceeding the comfortable standard (27°C) during the day, the humidity level is relatively low, but the wind speed is quite strong because the building is on a contoured land and there is no tall buildings blocking the surroundings. This will affect human activities in it, especially on holidays where there are more cafe visitors than weekdays so special controls are needed regarding temperature, humidity, and air velocity inside the building. Some materials and types of openings in the building are not sufficient to handle such weather conditions. This observation resulted in a design recommendation for a café building with a different story in order to create thermal comfort in the building. This observational data can also be used for further research on environmental/external factors that affect thermal comfort in Beda Cerita café buildings.

ACKNOWLEDGMENTS

This work was supported by the LP2M Institut Teknologi Nasional Bandung. The authors would like to thank all the students and staff who were involved in data collection.

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