The Effect of Openings on Thermal Comfort of Residential Building: Case study in Bandar Lampung

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Abstract

A good residence must be able to provide comfort, especially thermal comfort, so that it is comfortable to carry out activities in it. This can be done through openings such as windows, ventilation, doors or casing as a way for air to enter and exit. Openings are the main factor that influences the temperature and humidity of the air in a residential house. This research aims to evaluate the thermal comfort conditions of residential homes by analyzing openings, temperature and air humidity. Furthermore, this research also uses the Autodesk Ecotect Analysis 2011 application simulation on the design solutions provided to maximize the wind entering the house. This research uses descriptive and exploratory quantitative methods. Research results from case studies show that openings greatly influence air temperature which ultimately affects the thermal comfort of residential homes. The right shape, dimensions and orientation of window openings can make the air temperature cool and comfortable.

Keywords: Openings, thermal comfort, air temperature, humidity.

1. INTRODUCTION

A good residence must be able to change an uncomfortable outdoor climate into a comfortable indoor climate for its residents (Karyono, 2013). Thermal comfort is the condition of a person feeling comfortable with the temperature of their environment and not feeling too hot or too cold (ASHRAE, 2010). An increase in temperature can indirectly affect the thermal condition of a building, which can cause discomfort in residential buildings and disturb people doing activities inside (Rahmat et al., 2017). One way to passively increase the thermal comfort of a building is through openings such as windows,

ventilation, doors or casings in a building. Openings are the main factor that influences the air and temperature of a building. Openings can be considered good if there is cross ventilation, by making openings on both sides of the room to provide opportunities for optimal flow (Arifah et al., 2017).

Based on SNI 03-6572-2001, rooms must have ventilation of 5% of the floor area and windows of 10% of the floor area (Badan Standar Nasional Indonesia, 2001). In this type of tropical and humid climate, it is hoped that the opening design can respond by optimizing natural ventilation and minimizing solar heat entering the building to save on the use of air conditioning machines (Khedari et al., 1997); (Arminda & Kamaruddin, 2021). One way to obtain thermal comfort in tropical buildings is to increase the room wind speed with special designs in the openings (Arifah et al., 2017). Another important factor that can influence thermal comfort is air temperature (Arifin & Hidayat, 2018). Based on SNI 03-6390-2011, it is stated that in fulfilling the thermal comfort of building users, it is divided into highland and lowland areas. For highland or mountainous areas, the average maximum air temperature is around 28°C DB and 24°C WB or the average monthly temperature is 23°C. Meanwhile, for lowland areas or coastal areas, the average maximum air temperature is around 34°C DB and 28° WB or an average monthly temperature of 28° (SNI, 2010).

This research aims to evaluate the thermal conditions of residential homes and see how openings affect thermal comfort. The case study carried out was in a building with wide openings in the front area and not exposed to direct sunlight. This research is expected to provide an illustration of how openings influence the achievement of thermal comfort in residential buildings.

2. METHOD

The primary data of physical building condition obtained from direct observations in the field by collecting the necessary data from case studies and then analyzing them to determine conditions. Data regarding location, space, building dimensions, as well as temperature and humidity. Next, the data obtained is used as parameters in simulations using digital modeling or simulations using the *Autodesk Ecotect Analysis 2011* application. The object is a one-story residential house with a building area of ±70 m^2 which is located in the hot and humid climate in Bandar Lampung City (Figure 1).

In this research, a descriptive and exploratory quantitative method approach was applied. Steps in measuring and collecting data, by measuring room dimensions and ceiling height using a meter, as well as room temperature and humidity using the *HTC-2 Thermometer Hygrometer*. Time for taking temperature and humidity measurement data on 15 – 16 December 2021 using 1-hour intervals between 09.00 am and 04.00 pm.

After getting the measurement results, a house plan and appropriate openings can be created using the *Autodesk AutoCAD 2021* application. This can also be used to create a building simulation to determine the temperature and humidity in the room, following the dimensions on the plan using the *Autodesk Ecotect Analysis 2011* application.

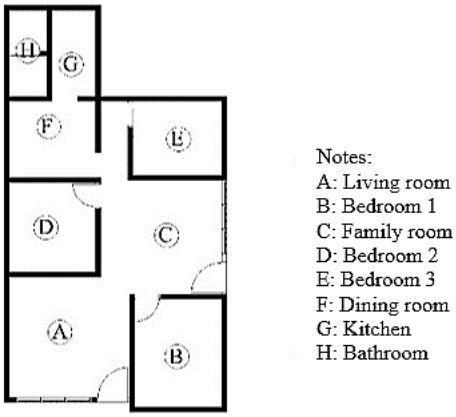


Figure 1. Floor Plan of Case Study

3. RESULTS

a. Room dimension

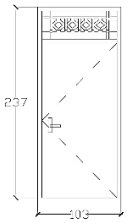
In table 1, the measurement results show that there are 5 rooms that require thermal comfort.

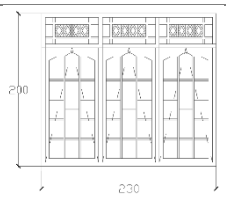
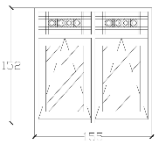
Table 1. Room Dimension

No	Room	Dimension (m)	Total area (m^2)
1	Living room	4 x 3.85	15.4
2	Family room	3.64 x 3.87	14.08
3	Bedroom 1	2.82 x 3.48	9.81
4	Bedroom 2	2.9 x 2.8	8.12
5	Bedroom 3	2.82 x 2.5	7.05

b. Opening dimension

Table 2. Dimension and type of openings

Opening type	Figure
Door 1 2 Unit This is the main door with ventilation above it, located in the living room and family room	
Door 2 2 Unit Doors with ventilation used for bedrooms 1 and 2	

Door 3 1 unit Sliding door without ventilation	
Window 1 2 Unit It is a window with ventilation located in the living room and family room.	
Window 2 1 Unit Located at bedroom 1	
Ventilation 1 Unit Located at bedroom 2	

Based on the size and shape of the openings in the house, the windows and doors are quite large in the front area so that in the living room and room 1, the air flow in the room is quite good. However, in the family room, placing the openings on the side which is rarely exposed to gusts of wind, makes the air temperature feel hotter and the humidity quite high. For rooms 2 and 3, the air that enters only rotates and gets trapped, making the room feel crowded, as can be seen in tables 3, 4, 5, 6.

Table 3. Air temperature on 15 December 2021

Time	Air temperature (°C) Room				
	1	2	3	4	5
09:00	26	26.4	26	26.1	26.2
10:00	27.5	27.5	27.5	27.9	27
11:00	28.3	28.6	28.9	31	30.9
12:00	29.1	28.9	29	28.9	29
13:00	31.2	31	31.2	31.5	31.5
14:00	29.5	29.1	29.2	29.5	29.1
15:00	29.2	29.3	30	30.3	31
16:00	29.7	29.4	31.7	32.1	32.3

Table 4. Air temperature on 16 December 2021

Time	Air temperature (°C)				
	Room				
	1	2	3	4	5
09:00	28.4	26.4	26	26.1	26.2
10:00	29.3	29.3	29.2	29.4	29.6
11:00	28.9	31.3	30.5	30.1	29.2
12:00	28.4	27.7	28.9	29.2	30.4
13:00	27.5	31	29.3	31.2	31.3
14:00	29.5	29.1	30.2	30.5	29.8
15:00	30.2	31.2	31.4	31.3	31.2
16:00	29.7	30.4	30.5	32.5	32

Table 5. Humidity on 15 December 2021

Time	Humidity (%)				
	Room				
	1	2	3	4	5
09:00	94	93	93	94	93
10:00	94	90	90	94	94
11:00	84	84	89	87	95
12:00	87	89	87	89	90
13:00	89	87	89	84	90
14:00	83	87	84	87	85
15:00	84	87	87	87	89
16:00	85	86	87	87	89

Table 6. Humidity on 16 December 2021

Time	Humidity (%)				
	Room				
	1	2	3	4	5
09:00	93	93	90	94	93
10:00	94	90	94	94	94
11:00	89	89	89	91	89
12:00	86	86	87	86	86
13:00	86	87	86	86	86
14:00	87	85	87	87	87
15:00	87	86	89	87	89
16:00	88	86	88	87	89

Notes:
1 : Ruang Tamu
2 : Ruang Keluarga
3 : Kamar
4 : Kamar 2
5 : Kamar 3

Based on the results of temperature and humidity measurements in each room, a graph of the average air temperature and humidity is obtained.

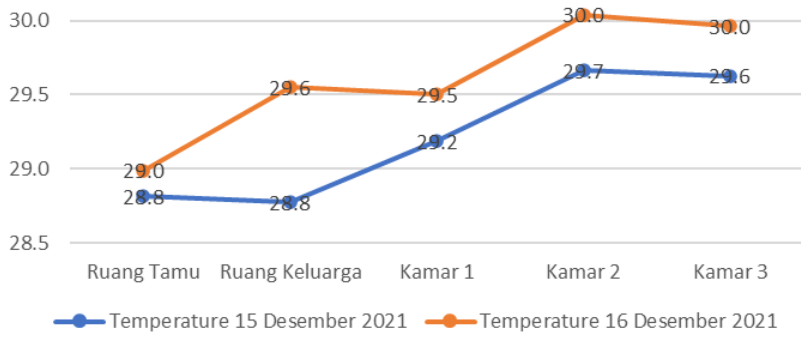


Figure 2. Average Temperature Daily

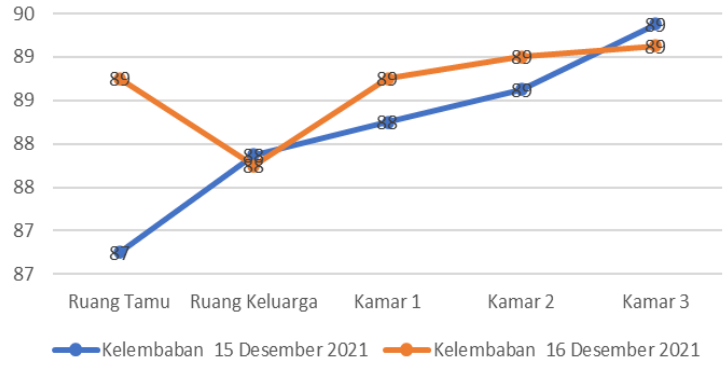


Figure 2. Average Humidity Daily

4. DISCUSSIONS

After carrying out measurements and collecting data, it was found that:

a) Room 1 has good cross openings between the windows at the front and the doors at the back, so that circulation can be optimal in the room.
b) Room 2 does not have a cross between the door and ventilation, but because of the small size of the ventilation at the top of the wall, this causes the temperature in the room to become hot and the humidity level to be quite high.
c) Room 3 only has a door opening without any openings that function to release trapped air, thus causing the temperature in the room to become hot and the humidity quite high.

Based on the measurements that have been carried out, the results obtained are that each room has a fairly high temperature and humidity with an average: the living room has an air temperature of 28.9°C and humidity of 88%, the family room has an air temperature of 29.2°C and humidity of 88%, room 1 has an air temperature of 29.3°C and humidity of 89%, room 2 has an air temperature of 29.9°C and humidity of 89%, room 3 has an air temperature of 29.8°C and humidity of 89%.

Thus, thermal comfort in residential homes is less comfortable due to high air temperature and room humidity (Mohd Arshard et al., 2022), this comes from less-than-optimal air circulation entering the interior because the dimensions of the openings do not meet the standard of 20% of the wall area and the direction of the window openings. There are several solutions that can be used to improve thermal comfort in residential spaces:

a) Provide sliding window openings in rooms 2 and 3, so that the wind can come in and out optimally and make the temperature in the room comfortable.

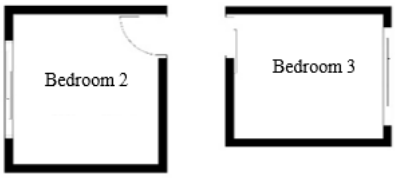


Figure 4. Room 2 and 3 window design solutions

b) Replace window opening 1, which was originally an awning, into a window with a side opening, to maximize wind entering the house and make the air temperature cooler.

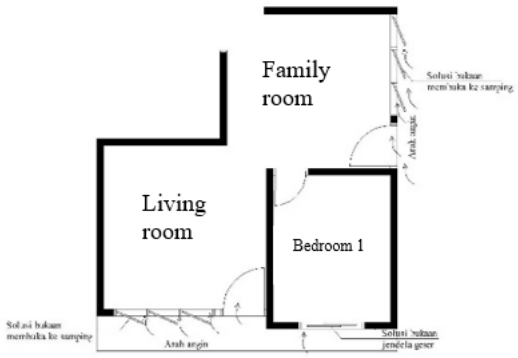


Figure 5. Design solution for window 1 and room

To find out whether there are differences in air temperature between the existing building temperature and new design solution, simulation using the Autodesk Ecotect Analysis 2011 was carried on (Figure 6).

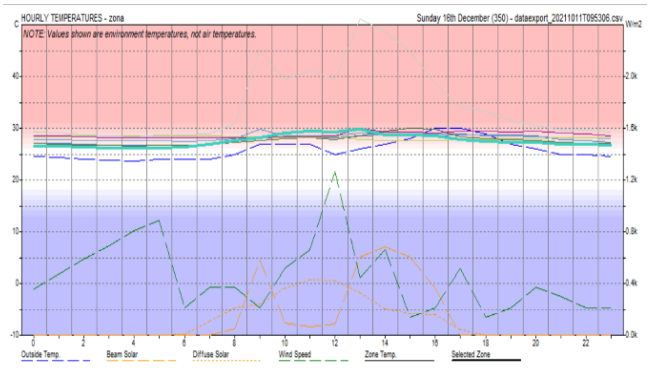


Figure 6. Autodesk Ecotect Analysis 2011 Simulation

The results of the analysis using the Autodesk Ecotect Analysis 2011 simulation show that the air temperature is marked with a blue dotted line with an average of 27.13°C or can be seen in table 8, the air temperature results at 1-hour intervals at 09.00 – 16.00 WIB. After trying to simulate the design solution in Autodesk Ecotect Analysis 2011, the results showed that the average air temperature in existing conditions, namely 29.4°C, had decreased by 2.27°C to 27.13°C.

Table 8. Autodesk Ecotect Analysis 2011 Simulation

Time	Air temperature (°C)
09:00	27
10:00	23
11:00	23
12:00	25
13:00	26
14:00	27
15:00	28
16:00	30
Average	27.13

5. CONCLUSIONS

Based on the simulation results using the Autodesk Ecotect Analysis 2011 application, openings greatly influence indoor comfort. The correct shape, dimensions and orientation of window openings can make the air temperature cool and comfortable. In the case study of the Ajeng boarding house, the lack of window openings in the room area and the inappropriate direction of the window openings meant that air could not flow optimally. The placement design solution, new opening dimensions are expected to make every room in the house more comfortable.

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