Wind Movement Comparison Between Student Dormitory 2 and 3 ITERA and The Correlation Toward its Indoor Thermal Comfort

Rendy Perdana Khidmat1, M.Donny Koerniawan2, Suhendri1

1Department of Architecture, Sumatera Institute of Technology, Lampung, Indonesia
2Department of Architecture, Bandung Institute of Technology, Ganesha street no 10, Bandung, Indonesia

Abstract. Student dormitory is a semi-private building that designated to occupies large number of habitats. This type of building mostly designated in simple type of vertical housing. In the context of utilization, dormitory surely requires indoor thermal comfort yet in the same way it requires the energy efficiency as well. Building in a tropical climate country is expected to be adequate to adopt a potential from its surrounding in order to switch air conditioner and gain efficiency in energy consume. One of its key factors is wind. This paper tries to describe and investigate wind movement that works on two different type of student dormitory in Sumatera Institute of Technology. The distinct difference between two blocks is one of the tower block utilizes void meanwhile the other are not. This research is conducted by using Computational Fluid Dynamic (CFD) based software. This study is expected to provide an overview of the wind movement and its effect on air temperature and its correlation to the indoor thermal comfort in both buildings.

1. Introduction

In recent years, the field research of thermal comfort has attracted the attention of many researchers around the world[1]. Student dormitories or other vertical flat always requires the thermal comfort of the inhabitants. Some of these are buildings constructed by the government, many of these buildings do not use air conditioning and only utilize existing local micro climate around the site. Some standard government building designs typically adopt a local climate approach with natural ventilated building to conserve energy.

The thermal comfort in the building depends on the local microclimate. To start a plan in designing buildings, it is necessary to examine the detailed local climatic conditions especially for humid tropics [2], some of these factors are sun, wind, rainfall, and humidity.

In 2016 and 2017 Sumatera Institute of Technology (ITERA) has a grant for three dormitories from the government. The buildings designed with two different type. The differences in these two buildings is the utilization of void in one of the buildings. This paper will simulate the movement of wind by using Autodesk CFD software. It aims to see whether there is a difference in the wind movement will affective thermal comfort in both buildings.

The metodology conducted on this research is quantitative and exploration through simulation [3].

2. Computational Fluid Dynamic (CFD)

CFDs are branches of fluid mechanics. Initially CFDs were used for the aerospace industry and turbo engines. But today many CFDs are also used for wind driven rain, pedestrian wind comfort, surface heat transfer and urban air pollution [4].

CFD (Computational Fluid Dynamics) is a method that can be used for simulation of the indoor climate in buildings. With this technique the climate inside the whole building can be illustrated with a detailed picture of possible problems that may occur [5].

This research tries to examine the wind-flow around the two dormitories using Autodesk CFD.
3. Thermal Comfort

As it is proven that buildings account for 40% of the global energy consumption and contribute over 30% of the CO2 emission and the large proportion of this energy is used for thermal comfort [6], the design consideration is shifted to maximizing the local microclimate potential to reaching thermal comfort for the occupants.

According to ANSI/ASHRAE Standard 55-2010, thermal comfort is defined as “that condition of mind which expresses satisfaction with the thermal environment and is assessed by subjective evaluation.” Also known as human comfort, thermal comfort is the occupants’ satisfaction with the surrounding thermal conditions and is essential to consider when designing a structure that will be occupied by people.

There is some factors that can be considered related to the human comfort. The factors are include:

- Metabolic rate (met): The energy generated from the human body
- Clothing insulation: the amount of thermal insulation the person is wearing
- Air temperature: temperature of the air surrounding the occupants
- Radiant temperature: The weighted average of all the temperatures from surfaces surrounding an occupant
- Air velocity: Rate of air movement given distance over time
- Relative humidity: Percentage of water vapor in the air

Human thermal comfort is measured by the Predicted Mean Vote (PMV). PMV is presented in sensation scale between -3 which represent cold to +3 which represent hot. When the recommended scale that can be called as comfort is a range between -0.5 to +0.5.

4. Project Description

ITERA student dormitories number 2 and 3 were built in 2016 and 2017. Each building consists of 5 floors and 92 rooms. Dormitory 2 has 60 meters long and 19.2 meters wide. This building has a void surrounded by a 1.4 meter wide corridor. It has three main accesses the ladder in the center and two emergencies stairs on each side. On both sides of this building there is a void with areas of 106 m². In this study the sample taken is typical floors 2 to 4. Where the ventilation contained in each room is a window on both sides that faces the outside of the building and toward the corridor. There is also a public pantry on each floor.

![Figure 1. Dormitory 2](image-url)
While the dormitory 3, built 2017 has no void in the center of the building. The building has a length of 64 meter and 12.75 meter wide. On each floor there are typically 22 rooms that are not equipped with a balcony. Room with area of 17.3 meter square has windows overlooking the corridor only. There is also a public sunroom on each floor. The corridor in this building has a width of 1.8 m.

This building has three main accesses, the ladder in the middle and two emergency stairs on each side. Both dormitories built with regular materials such as finished brick wall, aluminium in windows and door frames and ceramic tiles for flooring and gypsum board for its ceiling.
5. Bandar Lampung Climate
Bandar Lampung city is classified in zone that has a humid climate all over the year. Rainfall ranges between 2.257 - 2.454 mm/year. With air humidity ranged from 60% - 85% and average temperature ranges from 23 °C -37 °C. Wind velocity ranged from 2.78 - 3.80 knots with dominant direction from the west in November, from the north in March, from the east in June and from the south in September. And it located in latitude 700 mdpl.

6. Simulation
The simulation is conducted by using Autodesk Revit architecture software for modelling and Autodesk CFD to simulate wind movement that works on both buildings. The climatic data included for the analysis recipes in this simulation is microclimate data of Bandar Lampung city and the physical properties of the materials used in the two dormitory as well.

Firstly the geometry is constructed in revit according to actual buildings yet with less components. The used components is limited to the floor, ceiling, walls and the openings including the void in dormitory 2. This aims to get the shorter calculation process in simulation.

![Figure 5. Dormitory 2 geometry](image1)

![Figure 6. Dormitory 3 geometry](image2)

After the geometry is constructed, the next step is setting materials. The materials used in this simulation is regular materials that set to be similar for both buildings. Granite tiles is used for flooring and concrete is used for the walls. The ceiling again use the concrete as materials assuming to be an open exposed construction. Besid the physical materials, the void on both building is filled by fluid air materials with fixed materials properties.

![Figure 7. Dormitory 2 (a) inlet and (b) outlet](image3)

The next step is to set the inlet and outlet of the wind flow. Both building is set to get the force in same direction that is from the south west direction with velocity of 5 cm/s and temperature 27 °C. And the outlet is located in the opposite direction, north east. The outlet is set to have a 0 Pa pressure.
Figure 8. Dormitory 3 (a) inlet and (b) outlet

The simulation running in different iteration. The simulation for dormitory 2 is stopped in iteration 500 while the dormitory 3 is stopped in iteration 371.

Figure 9. (a) (b) Iteration graphic of the two dormitories

Figure 10. Wind velocity in dormitory 2
The results show that there is two different wind flow works on the two dormitories. In the dormitory 2, wind flow is locally accumulated around the void. The wind and temperature are not well-distributed to the student rooms. And the wind entering through the corridor opening is affected by the force that coming from the void. The result can be investigated in picture 10 and 11.

While the temperature that affected by the wind flow is works identicaly with the wind distribution. Here we can see that in dormitory 2 there is very hot area in the opposite side of the inlet while in the
dormitory 3 the temperature in the outlet side seems tend to be reasonable. The distribution can be investigated through picture 12 and 13. Picture 14 and 15 shows that the PMV distribution on the map is affected by the temperature as well. From the two picture below we can see that in dormitory 2 the distribution is concentrated in the void while in the dormitory 3 the better condition is spread around the corridor.

![Figure 14. PMV in dormitory 2](image1)

![Figure 15. PMV in dormitory 3](image2)

7. Conclusions
This paper might not shows the real world condition yet it investigates the results through the simulation. This paper tries to compare the wind flow works in the two buildings. The different is lies on the used of void. From the results we can see that the wind flow works in dormitory 3 is shows better distribution compared to the dormitory 2. It can be conclude that the void does not fully affects the expected better wind distribution. The PMV also distributed according to the temperature carries by the wind. The dormitory 3 shows the preferable reason in PMV distribution rather than the dormitory 2.

8. Acknowledgments
This research is part of the “Penelitian Hibah Mandiri” funded by the Institute Technology of Sumatera and dedicated to the Architecture Department of Institute Technology of Sumatera.

9. References
[1] Rupp.R.F., Vasquez.N.G., Lamberts.R., 2015. A review of Human thermal comfort in the built environment. A field Study. Energy and Buildings, volume 105, p. 178-205
[2] Lippsmeier 1980. Tropenbau Building in the Tropics. Translated by Syahmir Nasution. Erlangga. Jakarta.
[3] Suhendri., Koerniawan.D, 2016. Investigasi Ventilasi Gaya Angin Rumah Tradisional Indonesia
dengan Simulasi CFD. Prosiding Temu Ilmiah IPLBI.

[4] Kaijima, S., Bouffanas, R., Willcox, K., 2013. Computational Fluid Dynamics for Architectural Design. Proceedings of the 18th international conference of the association of Computer-Aided Architectural Design Research in Asia CAADRIA 2013. CAADRIA. Hong kong.

[5] Risberg, D. 2015. CFD Simulation of Indoor Climate in Low Energy Buildings. A Thesis. P. 1

[6] Yang, L., Yan, H., Lam, J., 2014 Thermal comfort and building energy consumption implication-A review. A field study. Applied energy, volume 115, p. 164-173.