A study of natural ventilation optimization in apartment living room in Pademangan, North Jakarta

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Abstract. Pademangan Barat is one of the most populous sub-districts in Pademangan with a density of 26,127 people/km². The demand for good housing is high and the slump area is growth everywhere in this area. Vertical housing as low consume energy building are the best solution for bad social settlement today. Therefore, this studiesaimed to find out whether vertical housing with natural ventilation can be built in this area. Through analyse of its local climate, spatial planning, and simulations of building orientation, size and position of windows, it is expected to find which orientation is the best for best wind flows annually, the best windows position, type and size, and the best unit plan. This research conduct with computer simulation using x-flows.

Keywords: Natural ventilation, vertical housing, Jakarta

1. Introduction

Referring to the program planned by the United Nations on Sustainable Development Goals, or point 11b, the objective of sustainable development becomes the background of this research on apartments with natural ventilation. The target in point 11.b is about cities and settlements that adopt and implement policies towards inclusion, resource efficiency, mitigation and adaptation to climate change, and disaster resilience. Of the several points that were targeted for sustainable development in point 11.b, the target taken by the author is regarding mitigation and adaptation to climate change. The location chosen for this research is in Pademangan.

Pademangan is located North Jakarta with an area of 11.92 km² which consists of three villages. One of the villages is PademanganBarat that has an area of 3.53 km² with a population of 2018 of 92,320 inhabitants. This area is the most populous sub-district in Pademangan with a population density of 26,127 people / km². [1]

The population density is very high compare to itsland area. It creates many area of slums. The biggest slum settlements are located in hamlet of 07, 10, and 13 in west area. Vertical housing was believed to be one of the solutions. However, based on data obtained from the North Jakarta Central Statistics Agency, there only one vertical housing in this area that is also provided only for middle income society. More vertical housing needs to be built in the area to counter the growth of slums.

As one of the strategy, to reduce apartment rent, the building should be comfort enough without the use of air conditioning system. So the role of natural ventilation should be increased in order to create better room temperature without consume more energy.
The importance of air circulation in a building in addition to exchanging \( \text{O}_2 \) and \( \text{CO}_2 \) in the room, but this also has an important impact on removing odour, humidity, and heat particles in the room. Poor air quality with high levels of \( \text{CO}_2 \) in the room can reduce the performance of its inhabitants and create health problems such as sleepy. By maximizing the wind coming in through ventilation, it can flow fresh air into the room for air exchange, remove odour particles, remove moisture and heat in the room. According to Norbert Lechner, ventilation design in the form of a window that is designed optimally will reduce energy consumption and \( \text{CO}_2 \) production up to 40\% [7].

2. Methodology
2.1. The method of study
As mentioned above that the goal of this study is to find the best building orientation and the optimal wind speed that enter the building through natural ventilation, as well as the windows performance, so some experiment of building orientation, building plan, window size and its natural ventilation will be create and furthermore, many simulation is ran using Autodesk flows design software. The Primary data were obtained from simulations using the Sketchup and Autodesk Flow Design software to determine the building orientation and room configuration of the apartment unit as well as optimal openings for natural ventilation. Meanwhile, data on the theory of natural ventilation were obtained from several books which is, Heating, Cooling, Lighting: Sustainable Design Methods for Architects; Designing Spaces for Natural Ventilation; and Advances in Passive Cooling.

2.2. The case study
The chosen location is located in West Pademangan, North Jakarta (Figure 1) This site can be accessed via two roads Jl. Gunung Sahari and Jl. Hidup Baru. Pademangan Barat is one of the most populous area with a population density of 26,127 people/km\(^2\).

![Figure 1](image-url)

**Figure 1.** (a) Surrounding area, (b) Site location

Pademangan sub-district is located in an area with a tropical climate that has two weather conditions, dry and rainy weather. Rainfall in the rainy season in October to June is 101-90 mm (Figure 2). The highest rainfall of 402 mm occurred in January. In the dry season from July to September the rainfall is quite low at 58-64 mm. The average temperature in Jakarta is 27.6 °C. The highest temperature occurs in October with a temperature of 28.3 °C. On the other hand, the lowest temperature occurred in January with a temperature of 26.8 °C. The average air pressure is 1,101.83 mbar. Meanwhile, the average wind speed in the site is 1.66 m/sat 10 m above ground. On average per year, wind direction comes from the east, from April to November [6].
3. Result and Discussion

3.1. Building Orientation Analysis

Based on the data regarding the wind conditions and to respond wind movement pattern on the site, therefore the shape of the building mass used is form I and L with an east-west orientation. Building typology with L can change and maximize winds from northward in order to flow between the two building masses. So that in this area it will be more optimal if the inlet openings are placed on that side.

Based on the results of the analysis (Figure 3), the inlet openings will optimally flow air into the building if they are placed on the side of the building facing the wind, on the south side of the building. On the west side of building I and the north side of building L it is also possible to put inlet openings because these sides are directly facing the wind. The inlet opening will act as a route for air to enter the building.

Then, for outlet openings it will be more optimal if they are placed on the side of the building that is not directly facing the wind or an area that is a shadow of the wind. Therefore, for the building mass I on the north and east side and the building mass L on the south and east sides which are the wind shadow area, outlet openings can be placed. Later, the outlet openings will act as a route for the wind to escape from the building.

3.2. Room configuration plan - Corridor Type Analysis

Based on the theory discussed in the book Heating, Cooling and Lighting regarding the Basic Principles of Air Flow Through Buildings, an open-plan type is the most effective for natural ventilation systems because there are no partitions that prevent the wind from entering and flowing in the building. A double-loaded corridor type building makes it almost impossible to use the cross-ventilation system [7].

![Figure 2. Location and its climate, (b) Wind rose.](image)

![Figure 3. Wind flow at (a) 2nd, (b) 4th, (c) 8th floor](image)
Single-loaded corridor type buildings are the most effective choice for cross-ventilation applications. Therefore, to maximize natural ventilation in the building, the type of corridor used in this apartment is single-loaded with the consideration of placing openings on the side of the unit facing the corridor (Figures 4-5).

![Figure 4. Corridor Type (Source: Heating, Cooling and Lighting, 2015)](image)

3.3. Opening Type Analysis
Based on the book *Sun, Wind, and Lighting*, the maximum opening for flowing air into the room is the openings on both sides of the room that are opposite to the ratio of 1/3 of the opening to the wall [8]. Therefore, the openings in the apartment unit, apart from being placed on the side facing the balcony area, also need to be placed on the side facing the corridor area to drain the wind properly with a cross-ventilation system (Figure 6).

![Figure 5. Wind flow simulation in 8th floor](image)

![Figure 6. Window Ratio (Source: Sun, Wind, and Lighting, 2013)](image)

The recommended wind speed according to the book *Teori dan Acuan Kenyamanan Termis dalam Arsitektur* is 1.5 m/s. The average air velocity at the site is 1.66 m/s. To achieve the ideal indoor air velocity, an opening is needed that can drain about 90% of the air from outside to the room. Based on the data above, the author tries to make a living room simulation for a young family type 3 with a family of three people with an area of 18.4 m². This simulation uses three types of openings, awning, casement, and jalousie (Table 1).
### Table 1. Opening Types Analysis

| Opening Types | Wind Speed | Analysis |
|---------------|------------|----------|
| Casement      | ± 1.49 m/s | Casement type drains 90% of the wind from the outdoors. The wind from outside flows evenly over almost the entire room. |
| Awning        | ± 1.24 m/s | Awning type can drain 75% of the wind from the outside. The wind speed is higher near the opening, on the far side of the opening gets almost no wind. |
| Jalousie      | ± 0.83 m/s | The slope of the angle and the density of the grating affect the percentage of the incoming wind. For a slope of 30° in this simulation, the incoming wind is around 50%. |
Based on the simulation and analysis results from the application of the three types of openings, casement, awning, and jalousie, it can be concluded that the most ideal type to flow air into the building is the casement type. This type is optimal because it can evenly flow the wind into the room. In addition, based on simulation, the wind speed in the room is closest to the standard of comfort with a speed of 1.49 m/s.

4. Concluding Remarks

From the results of simulation, it can be concluded that several aspects can be applied to the design of the apartment to maximize the air entering the building. Based on the analysis of the simulation using Autodesk Flow Design software, the conclusions are:

- The optimal building orientation and typology for natural ventilation are building masses with L-shaped in the northwest-east orientation and I-shaped building mass with west-east orientation.
- The optimal corridor type for natural ventilation is the single-loaded type.
- The most optimal type of opening in the family room is the casement type that can flow 90% of the wind from the outside. Thus, the wind speed in the room can approach the speed according to the standard of comfort, 1.49 m/s.

References

[1] BPS Kota Administrasi Jakarta Utara. (2019). *KecamatanPademanganDalamAngka*. Jakarta: BPS Kota Administrasi Jakarta Utara.
[2] Passe, U., & Battaglia, F. (2015). *Designing Spaces for Natural Ventilation*. New York: Routledge.
[3] Santamouris, M. (2007). *Advances in Passive Cooling*. London: Earthscan.
[4] JAKARTA CLIMATE. (n.d.). Retrieved from CLIMATE-DATA.ORG: https://en.climate-data.org/asia/indonesia/jakarta-special-capital-region/jakarta-714756/
[5] Global Wind Atlas. (n.d.). Retrieved from https://globalwindatlas.info/
[6] Average Weather in Jakarta. (n.d.). Retrieved from Weather Spark: https://weatherspark.com/y/116847/Average-Weather-in-Jakarta-Indonesia-Year-Round
[7] Lechner, N. (2015). *Heating, Cooling, Lighting: Sustainable Design Methods for Architects 4*th Edition. Hoboken, New Jersey: John Wiley & Sons, Inc.
[8] Mark DeKay, G. Z. (2013). *Sun, Wind, and Light: Architectural Design Strategies*. John Wiley & Sons.