Research Article

Analysis of Opening Positions, Layout Arrangements, Wind Movement Within Middle Class Urban Resident in East Java

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Abstract.

Global warming has impacted many regions and sectors around the world, including Indonesia. Unfortunately, Indonesia happens to be the third largest emitter of carbon in the world according to several reports, such as the NDC 2016 report, the 2019 Carbon Brief, and the 2020 UNEP Emission Gap Report. This has resulted in extreme weather in Indonesia such as longer monsoon seasons in Sumatra and Borneo temperatures in the regions of Java and Nusa Tenggara. There have been infrastructural developments made which aim to reduce the adverse effects caused by climate change, namely through studies and the redesigning of residential properties. The main purpose of designing these homes is to acclimate properly against these challenges. This is done in the form of thermal regulation by utilizing the surrounding environmental elements, such as ventilation, to achieve optimal thermal comfort as per the Air Circulation Hour process. Proper air circulation could provide comfort and boost the skin's evaporation process to provide cooler temperatures for the building's occupants. Proper air circulation could provide comfort and boost the skin's evaporation process to provide cooler temperatures for the building's occupants.

Keywords: residential houses, wind analysis, rising temperatures

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1. Introduction

Global warming has impacted many regions and sectors around the world, including Indonesia. Indonesia happens to be the third largest emitter of carbon in the world according to several reports, such as the 2019 Carbon Brief, the 2020 UNEP Emission Gap Report, and the NDC 2016 report. This has caused the occurrence of constant climate anomalies, and extreme weather in several areas, including regions of Java. Moreover, the natural and devastating effects of global warming have become visible as economic risk factors have surged as a result of the loss of land from the rising sea levels, which hinders the launch of business along with residential areas, and further increases the number of poverty-stricken regions around the globe. Indonesia is one of the many countries that has committed to mitigating and preventing further climate

disasters by creating policies that aim to achieve that goal, whether it be in the long term or short term, in each region across the nation.

This research spotlights the region of East Java which has a diverse geography within an approximate area of 48.039 km^2 [1 USAID]. It is divided into four sections based on land altitude from the lowlands that are close to sea level, followed by the areas that have many valleys, and several other places where there are mountainous terrains that are over 1000 meters above sea level. Generally, East Java has very fertile soil due to volcanic ash from mountains around the region. Yet even though the region has a good soil condition, East Java is known to have the lowest recorded amount of rainfall amongst the other provinces. Finally, from 2017 to 2019, East Java recorded a constant rise in temperature for two years in a row. For this research, the team will particularly choose Gresik city in hilly area with 16 m of altitude then Surabaya city in lowland area with 6 m of altitude and known for heat in East Java region.

In addition to the efforts, there have been infrastructural developments aiming to reduce the adverse effects of climate change, namely through studies and the redesigning of residential properties. The main purpose of designing these homes is to acclimate properly against climate change, this is done in the form of thermal regulation by utilizing the surrounding environmental elements. Design acclimatization can be achieved through two means, active and passive design. Active design uses more energy in the construction environment, while passive design is more natural and only relies on the surrounding natural environment, this creates a design that is natural and has been recommended by bio-climatic design experts worldwide. Unfortunately, the simple regulatory process can only be applied to simple residential houses, more complex structures are unable to apply this procedure due to the countless factors which could increase the structure's internal heat. As such, ventilation is the main goal for designers and architects today. The objective of the ASHRAE-compliant ventilation concept is to achieve what is known as Air Circulation Hours, or ACH. The Air Circulation Hour process refers to replacing dirty air, which contains carbon dioxide, inside a structure with clean air within an hour. Proper air circulation could provide comfort and boost the skin's evaporation process as a means to provide cooler temperatures for the building's occupants. Residential areas in the tropics could benefit from having a cross-ventilation system, where the placement of ventilated inlet openings is placed opposite to the ventilated outlet. The cross-ventilation process follows the Bernoulli principle, which states that if the inlet opening is smaller than the outlet across the room, it will result in a faster and smoother air circulation process in that room (Latifah, 2015).

According to *Undang-undang Republik Indonesia Nomor 1 Tahun 2011* about housing and settlement, it states that housing refers to a collection of residential houses in

an urban environment, with the presence of proper facilities and infrastructures that would fulfill the needs of the residents. From an environmental perspective, it could be assumed that everyone hopes to have a large private yard filled with small and medium plants for their comfort and good air circulation. However, with the ever-increasing dense population requiring more and more residential land, the availability of land becomes increasingly scarce. As such, a smart solution to this problem has been developed, in which researchers would indulge in a comparative study of an urban residential building's layout in East Java. An analytical approach would be taken as the openings and layout of the houses are examined to determine how smoothly and evenly thermal comfort is distributed to all of the rooms in the residence.

2. Methods and Equipment

2.1. Methods

The research method used in this study is the basic descriptive analysis method, in which the researchers will analyze three upper middle-class residential houses in East Java, which is known to have the highest recorded temperature in Java, whilst taking into account the movement of air in the building. The process began with the search for the appropriate three buildings which should have an approximate area of 100m^2 in the major cities of Surabaya and Gresik, since those size is favorable among upper middle-class society. Then, the team will do an exploration of data based on the phenomenon of climate change and the constant rising temperatures as evidence of the ongoing global warming crisis. Afterward, the team will sketch out and analyze the movement of air within the interior of the structures based on the guidelines for construction and the principles of wind movement. Lastly, a brief conclusion about the current condition of the residential buildings and design principles for the next phase.

3. Results and Discussion

The key factor to achieving one's basic human needs is the presence of comfort in their residence. One way to achieve optimal thermal comfort is through the movement of wind inside the room. This movement of air in the room is useful for replacing the dirty air, which contains carbon dioxide and comes from activities like smoking, cooking, or breathing, with clean air that contains a lot of oxygen. The movement of air inside the house is important because fulfilling the level of clean air inside is crucial to maintain the health and comfort of the residents of the home.

Designers can improve the ventilation in residential houses by implementing a buoyancy system that allows air to circulate. This system is driven by buoyancy forces, which are caused by temperature differences. The system starts with the cooling of air due to vegetation placed in front of the building. However, the temperature inside the building increases due to human activities. Vertical circulation areas, such as stairs, can be used as airways to increase the temperature upwards and allow it to exit through the roof gap. This buoyancy force is producing stack effect ventilation.

In this research, the team will utilize data from windy.com as the basis for wind direction for the three residential houses. Based on the data sources, it was found that the wind source comes from the back of the houses for each case study. The wind enters the houses through available doors and openings, and every open room can act as a gap for the wind to enter and distribute evenly. After swirling on the first floor, the wind moves upwards through the void area on the stairs and continues towards the balcony on the second floor at the front of the building.

In the first case study, the house has larger area than the other two cases. In this house, it has three close rooms, two living rooms and dining area on the first floor. On the second floor it has three bedrooms, additional living room and balcony on the front. Based on buoyancy force, the wind power is coming from back of house and then the air distributes properly throughout the rooms on the first floor, going up to the second floor and finally going outside to the balcony. Finally, due to the swimming pool at the back, there is a possibility that the air temperature could be lower when the ambient temperature heats up.

For the house in the second case study, the area is not much different from the previous one, but there is a lack of yards at the back and front of the house, and then the position of the bedrooms is not suitable so that it makes it difficult for air force to enter the area. Even if it is coming inside, the velocity will be low. Hence, there is a possibility that the air may not distribute correctly in the bedrooms and only moves well in the middle area of both the first and second floors of the building.

For the house in the third case study, being the narrowest of the three houses, the air moves from the back of the building to the front. However, similar to the second case study house, there is a lack of air distribution in the bedrooms on the second floor due to the improper position of the room and door area, which prevents air from turning inside. If there is an air force going up to the second floor, due to buoyancy force, it will be come from the stairs, going straight to the living area and finally coming outside to the balcony.

TABLE 1: the air velocity within the house comparison.

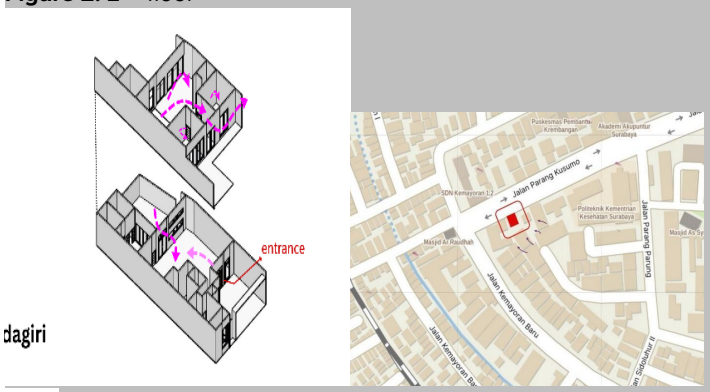
Building Images	Result Analysis
Indragiri, residential two-storey house.	
 **Figure 1:** 1st floor	
 **Figure 2:** 2nd floor	The wind enters from the back of the house and distributes evenly to every other area in the home. However, additional speed is required as the size of the house is larger than the other two. Dark Purple : the source of the wind. Light Purple : the additional wind that comes from front of the house.
 **Figure 3:** Axonometrical view and wind source view Source : windy.com	

TABLE 1: Continued.

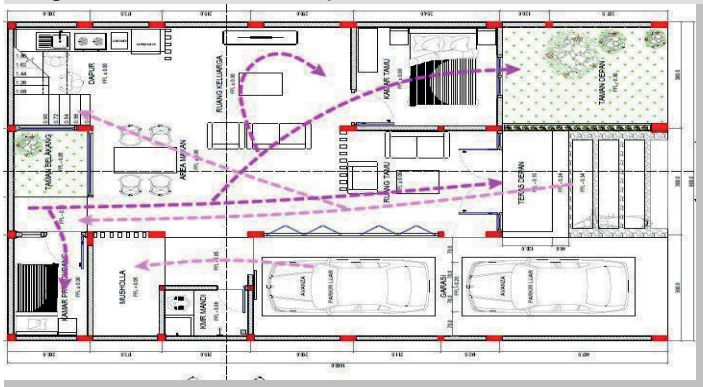
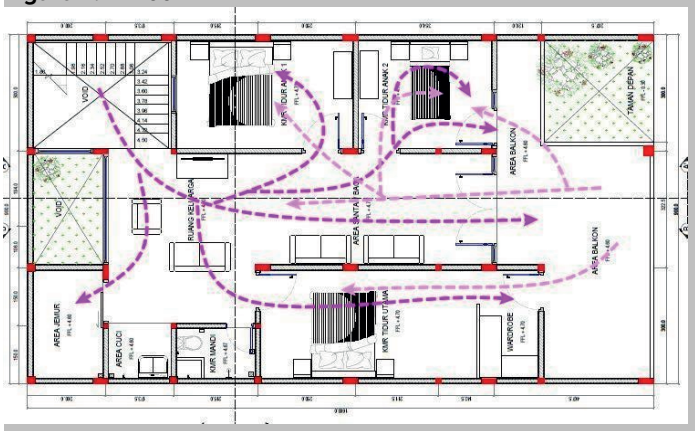
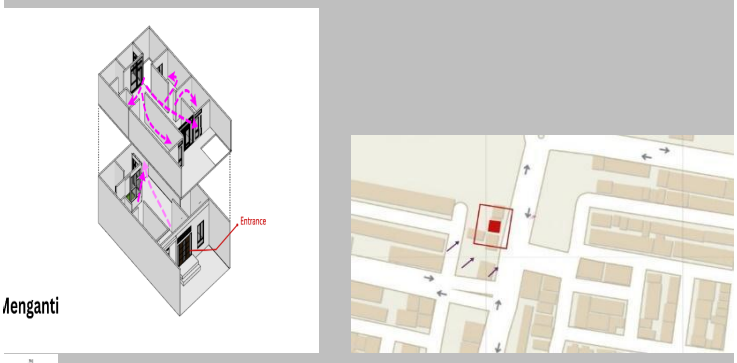
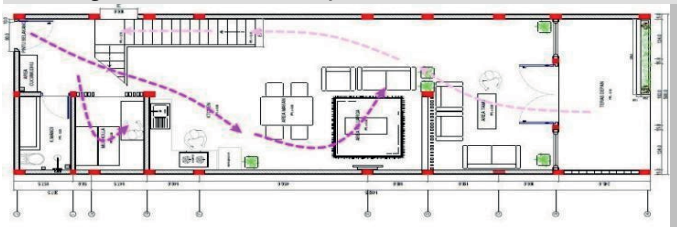
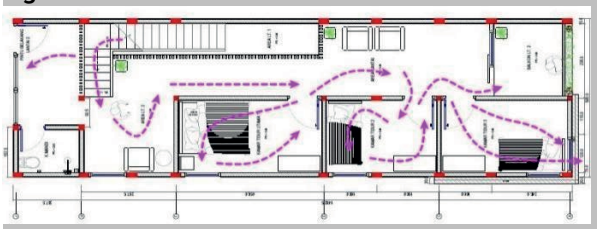
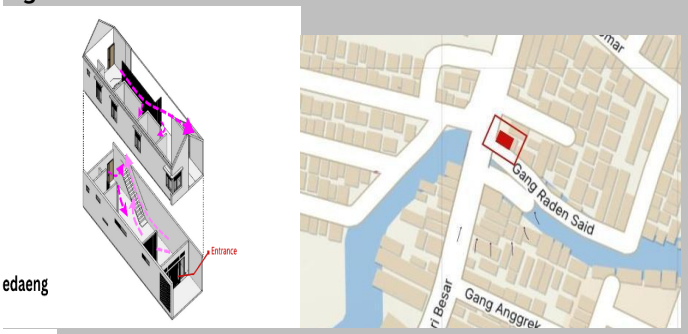
Building Images	Result Analysis
Menganti, residential two-storey house.  **Figure 4:** 1st floor  **Figure 5:** 2nd floor  **Figure 6:** Axonometrical view and wind source view Source : windy.com	The area of the floor is not as big as the first house, yet the position of every door in every room on the second floor doesn't allow proper air flow.

TABLE 1: Continued.

Building Images	Result Analysis
Medaeng, residential two-storey house.  **Figure 7:** 1st floor  **Figure 8:** 2nd floor  **Figure 9:** Axonometrical view and wind source view Source : windy.com	The shape of the house is long and narrow. The wind enters from the back of the house straight to the front. However, several rooms are improperly placed, which makes the wind distribute unevenly.

4. Conclusion

After analyzing three residential houses, it was found that the implementation of cross-ventilation guidelines for air movement is still minimal, resulting in many rooms not being affected by natural air distribution. Achieving thermal comfort can be difficult since air conditioner is often chosen as a shortcut. Additionally, modern humans have trouble adapting to rising temperatures and may resort to using air conditioning. Despite these challenges, upper-middle-class homeowners still attempt to create small gardens that are common in middle-upper residence facilitated in some way natural cooling of rooms. This article only analyzes the basic problems in building with the help of literature guidelines and uses limited data. Further analysis, including simulation calculations and wind speed effects on thermal comfort and larger data, is still needed to accurately

portray the situation in East Java. The team plans to conduct a more in-depth analysis in the future and provide design suggestions based on cross-ventilation guidelines to achieve thermal comfort through natural ventilation.

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