Passive design implementation as sustainable development approach on vertical housing case study: Sentra Timur Residence

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Abstract. Vertical housing development is a solution to solve the housing needs problem in Jakarta, which already had a land limitation issue. However, the development also contributes to environmental degradation. Building uses materials and energy in the development process, and when it operates. Most of energy use in Heating, Ventilating, and Air Conditioning (HVAC) to create physical comfort for user. Passive design strategies applied to maintain comfortable temperature in building such as building orientation, shading, and ventilation, so energy usage could be reduced. The purpose of this research was to analyse the implementation of passive design in vertical housing, as an approach to achieve sustainable building. Observation carried on Sentra Timur Residence, one of vertical housing in East Jakarta. This research used building data to create mass modelling to help analyse the passive design implementation. The results show that some passive design strategies are applied such as building orientation, shading, and ventilation, mainly in the housing unit. These strategies help to maintain thermal comfort inside the housing unit, so the users can feel comfort without using an air conditioner. It reduces energy usage in the building so negative impact on environment could be minimized.

1. Introduction

Human activities contribute to environmental issues, such as climate change and air pollution. Development carried out in order to fulfill human needs, sometimes does not consider the ecological impacts that cause environmental degradation. Therefore, the concept of sustainable development arises, in order to reduce environmental impacts and on the other hand improve the quality of human life.

The United Nations assigns 17 Sustainable Development Goals (SDGs), which one of them is sustainable cities and communities. Cities only occupy 3% of the land area, but their energy use reaches 60-80%. Building is one of the elements in the city as a place for people to live, work, and do various activities. However, on the other side, the building also contributes to environmental problems. Buildings produce 40% of existing carbon emissions and use resources such as material, water, and energy [1].
Jakarta is a high population density city, with about 10.3 million residents [2]. Besides humans, Jakarta is also filled with a lot of buildings, ranging from houses, offices, and skyscrapers. With the increasing number of residents every year, it will affect the needs of housing.

Housing backlog based on ownership in Indonesia amounted to 13.5 million units in 2014, and handling target was 6.8 million units in 2019 [3]. Jakarta, as a densely populated city in Indonesia also become a target of housing development. However, this city is already had land limitation issue, so the development directed to vertical housing.

The building development needs to consider the sustainability aspect, since the building give a negative impact to the environment such as consume a lot of material, water, and energy [4][5][6]. Building also consumes electricity to support the human activities inside, which is the source of electric power supply mostly come from fossil power. So, building also contributes to the production of emission [4]. Heating, Ventilating, and Air Conditioning (HVAC) is the most energy consumption in building [7] that needed to create thermal comfort for the user. Human thermal comfort can be achieved when the average temperature is around 23ºC -27ºC [8].

Jakarta has a high average temperature, around 28-31ºC [9], which means there are gaps to achieve thermal comfort. It needs some effort to reduce the temperature in the building. Air conditioner usually used to solve this problem, although it means there are more energy needed and emission produced.

In architecture, there are some strategies that can be applied, namely passive and active design. Different with active design that need mechanical device and high technology, such as air conditioner, passive design is applied through the planning process that makes building can adapt to the environment. Passive design strategies that commonly applied, such as building orientation, shading, and ventilation.

1) Building orientation
   Building orientation refers to the way building is placed on the site. The position of the building will affect the solar heat accepted by the building. Solar analysis could help to determine which direction the building should oriented. Usually, the building planner avoids north-west orientation because there is more heat exposure that accepted by the building, especially in the afternoon.

2) Shading
   Shading is used to control the amount of sunlight that expose the building. To apply shading strategy, there are some ways that can be used, first create façade that adaptive to sun movement, and the other way is using shading devices such as trellises, roller blind, and curtain.

3) Ventilation
   Ventilation is important element in building, it useful to air exchange in the building. Through ventilation, fresh air can enter the room and replace the air inside.

   East Jakarta is part of Jakarta with the highest resident population among the other regencies. To fulfil the housing needs, there are a lot of residential developed in East Jakarta. Vertical housing development also increase, due to land limitation issue. One of the vertical housing in East Jakarta is Sentra Timur Residence.

   Vertical building consists of some housing units, and every unit need to fulfil thermal comfort for its user. This paper aims to find the passive design implementation in Sentra Timur Residence and analyse its effect to the building. Passive design could help building to achieve thermal comfort, so energy usage will reduce, and make building more sustainable.

2. Methods

2.1. Study Area
   This study held in Sentra Timur Residence, one of vertical housing in East Jakarta. This building located in a high-density housing area, and the surrounding area is filled with lot buildings, as shown
in figure 1. Sentra Timur Residence consists of six towers, named Orange, Ruby, Green, Grey, Yellow, and Tosca Tower, as the color of each tower.

Figure 1. Sentra Timur Residence Location.

2.2. Data Collection
This study used building drawing such as plan, section, and elevation to create mass modelling. This model then analysed using solar path software. Other data such as solar movement, temperature, and map used to help to identify the issue. Observation also carried to identify the implementation of passive design in the building.

3. Results and Discussion

3.1. Building Orientation
Figure 2 showed the orientation of Sentra Timur Residence building and sun path in Jakarta. There are six towers, and as it is shown in Figure 2, none of the building exactly face east-west orientation. Two towers face southeast-northwest orientation, and four towers face southwest-northeast orientation. These orientations make the housing units not directly exposed to sunlight. Thus, the potential of heat entering the building through wall and openings can be reduced.

Figure 2. Sentra Timur Residence Building orientation.
3.2. Shading
Shading is useful for eliminating the heat of the sun entering the building. Shading can be achieved by façade design or using a shading device. In Sentra Timur residence buildings, shading is formed from an asymmetrical building mass. The towers position and height difference of the towers form shading for each other as can be seen in figure 3.

In figure 3a shows the condition when the morning when the sun rises, it can be seen that shading on the west side makes the units on that side cooler. Figure 3b shows the situation in the afternoon where the sun is on the west side. It can be seen that the shading formed covered many sides of the housing units.

![Figure 3. Sentra Timur Residence Building Shading.](image)

3.3. Ventilation
Figure 4 showed the unit plan of Sentra Timur Residence, which consists of a living room, two bedrooms and a toilet. Each unit is designed to have windows facing outwards. This window is a vent to put fresh air into the unit. The windows position in the room are in the bedroom 1 and living room. Considering the configuration of the room and windows, the room that needs air conditioner is bedroom 2 due to the absence of ventilation to flow fresh air inside. The use of air conditioners in the living room and bedroom 1 can be reduced by utilizing ventilation.

![Figure 4. Housing Units Ventilation Illustration.](image)
4. Conclusion
Sentra Timur Residence building applied passive design strategies, such as building orientation, shading, and ventilation. These strategies help to create thermal comfort inside the housing units, so air conditioner usage could be reduced. It means the energy usage also reduced and make the building more sustainable to contribute to achieving SDGs number 11, sustainable cities and communities.

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