Solar Radiation Study of Office Building Shapes at a Business District in South Jakarta

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Abstract. Setiabudi area is a business district located in South Jakarta and is one of the business and office centers in Jakarta. With the development of the economy in Jakarta, the need for office buildings has increased. Electricity usage in the building sector reached 41% and is the biggest sector in consuming energy. The cause of excessive use of electricity is the use of AC. This is influenced by the level of solar radiation to the building. With the increasing solar radiation, building’s OTTV became out of standard. According to Governor Regulation No. 38/2012 OTTV for buildings may not exceed 45 watts / m². This electricity usage can be minimized by reducing solar radiation to the building, thus reducing the power usage of AC usage. This paper presents the study of different building shapes. The study is aimed to investigate the impact of building shapes to reduce solar radiation. The steps of study is as follows: (1) analyzing the site, (2) Making the alternatives of building shape (3) Solar radiation simulation.

Keywords: Office, Building shapes, Solar radiation

1. Introduction
This study was raised based on one of United Nations Sustainable Cities and Communities that focused on a resource efficiency and adaptation to climate change[1]. The Setiabudi area is a business district located in South Jakarta and one of the business and office centers in Jakarta. With the development of the economy in Jakarta, the need for office buildings has increased. Electricity usage in the building sector reached 41% and is the biggest sector in consuming energy[2]. The cause of excessive use of electricity is the use of air conditioners. AC usage is influenced by solar radiation to the building. With the increasing solar radiation, OTTV building’s also become high and out of the standard. The regulation for buildings in Jakarta according to Governor Regulation No. 38/2012 OTTV for buildings may not exceed 45 watts / m²[3].

To find out Solar radiation of office buildings in the Setiabudi are at specified site, a solar radiation simulation will be conducted by assuming the wall construction uses white brick walls without using sunshading. The building size follows the site index guidelines so that the building size used for the simulation calculates OTTV at the site the size is 55m² for the first 3 floors and the size drops by 1m².
for every 3 floors. From the solar radiation simulation using FormIt application at yearly analysis the results are:

- Building mass in the north were exposed to solar radiation at 724.6 kWh / m²
- Building mass in the west were exposed to solar radiation at 883.8 kWh / m²
- Building mass in the east were exposed to solar radiation at 908.4 kWh / m²
- Building mass in the south were exposed to solar radiation at 522.7 kWh / m²

![Figure 1. solar radiation office value simulation results](image)

Based on Jakarta Green Building Buildings User Guide Vol.1 Building Envelopes, the potential for energy savings can be achieved through building envelopes with a passive design strategy. They are as follows [3]:

- wall insulation
- wall reflectivity
- natural light
- glass
- window to wall ratio
- sunshade

According to the Jakarta Green Building Buildings User Guide Vol.1 Building Envelopes (2020) book by the Indonesian Governor sunshading as building envelopes has the greatest energy saving potential followed by window to wall ratio[3]. Therefore the use of sunshading as building envelopes is very important to reduce electricity usage of the building.

The shape of the building affects the amount of solar radiation from the sun. Therefore the shapes of the building will follow the site context in this case are sun path.

The strategy was achieved through theories from Mark DeKay’s Sun, Wind, and Lighting Books. The book reveals various strategies for optimizing building’s envelope. One is aspect is external shades. According to the Responsive Envelopes diagram of the book, it can be illustrated as follows[4]:
2. The methodology

2.1. The method of study
The study is mainly using simulation to find the solar radiation value of the site and using simulation to find the best building shapes that can reduce the solar radiation. The study is based on several variables such as orientation, sun solstice, and sun equinox. The result of the study will be tested with a simulation, that is going to prove if the solar radiation to the building has been reduced. The study is basically a simulation result of solar radiation to find the most effective building shape for office building.

2.3. The case study
The study selected is at Jalan Perintis RT.3/RW.5, Kuningan, East Kuningan, Setiabudi, South Jakarta, Daerah Khusus Ibukota Jakarta. This location is office, market, and services zone according to Jakarta Zoning Map. This location is among one of the many high rise, mid rise building area in Jakarta. With the number of high rise and mid rise buildings in this area, the buildings in this area will be exposed to large solar radiation causing the building to heat up and the room inside the building will use a lot of air conditioning to lower the room temperature and use a lot electrical energy. Solar radiation can be reduced by applying an external shades to the building. Therefore, the study of kinetic sunshading is considered suitable for this particular area.
3. Result and Discussion

3.1. Solar radiation simulation of the building

Based on earth revolution motion, the sun has shifted its position to the northern hemisphere, precisely on December 22 - June 21 and the shift from the northern hemisphere to the south on June 21 - December 21\[\].

![Figure 5. Sun movement through the year](image)

The building mass that used as simulation is based on A-Z Persyaratan Teknis bangunan guide book regarding site index, initial building mass is formed following the shape of the building footprint, then adjusted to the Building Border. At each additional floor or level, the distance of the Building boundary is added 0.5m from the floor clearance below. Addition is made until it reaches the farthest free range of 12.50m [].

![Fig 6. Solar radiation simulation results](image)

From the solar radiation simulation using FormIt application at yearly analysis the results are:

- Building mass in the north were exposed to solar radiation at 724.6 kWh / m$^2$
- Building mass in the west were exposed to solar radiation at 883.8 kWh / m$^2$
• Building mass in the east were exposed to solar radiation at 908.4 kWh / m²
• Building mass in the south were exposed to solar radiation at 522.7 kWh / m²

After analysing initial solar radiation value, we must calculate solar radiation using alternative shapes. In this study, there will be 10 different office building shapes. The alternative shapes are:

![Alternative Building Shapes](image-url)

After finding the shape of an office building, a simulation test of solar radiation will be carried out using Formit Application. More detailed result from Formit simulations will be explained in this following figures:

![Solar Radiation Simulation Results](image-url)
After conducting solar radiation simulations using Formit application, we will find the most effective building shapes. The most effective shapes have the lowest average solar radiation value. For more detailed solar radiation value will be explained in this following figures:

| Shape type | Orientation | North East | East | South East | South | South West | West | North West | Total average radiation |
|------------|-------------|------------|------|------------|-------|------------|------|------------|------------------------|
| Shape type A | North       | 724,6      | 908,4| 522,7      | 883,3 | 759,7      |
| Shape type B | North       | 724,6      | 908,4| 522,7      | 883,8 | 759,8      |
| Shape type C | East        | 705,7      | 800,1| 501,2      | 790,3 | 699,3      |
| Shape type D | East        | 701,3      | 778,4| 498,7      | 742,9 | 680,1      |
| Shape type E | South       | 661,5      | 740,7| 467,6      | 627,3 | 624,2      |
| Shape type F | South       | 724,6      | 906,8| 522,7      | 910,1 | 766,1      |
| Shape type G | South       | 658,2      | 704  | 465,2      | 612,7 | 610        |
| Shape type H | West        | 656,3      | 570,3| 463,3      | 657,2 | 586,7      |
| Shape type I | West        | 724,6      | 827,2| 898,3      | 740,1 | 883,8      |
| Shape type J | West        | 636,2      | 685,9| 710,1      | 593,6 | 611,3      |

Figures 9 Solar radiation value

3.2. Simulation results

Based on the results of the following research, it can be concluded that the type H shape is the most effective form in reducing the amount of solar radiation that enters the building. Building type H have the lowest solar radiation because building type H have natural shading that makes solar radiation value go lower.
Figures 10 Building type H

4. Concluding Remarks
The Solar radiation study of office building shapes has been conducted and the remarks can be conclude as follows:

- The building’s solar radiation varies on each side
- South orientation have the lowest solar radiation followed by south east, east, north east, north, south west, north west, west.
- Building shapes that have natural shading have lower solar radiation value

References
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