OTTV based shading devices optimization for multi-storey building in tropical Jakarta

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Abstract. Energy conservation efforts are being carried out by countries in the world as a result of energy crisis. The efforts are carried out in various aspects including in an office building that tends to use a large amount of energy. Based on regulations from the Jakarta Green Building, the OTTV standard for the city of Jakarta is 45 W/m2. To achieve the ideal OTTV value, efforts are needed on building to meet the standards which is applying shading devices. This method of study uses quantitative methods by simulating OTTV on the building envelope using the OTTV Calculator from the Jakarta Green Building. The simulation produces an ideal and effective shading device design in reducing the value of OTTV in buildings.

Keywords: OTTV, Shading device, Multi-storey

1. Introduction
The energy crisis is a problem that is starting to emerge recently. The use of high energy is one of the causes. One of the efforts to solve this problem is energy conservation. Energy Conservation is one of the national policies implemented by Indonesia to reduce energy consumption and growth without having to reduce the acceleration of Indonesia's development [1]. Based on the ASEAN Centre for Energy, a fairly high energy saving opportunity in Indonesia through buildings sector [2]. The largest energy consumption in building sector dominated by electrical energy consumption, which is around 50-70%, comes from the cooling system [3].

In the warm humid tropics, building energy consumption is dominated by energy for cooling the room. In Indonesia, cooling load is the largest energy use of total energy in a building. It consumes up to 55% of total energy use, especially in office building. The loads mostly come from external and internal heat load. In typical office building, the heat load from walls and windows is around 63% and the internal heat load from equipment, lighting and occupancy around 37% [4]. Therefore, it is crucial to reduce the building heat load by reducing external heat load through passive design.

In Office building, passive design has energy saving potential about 31%. This can be achieved through the design of the building envelope such as using the shading devices, adjusting the area of the window to wall ratio (WWR), selecting glass with a low shading coefficient and utilizing natural light for indoor lighting. According to DKI Jakarta Governor Regulation No. 38 of 2012, the Overall Thermal Transfer Value (OTTV) on the ideal building envelope does not exceed 45 Watt / m2 for energy conservation [4].
The office building is located at a Central Business District of the Mega Kuningan, South Jakarta, typically an office tower above the 15 m height podium (Figure 1). The shape of the building mass is determined based on the building regulations of the site location. (Figure 2).

An initial calculation of the OTTV value is carried out using graphical methods. The initial calculation is calculated assuming using 8 mm coloured glass with a solar heat gain coefficient (SHGC) value of 0.49 and a window to wall ratio (WWR) of 50%, OTTV on the building envelope and building mass as shown in Table 1.

![Figure 1. Building site in Mega Kuningan](image1)

![Figure 2. The initial building mass assumption (1)](image2)

| Façade Orientation | OTTV (W/m²) | Area (m²) | Total Increase in External Heat |
|--------------------|-------------|-----------|--------------------------------|
| North              | 55          | 3450      | 189750                         |
| West               | 76          | 2875      | 218500                         |
| East               | 69          | 2875      | 198375                         |
| South              | 39          | 3450      | 134940                         |
| **Total**          | **12650**   | **741565**|                                 |

Based on the formula listed in SNI 03-6389, the total OTTV building envelope can be calculated in the following formula:

\[
\text{OTTV}_{\text{total}} = \frac{(\text{OTTV}_1 \times A_1) + (\text{OTTV}_2 \times A_2) + (\text{OTTV}_3 \times A_3) + (\text{OTTV}_4 \times A_4)}{A_1 + A_2 + A_3 + A_4}
\]

\[
\text{OTTV}_{\text{total}} = \frac{741565}{12650} = 58.6 \text{ W/m²}
\]

The building envelope model study in the Mega Kuningan area, South Jakarta resulted OTTV total as 58.6 W/m². It exceeds the OTTV standard which is 45 W/m². Therefore, efforts are needed to reduce the value of OTTV by applying shade elements to the building envelope.

2. Method

2.1 Research methods

In this research, the research method (Figure 3) used is quantitative research methods. The data obtained from the result of simulation analysis using OTTV calculator. The formula for calculating OTTV is spelled out in a spreadsheet on the OTTV calculator.

2.2 Simulation Input Parameter

In the spreadsheet input parameter needed to conduct the simulation are exterior wall specifications, fenestration system specifications, dimensions of the shade elements, area of the façade that will be simulated, and openings in buildings or Window to Wall Ratio (WWR). In order to determine the simulated façade, it is necessary to determine the building mass modelled. The mass of the building
determined based on the site index. On previous studies, WWR between 50% and 70% in the North, 60% in the South and 50% -60% in the east and west orientations were observed for points of intersection beyond optimal visual comfort and minimum criteria [5]. In this research, the WWR that will be used is 56% due to the consideration of the human view from inside the building and the glass modules use Sunergy EuroGrey SNGE 8 mm and Sunergy EuroGrey SNGE 6 mm products.

2.3 Research Variable
Research variables include the type of shading device’s sample that being tested and the assumed dimensions used. There are three types of shading devices being tested, namely horizontal shading devices, vertical shading devices, and egg crate shading devices. For horizontal and vertical shading devices, 18 samples were tested (SH1/SV1-SH18/SV18). For egg crate shading device, there are 15 samples tested (SE1-SE15). The sample shading device being tested is determined from a combination of the dimensions and the slope specified. The assumed dimensions used are the shading device length of 0.5 m, 1 m, 1.5 m. The width of the shading device is 3.2 m. Shading device height is 2.25 m. The shading device slope between 0, 10, 20, 30, 40, 50 (degrees).

![Figure 3. Methodology diagram](image)

3. Result and discussion

3.1 Site index simulation without shading device
Based on the site index that has been determined (Figure 4), an OTTV calculation is performed without a shade element on the site index. Simulations were carried out using the OTTV calculator. The simulation is done by assuming a floor to floor 4 m, opening or WWR of 0.56 (56%) with the type of construction of the fenestration system using 6 mm Sunergy EuroGrey SNGE brand glass with a SHGC value of 0.4 and U-Value of 4.1 W/m²K and a type of wall construction Brick Wall.

![Figure 4. Building mass site index](image)

As shown in Table 2, the resulted OTTV from the simulation results calculated on the site index has a total of 52.64 W/m². The North and West-oriented facades have OTTV values above the ideal OTTV in Jakarta, which is 45 W/m². Each has an OTTV value of 49.21 W/m² for the North facade and 78.78 W/m² for the Western facade. The facades with East and South orientation, they have fulfilled the ideal OTTV values in Jakarta.
Table 2. Site Index Simulation Results without Shading Device

| No | Side  | Conduction through the wall A Watt | Conduction through openings B Watt | Radiation through openings C Watt | Total Watt D = A + B + C | Total Area of the Facade E m² | OTTV Watt/m² D / E |
|----|-------|----------------------------------|----------------------------------|----------------------------------|--------------------------|-----------------------------|---------------------|
| 1  | North | 22790.67                         | 71020.20                         | 209475.35                       | 303286.22                | 6180                        | 49.08               |
| 3  | East  | 21045.37                         | 65443.38                        | 166299.68                       | 252788.43                | 5700                        | 44.35               |
| 5  | South | 22790.67                         | 71020.20                         | 156300.84                       | 250111.71                | 6180                        | 40.47               |
| 7  | West  | 20602.25                         | 64065.78                        | 353215.76                       | 437883.78                | 5580                        | 78.47               |
|    | Total | 87228.96                         | 271549.56                       | 885291.63                       | 1244070.15               | 23640                      | 52.63               |

3.2 Site index simulation with shading device

To reduce the value of OTTV, it is necessary to apply shading elements to the orientation of the North and South facades. Calculation is carried out to obtain the ideal shading elements that can reduce the OTTV value of the building envelope. A calculation (Tables 3-4) is performed with certain dimensions and brick wall type construction, types of shade elements and WWR of 0.56 (56%) with the type of fenestration construction using 6 mm glass with a SHGC value of 0.4 and a U Value of 4.1 W/m²K for north façade and 8 mm glass with a SHGC value of 0.35 and a U Value of 4.1 W/m²K for west façade.

Table 3. OTTV simulation with shading device results

| No | Shading code Horizontal | Length (L1) [m] | Height (H) [m] | Slope | Scf | OTTV |
|----|-------------------------|-----------------|----------------|-------|-----|------|
|    | SH1 (North)            | 0.5             | 2.25           | 0     | 0.88| 44.92|
|    | SH15 (West)            | 1.5             | 2.25           | 40    | 0.55| 45.45|

| No | Shading code | Vertical Length (L1) | Width (W) | Slope | Scef | OTTV |
|----|--------------|----------------------|-----------|-------|------|------|
| 3  | SV2 (North)  | 1                    | 3.2       | 0     |      | 44.35|

| No | Shading code | Eggcrate Length (L1) | Height (H) | Length (P2) | Width (W) | Slope [derajat] | Scef | OTTV |
|----|--------------|-----------------------|------------|-------------|-----------|----------------|------|------|
| 4  | SE1 (North)  | 0.5                   | 2.25       | 0.5         | 3.2       | 0              | 0.81 | 42.72|
| 5  | SE15 (West)  | 1.5                   | 2.25       | 1.5         | 3.2       | 40             | 0.53 | 44.69|
Simulation on the North façade resulted that horizontal shading elements require a length of 0.5 meters from the building envelope and 0-degree slope with the SH1 specification code to produce an OTTV value of 44.92 W/m². Vertical shelter element requires a length of 1 meter and a width or distance between elements of 3.2 meters with a slope of 0 degrees with the SV2 specification code to produce an OTTV value of 44.35 W/m². For the egg crate shade element requires a length of 0.5 meters with a slope of 0 degrees in the horizontal plane and a length of 0.5 meters with a width or distance of 3.2 meters with a slope of 0 degrees in the vertical plane with the SE1 specification code to produce an OTTV 42.72 W/m² (Figure 5).

Simulation result on the Western facade with the type of glass construction system 8 mm glass with a SHGC value of 0.35 and a U Value of 4.1 W/m²K, for horizontal shade elements requires a length of 1.5 meters from the building envelope and 40-degree slope with the SH15 specification code to produce an OTTV value of 45.62 W/m². For vertical shade elements it cannot reach the OTTV value...
of 45 W/m². For egg crate shade elements require a length of 1.5 meters with a slope of 40 degrees in the horizontal plane and a length of 1.5 meters in width or a distance of 3.2 meters with a slope of 40 degrees in the vertical plane with the SE15 specification code to produce OTTV 44.85 W/m².

The western façade shading device degree of slope is too large causing the view from inside the building will be disturbed if using SH15 & SE15 shade elements. Considering the view from people inside the building, the opening to the building is place more backward and the shade elements are reduced in length.

4. Conclusion
Based on the simulation results, taking into account the view from inside the building in the North facade is recommended using a horizontal shade element with a length of 0.5 m from the building envelope and 0-degree slope with the SH1 specification code to produce an OTTV value of 44.92 W/m². In the East and South facades there is no need for a shade element, assuming a 56% WWR because the results of the East facade simulation have an OTTV of 44.51 W/m². The South facade has an OTTV of 40.58 W/m². In the Western facade with a type of glass construction system 8 mm glass with a SHGC value of 0.35 and a U Value of 4.1 W/m²K in the recommendation using a horizontal shade element with a length of 1.5 m from the building envelope and slope 40 degree with the SH15 specification code to produce an OTTV value of 45.45 W/m². Based on this, the total OTTV value of the building envelope is 43.74 W/m² in accordance with the ideal OTTV in Jakarta, which is 45 W/m².

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