OTTV recalculation of Suara Merdeka Tower: a recommendation design towards energy efficient building

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Abstract. This paper discusses how a building facade design possess an immense significant effect on thermal value transfer on building envelopes. The thermal transfer from outside into the building through the building envelope affects the thermal conditions in the building. Hence it determines the energy requirements in the room, such as the need for indoor air conditioning. Calculation on the southwest facade of Suara Merdeka Tower Semarang using the Ecotect software with the result that the OTTV (Overall Thermal Transfer Value) reaches above 35 W/m^2 that is 59.44 W/m^2. This facade is the face of the building as well as the smallest facade area. This smallest area remarkably influences on conditions in the building since the combination of glass types dominate and no shading devices on the entire side of the building. Solar radiation falls directly on the Southwest side after 12.00 pm and is not shadowed at all (overshadowed by 0%). This study simulates the redesign of the southwest façade and recalculates the OTTV value after the redesign process using the Ecotect software. The result obtained is a decrease in OTTV value by up to 35% after redesign recommendation applied.

1. Introduction

The facade turns as the most significant architectural element for communicating the function and sign of a building. The building facade is a building envelope that is second intensely exposes to solar radiation after the roof. Indonesia is a humid tropical climates country, apart from humidity and the influence of wind speed factors, solar radiation is the main factor encountered by building facades [1]. The building envelope is not only a two-dimensional form of the outer surface but a transitional space that acts as a theatre of interaction between outer and inner space [2].

The building envelope as a building's outer skin reacts directly to climatic conditions is determined by the type of material used. Building material becomes an intermediary medium between outdoor temperature and solar radiation and indoor temperature. Climate considerations influence the choice of building materials used. The factors that need to consider are the material's characteristics and thickness and the colour of the outer surface of the material. The most determining factors of material characteristics are the heat transmission value or u-value and thermal resistance [3]. Researches revealed that solar radiation becomes the largest contributor to the amount of thermal transfer to the building [4]. The amount of solar radiation transmitted through the building envelope is influenced by

the building facade, namely the ratio of the glass area and the wall to wall ratio, as well as the type and thickness of the glass used.

Suara Merdeka Tower is one of the high rise buildings in Semarang functioned as rental office prioritizing tenants' comfort. This 15 floors + 2 basement storeys building is located in the tropical area. Hence it requires to respond to specific climate conditions such as:

a. Air temperature: maximum average 27°C – 32°C; minimum average 20°C – 23°C
b. Average air humidity 75-80%
c. Annual rainfall between 1,000 mm-5,000 mm
d. Sky conditions are generally cloudy with clouds between 60%-90%
e. Sky luminance for a sky that is completely covered by thin clouds is relatively high, it can reach more than 7,000 candela/m², while those that are entirely covered by thick clouds are around 850 candelas/m²
f. Low average wind speed, around 2-4 m/sec.

Glass dominates the appearance of this building; hence it requires a well calculated of Overall Thermal Transfer (OTTV) [5]. Calculation of OTTV to reveal thermal transfer generated by this building. Suara Merdeka Tower Semarang is a 15-story building (+2 basement) which is dominated by glass as a building envelope material. To determine the heat transfer in the Suara Merdeka Tower building, calculations are carried out using the Overall Thermal Transfer Value (OTTV) formula on the entire facade of the building. In accordance with the National Standard of Indonesia (*SNI*) regarding "Energy Conservation of Building's Envelopes on Buildings" *SNI* 03-6389 2011, the overall thermal transfer for walls and roofs must not exceed the total thermal transfer value of 35 W/m² [6].

2. Methodology

This study focused on the southwest facade which is the face of the building with the smallest casing area as well as stopsol glass is the majority material. OTTV mapping was carried out on the southwest side of the Suara Merdeka Semarang Tower, as follows:

Table 1. OTTV mapping on whole southwest façade.

	Partial OTTV (w/m^2)	*SNI* 6389 : 2011 ≤ 35 W/m²
Ground Floor	144.62	X
1st floor	88.85	X
2nd floor	43.54	X
3rd – 9th floor	47.03	X
10th – 15th floor	60.60	X
16th - 17th , Lounge floor	46.18	X
TOTAL	59.44	

Calculation using Autodesk Ecotect software generates OTTV value of this facade exceeds the SNI provisions. In consequence, it requires a recommendation design to diminish OTTV value on southwest façade.

3. Results and discussion

3.1. Analysist

On southwest façade obtained data conditions as follow:

a. Southwest side is facing the main road (Jalan Pandanaran) and the face of Suara Merdeka Tower outright;

b. The Southwest side has the smallest building width, whilst the widest side is on the Southeast side and the Northwest side.
c. The entire Southwest side of the building is dominated by the glass as a building envelope, with a combination of stained glass, stopsol + reflective glass, and reflexindo glass.
d. The Southwest side has no shading devices, neither do the other sides. This building does not apply shading devices; the shading formed on the building is caused by the design of the building mass, which is influenced by the daily movement of the sun.
e. Solar radiation falls directly on the Southwest side above 12.00 and is not shadowed at all (overshadowed by 0%).
f. Southwest side OTTV value is 59.44 Watt/m^2.

3.2. Recommendation design

Sun shading devices and material manipulations proposed to diminish OTTV value on southwest façade whilst considering several points as follow:

3.2.1. Design. Shading device design is prioritized on the optimal size and shape to reduce heat from solar radiation without forsaking construction aspect. In this case, the horizontal shading device is highly recommended, vertical or simple combination (eggrate). The focus of this design is to provide optimal solutions applicable to Suara Merdeka Tower Semarang.

Several practical and efficient sun shading design on the southwest side of Suara Merdeka Tower as follow:

a. Vertical shape combination
   By certain dimensions and density, the combination of vertical shapes adequate to reduce solar radiation penetration to building envelope. If applied on the southwest side of the tower, the effective dimensions and shapes of shading devices are:
   - Width : 40 cm
   - Length : along the floor height
   - Distance between devices : 80 cm
   - Thickness : 10 cm

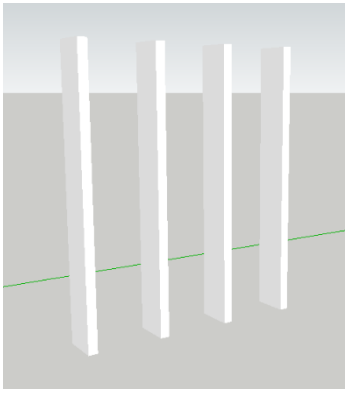
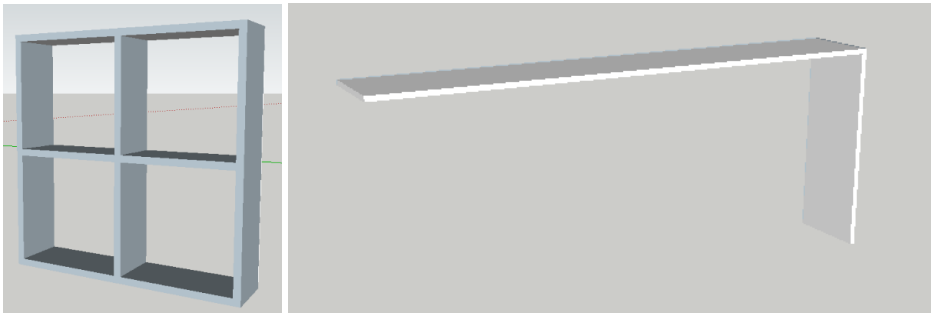


Figure 1. Vertical sun shading design.

b. Eggrate Shape
   This shape is a combination of vertical and horizontal, in such a way as to form a rectangular pattern that is line up and down a certain amount. By certain dimensions and density, the shape of the eggrate capable of reducing solar radiation penetration. If applied to the Southwest side of Suara Merdeka Tower, the potential dimensions and shapes of shading tools are:
   - Eggrate thickness : 40 cm
   - Square Eggrate length : 80 cm

- Square Eggrate width : 80 cm

c. L Shape
The l shape is combination of vertical and horizontal and expected to reduce the penetration of solar radiation. Suggested dimension for application of L shape sun shading as follow:
- Horizontal length : adjusted
- Horizontal width : 80 cm
- Horizontal thickness : 5 cm
- Vertical length : adjusted
- Vertical width : 80 cm
- Vertical thickness : 5 cm



(a) (b)

Figure 2. (a) Eggrate *sun shading* design, (b) shape *sun shading* design.

3.2.2. Material

a. Applied glass material on façade beyond the bounds of possibility to be replaced, hence additional reflective layer suggested to reduce solar radiation on the glass. In order to remain synchronous with the type of glass material installed on Menara Suara Tower, a 60% reflective glass coating selected with the following specifications:

Glass type	*Stopsol + film coating*(PR60 3m film)*	
Thickness	*8*	mm
U-value	*5.6*	W/m2K
Glass SC	*0.47*	

b. Material of selected sun shading device required low conductivity to avoid intencify on material. This can be seen in the U-value of a material, the lower the U-Value, the lower the conductivity value. The recommended material is ACP (Aluminum Composite Panel) with the following composition :

Material	ACP
Surface character	Metallic
Color	Soft grey
Absortantion	0.40
Thick	4 mm
Thermal Conductivity	0.33 W/mK
Density	1900 Kg/m³
Material	*Air Gap*
Thickness	920 mm
Thermal Conductivity	0.216 W/mK
Density	1.3 Kg/ m³
Material	ACP
Thickness	4 mm
Thermal Conductivity	0.33 W/mK
Density	1900 Kg/m³
Weight	16.396 Kg/m²

3.2.3. Application of recommendations. The application of recommendation designs and materials as follows:

a. The vertical shading combination design is placed on the right side of the Southwest facade specifically for the ground floor and 1st floor, added with a 60% reflective layer to the glass due to the existing glass contributed the highest percentage of OTTV values. This design application can be seen in figures 4 and 5.
b. The Eggrate shape shading design is placed on the right side of the Southwest façade specifically for floors 2 to 17, adding a 60% reflective layer to the glass as an effort to reduce the OTTV value in this area. This design application can also be seen in figures 4 and 5.
c. L-shape design on the left side of the Southwest façade specifically for 2nd to 17th floor and 8-9-10th floor. A 60% reflective layer also added on the existing glass. This design application can also be seen in figures 4 and 5.

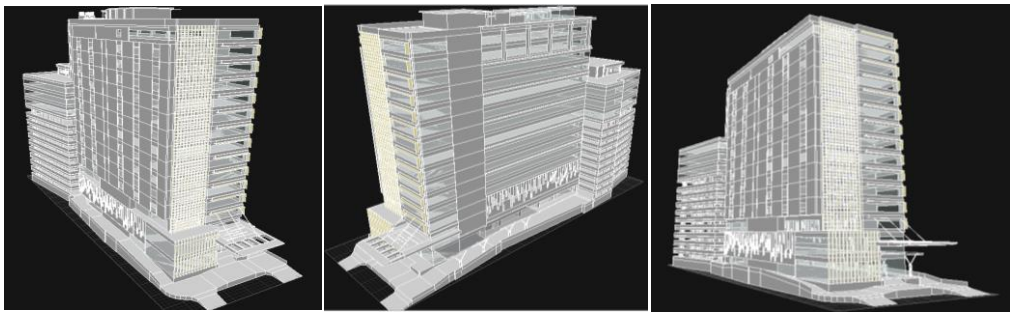


Figure 3. Application of design and material recommendations in existing buildings.

3.2.4. Detail

a. Vertical combination
b. Eggrate
c. L shape

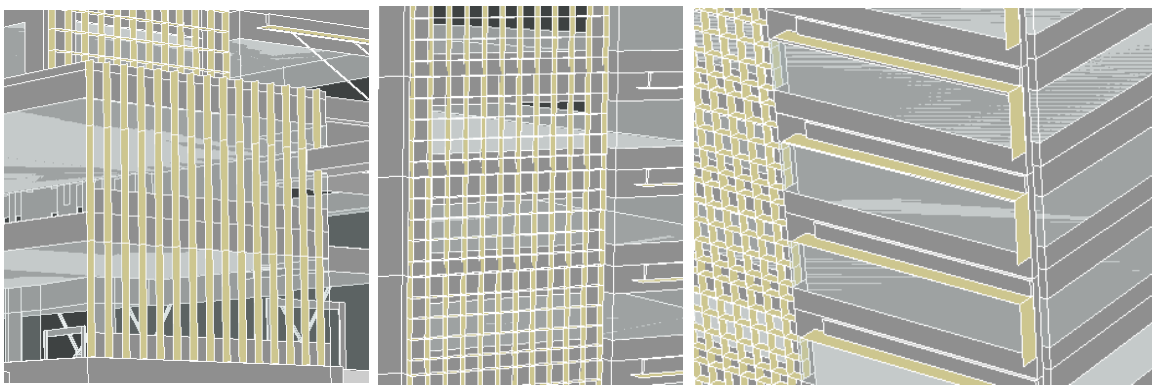


Figure 4. Detail on the application of the vertical combination: vertical combination (left), eggrate (center), L shape (right).

4. Conclusion

After making a design recommendation to reduce the OTTV value on the Southwest facade, the calculation of the OTTV value obtained. Recommendation design generates OTTV value as 38.80 W/m², a decrease of up to 35% from the existing OTTV value of 59.44 W/m². The reduce of OTTV value on the Southwest side expected to reduce energy demand/consumption then provides energy efficiency of Suara Merdeka Tower Semarang.

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