The application of exterior sun shading on an office building in Kuningan Jakarta Selatan

FE Alaydrus, W Wizaka, A G Prawata

Architecture Department, Faculty of Engineering, Bina Nusantara University, Jakarta, Indonesia, 11480

Corresponding author: wwizaka@binus.ac.id

Abstract. The golden triangle area marked Jakarta city as a business center. Many people interested in land and buildings in this area with one of the reasons by having a strategic location, with no exception for office spaces and buildings. Kuningan, South Jakarta is a Central Business District, which in fact is filled with skyscrapers which mostly uses reflective materials for it’s skin, makes the radiation reflected and increases the temperature in the air and also inside the building. One of few strategies that is effective to prevent heat from radiation is to use exterior sun shading. The method used in this paper is quantitative approach from the simulation results using software to obtain the solar radiation values to determine the ideal sun shading types to be used in the East and West side of the building. The result of this research is the eggcrate and horizontal louvers are the ideal types of exterior sun shading to be used in the East and West side of the building in Kuningan, South Jakarta.

Keywords: radiation, exterior sun shading.

1. Introduction

The impact of global warming is already getting real and increasingly felt around us. One of the reasons is because the reflective surfaces used in the buildings reflected solar radiation, making the air temperature increases. The biggest radiation that we feel comes from the sun, as well as that obtained by the building that is direct radiation from the sun.

According to Panduan Pengguna Bangunan Gedung Hijau Jakarta Berdasarkan Peraturan Gubernur No. 38/2012 (Guide for Jakarta Green Building Based on Governor Regulation Number 38/2012), building envelope gives a big impact on the building's energy consumption since it's significantly influencing the cooling load of the building, mainly because of the radiation acquisition control through windows, and the utilization of natural light.

The biggest energy consumption in a building is on HVAC. It contributes about 47-65% of total energy consumption with energy consumption of HVAC in an office building is about 55% and the biggest external heat gain in an office building in Jakarta gained from walls and windows which is about 63%. Radiation transmission through windows is usually bigger than through walls. Therefore, the planning and design process for windows should be done carefully to avoid excessive heat gain through orientation adjustment, area of the window opening, shading coefficient, and the use of exterior sun shading.
Table 1 shows the simulation result of the radiation conducted in an office building in Kuningan South Jakarta. The simulation was done in four times which are on 21st March (0°), 21st June (23.5° north latitude), 23rd September (0°), and 22nd December (23.5° south latitude) and in the time of office hour which starts from 09:00 to 17.00.

| Solar Radiation Value on a High Rise Building in Site | North  | East  | South | West  |
|------------------------------------------------------|--------|-------|-------|-------|
| 21st March                                           | 181.0  | 595.3 | 70.4  | 594.6 |
| 21st June                                            | 429.2  | 459.5 | 60.8  | 465.4 |
| 23rd September                                       | 203.9  | 572.6 | 65.7  | 559.6 |
| 22nd December                                        | 63.7   | 556.3 | 295.9 | 541.4 |

Based on the simulation's result stated in Table 1, the solar radiation value tends to be high on every side, but the east and west side are the two sides that have the highest radiation value throughout the year.

According to Givoni (1994) in his book titled Passive Low Energy Cooling of Buildings, solar radiation on buildings can be controlled with shading on its openings and with colour on the walls. White-coloured walls or walls shaded by vegetation is effectively exposed to lower radiation even when it is facing east or west. It is almost the same with eastern and western openings, if completed with shutters, it can be protected from solar radiation while taking advantage of the east or west wind as ventilation.

According to World Building Design Guide, solar control and shading devices can be applied with various building components, that are landscape features, exterior elements such as overhangs or vertical fins, low Shading Coefficient (SC) glass, and interior glare control devices.

Basically, exterior shading designed to protect the building from direct solar radiation and glare. According to Lechner (2015) on his book, Heating, Cooling, Lighting Sustainable Design Methods For Architects (4th Edition), shading is one of the most important sustainability strategies because almost all buildings overheat in the summer and usually they use air conditioner to reduce the heat, but the energy needed will be increasing because of the air conditioner. The increasing energy demand for cooling should be minimized by heat avoidance and passive cooling, and the number-one heat-avoidance strategy is shading, which is part of tier one of the three-tier design approach to cooling a building. Al-Musaed, on his book, Biophilic and Bioclimatic Architecture (2011), writes that a well planned exterior shading can be the most effective method to reduce solar heat gain. The most important benefit of exterior shading, out of all categories is that the absorbed solar heat released to open spaces and not released to the building like with internal shading.

Therefore, based on the explanation above, this research will be focusing on the types and dimensions that can be effectively used to reduce solar radiation in an office building. This research is also focusing on the planning and design of the exterior shading on the east and west side of the building since these two sides based on the simulation's result explained before are the sides that have the highest solar radiation value throughout the year.

2. The methodology

The research methodology used in this paper is the quantitative method, which will produce number of dimensions and space in between the sun shading. The sun shading then will be applied to the building mass and simulated with Autodesk FormIt to get the solar radiation value on the building. The simulation is used to first get the solar radiation values in a building before using exterior shading, then by comparing the application of exterior shading in buildings that were already built, the type of exterior shading to be used in the East and West direction will be obtained. After that, simulation is done once again to get the solar radiation values and obtain the ideal shading type to be used in the building.
3. Result and discussion

3.1 Solar Radiation analysis on site

This analysis is done by simulating the radiation conducted in a building in Kuningan South Jakarta. The simulation was done in four times which is on 21st March (0°), 21st June (23.5° north latitude), 23rd September (0°), and 22nd December (23.5° south latitude) and in the time of office hour which starts from 09:00 to 17.00. Below is the result of the simulation.

| Table 2. Average Solar Radiation Value on a High Rise Building in Site |
|-----------------------------|-----------------|-------------|-------------|
| Solar Radiation value (W/sqm) | North | East | South | West |
| 21st March | 181.0 | 595.3 | 70.4 | 594.6 |
| 21st June | 429.2 | 459.5 | 60.8 | 465.4 |
| 23rd September | 203.9 | 572.6 | 65.7 | 559.6 |
| 22nd December | 63.7 | 556.3 | 295.9 | 541.4 |

From the table above, the result shows that the solar radiation value tends to be high on every side. From that table, the following result are obtained.

- On 21st March, the highest solar radiation value is on the East side (595.3 W/sqm), followed by West side (594.6 W/sqm), North (181 W/sqm), and South (70.4 W/sqm).
- On 21st June, the highest solar radiation value is on the West side (465.4 W/sqm), followed by East side (459.5 W/sqm), North (429.2 W/sqm), and South (60.8 W/sqm).
- On 23rd September, the highest solar radiation value is on the East side (572.6 W/sqm), followed by West side (559.6 W/sqm), North (203.9 W/sqm), and South (65.7 W/sqm).
- On 22nd December, the highest solar radiation value is on the East side (556.3 W/sqm), followed by West side (541.4 W/sqm), South (295.9 W/sqm), and North (63.7 W/sqm).

According to the result, it can be confirmed that two sides with the highest solar radiation value are the East and West side. Therefore, the further research will be focusing on solar radiation that affects the East and West side.

3.2 Comparison of the application of exterior shading in local and overseas buildings

Choosing an exterior sun shading cannot be chosen just like that but must be well planned. To determine the type of sun shading that will be used on the east and west side of the building, a comparison is done with the precedents from Indonesia and other countries with a similar climate.

| Table 3. Comparison of Sun Shading Types Used in Buildings |
|---------------|-----------------|-----------------|-----------|
| Building      | Function        | Location        | Orientation          | Shaded Side | Shading Types       |
| SQ Dome       | Mixed-Use       | Jakarta, Indonesia | North West – South East | All Sides | Horizontal Louvers |
| Perpustakaan Pusat UGM | Library | Yogyakarta, Indonesia | South West – North East | South-West | Slanted Vertical Fins |
| Unilever HQ   | Office          | Jakarta, Indonesia | North – South       | All Sides | Horizontal Louvers |
| Sequis Center | Office          | Jakarta, Indonesia | North East – South West | All Sides | Eggcrate |
| Pertubuhan    | Office          | Malaysia         | North West – North West | North West | Vertical |
From the table above we can get which types of shading that can be used in which direction. We can take the conclusion that the types of exterior shading which can be used at the east and west directions are Horizontal louvers, Eggcrate, Vertical fins, dan Slanted vertical fins.

3.3 Sun path analysis

Before simulating the sun shading, the dimension of the shading must be determined first. Which will be obtained by analyzing the sun path on the site. The sun path that will be analyzed is the sun path on 21st March (0°), 21st June (23.5° north latitude), and 23rd September (0°).

First, the analysis was done to determine the vertical shadow angle (VSA) by using the sun path of 21st March. As can be seen in Figure 1, the altitude of 40° at 09.45 is obtained.
After the altitude is obtained, then the length of the overhang is also obtained which is 1.15 m (for one overhang in every floor) and 80 cm long with the gap 90 cm for every overhang (for two or three overhangs in every floor), and horizontal louvers with 50 cm distance from the building skin and the length of 35 cm with the gap of 30 cm in between every louvers.

Then, the sun path of 23rd September was analyzed, and as can be seen on Figure 3, the altitude of 46° at 09.50 is obtained.

After the altitude is obtained, then the length of the overhang and horizontal louvers are obtained. The lengths are the same which is 1.15 m and 80 cm long with the gap 90 cm (for two or three overhangs in every floor), and horizontal louvers with 50 cm distance from the building skin and the length of 35 cm with the gap of 30 cm in between every louvers.
Figure 4. Horizontal Shading

After that, the sun path of 21st June is analyzed to find out the angle of the sunlight to determine the dimension of fins, and the angle of 60° is obtained. From that angle, the depth of the fins is 75 cm with the distance between fins is 95 cm. as for slanted vertical fins with 30° tilt to the north, with the depth of 75 cm and the distance between fins are 80 cm.

Figure 5. Vertical Shading

3.4 Analysis of the application of exterior shading on high rise building in Kuningan

From the previous analysis, the type of sun shading can be used in the East and West are already obtained, which is Horizontal louvers, Eggcrate, Vertical fins, dan Slanted vertical fins. In this analysis, the sun shading will be applied in the building and simulated using Autodesk FormIt to get the solar radiation value and determine which types is the most effective to be used on each side. This analysis is also done in four times which is on 21st March (0°), 21st June (23.5° north latitude), 23rd September (0°), and 22nd December (23.5° south latitude) and in the time of office hour which starts from 09:00 to 17.00.

Table 4. Solar Radiation Value from Sun Shading Simulation

| Types of shading       | Solar Radiation Values (W/sqm) | Average Value of the Solar Radiation (W/sqm) | Reduction percentage |
|------------------------|--------------------------------|-----------------------------------------------|----------------------|
|                        | 21st March | 21st June | 23rd September | 22nd December | | |
| **East**               |            |           |                |               | | |
| Vertical Fins          | 97.6       | 97.9      | 104            | 108.6         | 102.0 | 81.31% |
| Slanted Vertical Fins  | 594.6      | 459.5     | 572.6          | 100.2         | 431.7 | 20.92% |
| Eggcrate               | 98.6       | 83.5      | 81.1           | 75.7          | 84.7  | 84.48% |
| Horizontal Louvers     | 91.6       | 79.2      | 92.5           | 75.4          | 84.7  | 84.48% |
| **West**               |            |           |                |               | | |
| Vertical Fins          | 109.6      | 90.3      | 105.9          | 87.3          | 98.3  | 81.05% |
| Slanted Vertical Fins  | 594.6      | 85        | 559.6          | 541.4         | 445.2 | 17.59% |
| Eggcrate               | 100.7      | 90.8      | 84.7           | 81.7          | 89.5  | 83.43% |
| Horizontal Louvers     | 76.5       | 83.9      | 96.2           | 92.1          | 87.2  | 83.86% |

From the table above, the lowest solar radiation value we can get on the East side is with using either eggcrate or horizontal louvers since they have the same Solar Radiation value and reduction percentage. While on the West side is only with using horizontal louvers since it is the only one that
has the lowest solar radiation value and the biggest reduction. We can also use the eggcrate on the west side but we can’t get the reduction as high as we’re using horizontal louvers. Seeing on the illustration of the simulated building in Figure 6 and Figure 7, the surface with Horizontal Louvers are evenly shaded compared to the surfaces shaded by Eggcrates. The average solar radiation value of Eggcrate and Horizontal Louvers in the East side throughout the years are the same which is approximately 84.7 W/sqm with the reduction as high as 84.48%, and the average solar radiation value of horizontal louvers on the West side is approximately 87.2 W/sqm with the reduction as high as 83.86%.

3.5 Analysis of the application of exterior shading with material on high rise building in Kuningan

After the exterior shading type that is effective is obtained, materials are applied to know it’s impact. The materials used are light grey coloured aluminium, dark grey coloured aluminium, wood, and concrete. These materials then applied on the shading in east and west side of the building and also on eggcrates on east side of the building, then simulated using Autodesk FormIt to get the reduction percentage of solar radiation value.

| Types of Shading | Types of Materials | Reduction of Solar Radiation Values (%) |
|------------------|--------------------|-----------------------------------------|
|                  |                    | East                  | West                    |
| Horizontal Louvers | Aluminium (light grey) | 83.32               | 83.27               |
|                  | Aluminium (dark grey) | 83.13               | 82.71               |
|                  | Wood                | 82.66               | 82.13               |
|                  | Concrete            | 82.26               | 82.53               |
| Eggcrate         | Aluminium (light grey) | 83.02               | -                   |

Figure 6. Illustration of the Solar Radiation Value on A Building Shaded by Horizontal Louvers

Figure 7. Illustration of the Solar Radiation Value on A Building Shaded by Eggcrate
From the table above, the highest reduction of the solar radiation value we can get is by using light grey coloured aluminium on horizontal louvers on the east side and using light coloured aluminium on the west side. There is no significant difference on the result which is only 1.19%. This shows that choosing materials for the exterior shading can also be done by considering other aspects.

4. Conclusion

Based on the research above, we can conclude that the type of exterior shading that can be effectively used on an office building in Kuningan, South Jakarta is horizontal louvers in the West side of the building and either horizontal louvers or eggcrate on the East side of the building. The dimension of the horizontal louvers is 40 cm length with a gap of 30 cm and with 50 cm distance from the building skin for every louvers while the dimension of the eggcrates is 75 cm length and 75 cm depth. With this shading the solar radiation value is decreased to approximately 84.7 W/sqm on the East side and 87.2 W/sqm on the West side of the building, and the material that is used for the exterior shading is aluminium with the colour light grey.

References
[1] Lechner, N. (2015). Heating, Cooling, Lighting Sustainable Design Methods For Architects. Canada: John Wiley & Sons.
[2] Almusaed, A. (2011). Biophilic and Bioclimatic Architecture “Analytical Therapy for the Next Generation of Passive Sustainable Architecture. Denmark: Authors
[3] Givoni, B. (1994). Passive Low Energy Cooling of Buildings.
[4] Whole Building Design Guide. (2016). Sun Control And Shading Devices.
[5] Dinas Penataan Kota Pemerintah Provinsi DKI Jakarta. Panduan Pengguna Bangunan Gedung Hijau Jakarta Berdasarkan Peraturan Gubernur No. 38/2012 vol. 1 Selubung Bangunan.
[6] Gubernur Provinsi DKI Jakarta. Peraturan Gubernur Provinsi Daerah Khusus Ibukota Jakarta Nomor 38 Tahun 2012 Tentang Bangunan Gedung Hijau.