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Original Paper

Characteristics of Building Envelope that Influence the Value of Operative Temperature on Office Buildings Based on Jakarta Climate Data

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ABSTRACT

Architecture is accused of being an energy user and the most significant contributor to global warming, so it is the architect's responsibility to ensure that indoor comfort conditions are achieved with little or no traditional energy. This study focuses on knowing the best Range in building envelope configurations to obtain Operative Temperature comfort values. Simulation methods is used for model this research. Software that b used for this research are EnergyPlus v8.1 and Open Studio plugin version 0.7. The results show that the temperature of operative temperature (Top) does not reach a comfort value of 25 ° C by SNI 03-6572-2001 standards. If the air temperature setting is smaller, the energy consumption of the building will be higher. In the WWR variation, intensity of energy consumption per Ta was reduced by 1 ° C by 3.68 kWh / m2. Then in the variation of SHGC, increase energy consumption value of each Ta is reduced by 1 ° C by 3.44 kWh / m2. While for shading variations, the increase in value is 3.57 kWh / m2.

***Keywords**: window to wall ratio (wwr), shading, building envelope, thermal, architecture*

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ABSTRAK

Arsitektur dituduh sebagai pengguna energi dan penyumbang paling signifikan terhadap pemanasan global, sehingga merupakan tanggung jawab arsitek untuk memastikan kondisi kenyamanan dalam ruangan dapat dicapai dengan sedikit atau tanpa energi tradisional. Penelitian ini fokus untuk mengetahui Range terbaik pada konfigurasi selubung bangunan untuk memperoleh nilai kenyamanan Suhu Operasional. Metode simulasi digunakan untuk memodelkan penelitian ini. Perangkat lunak yang digunakan dalam penelitian ini adalah EnergyPlus v8.1 dan plugin Open Studio versi 0.7. Hasil penelitian menunjukkan bahwa suhu suhu operasi (Top) belum mencapai nilai kenyamanan sebesar 25°C menurut standar SNI 03-6572-2001. Jika pengaturan suhu udara semakin kecil maka konsumsi energi gedung akan semakin tinggi. Pada variasi WWR, intensitas konsumsi energi per Ta berkurang 1 °C sebesar 3,68 kWh/m2. Kemudian pada variasi SHGC, peningkatan nilai konsumsi energi setiap Ta berkurang sebesar 1 °C sebesar 3,44 kWh/m2. Sedangkan untuk variasi peneduh mengalami kenaikan nilai sebesar 3,57 kWh/m2.
Kata Kunci: window to wall ratio (wwr), Shading, selubung bangunan, energi, termal, arsitektur

INTRODUCTION

Architecture is accused of being an energy user and the most significant contributor to global warming, so it is the architect's responsibility to ensure that indoor comfort conditions are achieved with little or no traditional energy [1]. Energy-efficient architecture is an architecture with the lowest possible energy requirements that can be achieved by reducing the number of resources that make sense. The heat source in the building itself can be divided into two, namely external and internal heat loads [2]. The heat that comes with natural light is an example of external heat, while heat derived from body metabolism, lighting, and equipment is an example of internal heat. This aspect has a significant share in contributing to energy consumption in buildings. Thermal comfort we can talk about [3], indeed will not be separated by making the temperature indicator a benchmark. The actual indicator that must be considered in achieving the comfort level of humans inhabiting that space is the Operative Temperature value, where Operative Temperature is the average value of the sum between water temperature and mean radiant temperature and is the temperature directlyfelt by skin [4].

This study explains in more detail the use of heating systems that oppose cooling systems. This shows that the farther away the area is from the site of the outermost opening, the higher the temperature will be felt. In the case of buildings with a heating system and a sub-tropical climate with four seasons. If the building uses a cooling system, the farther the distance from the opening area, the lower the temperature felt [5].

So far, storeys buildings that use artificial ventilation just pay attention to air temperature in the cooling system / HVAC [6]. The Operative Temperature value must be achieving human comfort level, where Operative Temperature is the temperature directly felt by human skin (Borgstein, 2014). This study aimed to determine the characteristics of building envelopes to attain optimal operative temperature values based on climate data. In addition, it is also associated with the amount of energy consumption in buildings when affected by a decrease in the Operative Temperature value if applied in the city of Jakarta [7].

RESEARCH METHOD

This research uses simulation methods using modelling on computer The simulation in this research was carried out computerized with the help of the superior software used [8], namely EnergyPlus v8.1 and the Open Studio plugin version 0.7 which was run on Google Sketchup v7.0 software. Modeling in this system is carried out on the middle floor with modeling only on typical floors [9]. In Figure 1, the hypothetical floor dimensions are 40m x 40m. The division of zones in a typical floor model can be explained as follows, four office activity zones (air-cooled) and one core zone in the middle of the building (not air-conditioned). The naming of office zones includes east, south, west and north zones. The top and bottom floors of the simulation floor will be modeled adiabatically [10].

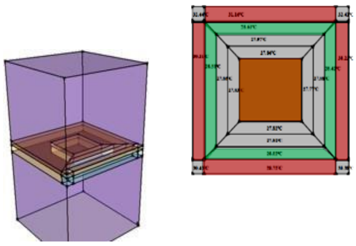

Figure 1. Hypothetic Building Modelling Source: Personal Analysis, 2019

This type of building modelling is divided into six parts from each orientation, namely two parts of the corner or angle which gets sunlight from two directions and four parts of depth. Between depth is taken as a 3.5m drive because, at that distance, the Top temperature data is obtained, significantly different from the temperature of the Top zone in the first [11]. The function of the building to be studied is an office with an open plan layout set to simplify the calculation of air-cooling load (cooling load). Work time is set 5 days a week starting at 08.00-18.00.

The simulated variables include (applied to each orientation) the area of glass (WWR 30%; 40%; 50%; 60%; 65%). In this study WWR 10% -20% was very rarely applied in building design so it was not applied as a variable. Besides that, it also shows water temperature as a variable, where the variations include Ta 20 ° C, 18 ° C, 15 ° C. Then horizontal shade element variables (VSA 30, VSA 50, VSA 70, VSA 90).

RESULT AND DISCUSSION

Effect of Window to Wall Ratio (WWR)

<u>Effect of WWR Variation on the Radiant Temperature Mean Value</u>

The size of the opening is very influential on the value of Mean Radiant Temperature (TMRT) [12] . In this simulation, the application of a large number of openings from 30% to 65%, by locking the glass SHGC at a value of 0.4 (Stopsol Dark Blue type) and the value of water temperature in the HVAC setting of 25 ° C without using shading. This comparison is done to show the effect of increasing the WWR number on changes in the value of TMRT. If the larger WWR means the wider the area of the glass and the smaller the size of the massive wall. The larger the area of the glass will give effect to raise heat that get into the room which will directly affect the value of TMRT [13].

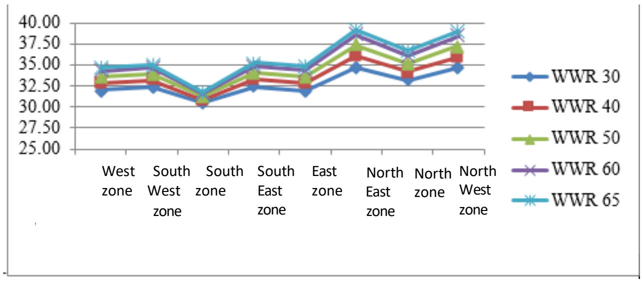

Figure 2. Graph Value of the WWR Intermediate Radiant Temperature Mean
Source: Personal Analysis, 2019

Based on the figure 2, the simulation results show that the greater the ratio of the glass field will the greater the value of the value obtained. In addition, it can be seen that the simulation results showthe influence of WWR on the value of each orientation obtained that is highest in the northwest orientation and lowest in the southern orientation. The range of TMRT values when carried out by WWR variations is at a temperature of 30.49 ° C-39.26 ° C. From a 10% drop WWR can reduce the temperature of the Tm by approximately 1 ° C-1.5 ° C.

From the explanation above it can be explained on the Table 1 that the glass field provides the greatest contribution to indoor heat compared to a massive field or wall. Thus, increasing the area of the wall will reduce the value of TMRT so that the heat will get into the building less.

Table 1. Comparison of the Maximum Value and Minimum Surface Inside Temperature with Mean Radiant Temperature

	WWR	**SHGC**	**Shading**
***Surface Inside Temperature* Minimum**	31.44°C	30.40	**31.40°C**
***Surface Inside Temperature* Maximum**	40.98°C	39.18	**38.85°C**
Surface Inside Temperature Decrease range	0.2°C-1°C	1.2°C-4.5°C	**1°C-3°C**
	WWR Variation	SHGC Variation	**Shading Variation**
T_{mrt} Minimum	30.49°C	30.01°C	**30.54°C**
T_{mrt} Maximum	39.26°C	39.09°C	**36.07°C**
T_{mrt} Decrease range	**1°C-1.5°C**	**1°C-3.5°C**	**0.2°C-2°C**

<u>Effect of WWR Variation on Operative Temperature Value</u>

In Figure 3 that have been carried out, the lowest Top value when varying WWR is 30% -65% with the condition of SHGC still 0.4 and Ta 25 ° C achieved in WWR 30% conditions, 28.31 ° C and the highest Top value in WWR 65%, namely 32.44 ° C. Every 10% reduction in WWR can reduce the Top value by 1 ° C to 2 ° C as shown in the graph below.

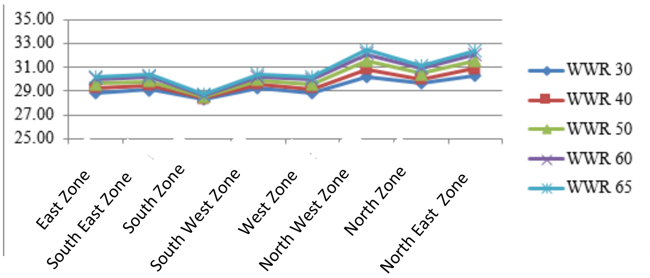

Figure 3. Graph of Correlation between WWR and Operative Temperature Value
Source: Personal Analysis, 2019.

Further simulation analysis is carried out by looking at the energy consumption consumed by the building. The size of the temperature or temperature is closely related to the size of the energy consumed by the building, this is because the lower the perceived value, the greater the consumption of energy used to cool the room, but despite the greater energy consumption but the occupants of the building will reach the optimal level of comfort. The table below is a table of obtaining energy consumption from WWR 40 compared to WWR 65 in conditions of HGC still 0.4, Ta 25 ° C and without using shading.

Table 2. Table of Acquisition of Energy Consumption between WWR

	Electricity Intensity [kWh/m2]
Lighting	**26.58**
HVAC	**58.48**
Other	**28.24**
Total	**113.3**

	Electricity Intensity [kWh/m2]
Lighting	**26.58**
HVAC	**63.95**
Other	**28.24**
Total	**118.77**

Source: Personal Analysis, 2019.

The difference in the amount of energy consumption between WWR 40% and WWR 65% is 5 kWh / m2 explain ini Table 2 dan 3. These results show the greater the WWR the greater the energy consumption. This is becausethe bigger the WWR will be the greater the heat that will be received by the building. With this condition, the greater the energy needed to be able to cool the building.

Table 3. Table Comparison of Operative Temperature Values between Variables

	WWR Variation	**SHGC Variation**	**Shading Variation**
T_{op} Minimal Value	28.31°C	28.25°C	**28.61°C**
T_{op} Maximal Value	32.44°C	32.37°C	**30.83°C**
Decrease range	**0.1°C-0.6°C (Every 10% reduction in WWR)**	**0.2°C-1.7°C (Each decrease inSHGC is 0.2)**	**1.5°C (Non Shading-ShadingVSA 70)**

Effect of Air Temperature on Operative Temperature Value

The lowest Top temperature value when using the Ta setting of 25 ° C [14] which is 28.25 ° C. This shows on figure 4 that what has been done so far in designing comfort in space does not meet the appropriate standards. Then the next simulation is carried out by using air temperature (Ta) as a variable. The process carried out in the experiment is by changing the air temperature setting. Air Temperature variable values include 20°C, 18°C and 15°C. The target comfort value to be achieved is depends on the comfort value or operative temperature stated in SNI 03-6572-2001, namely 25°C.

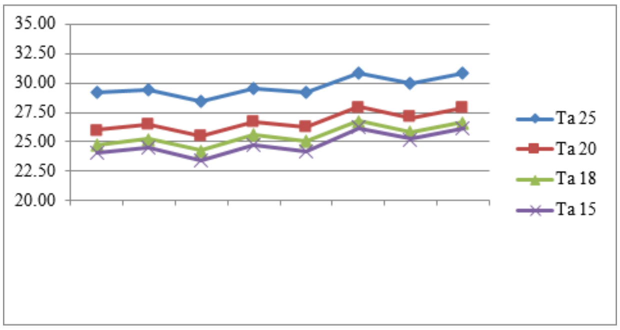

Figure 4. Graph of Operative Temperature Value When Decreased in Air Temperature Settings
Source: Personal Analysis, 2019.

The results of advanced simulations that have been done by changing the Ta settings and locking the WWR at 40%, SHGC 0.4, without using shading it can be seen that the Top value decreases with the Ta setting below 25 ° C. When the Ta setting is decrease to 20 ° C, the lowest Top value is reached at 25.47 ° C and the highest value is 27.95 ° C. The second step is to reduce the Ta setting to 18 ° C, the results obtained are the lowest Top value of 24.23 ° C and the highest value of

26.79 ° C. Further simulations are still carried out, namely by reducing the Ta setting to 15 ° C. This simulation shows the results of almost all sides reaching numbers below 25 ° C except the northwest and northeast areas. The lowest Top result in this Ta 15 ° C setting is 23.38 ° C and the highest value is reached at 26.17 ° C.

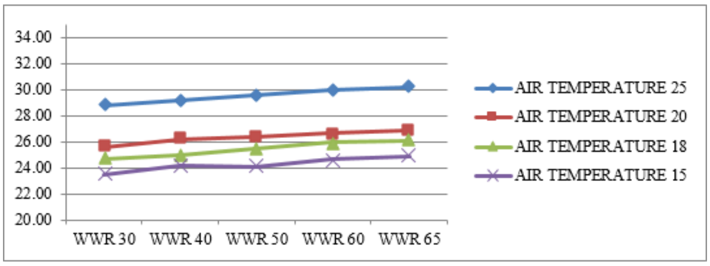

Figure 5. Operative Temperature Value Chart When Performed in Decreasing Inter-WWR Temperature Water Settings
Source: Personal Analysis, 2019.

The Figure 5 is a graph of Ta modification in WWR 30% -65% on the western wall. When the Ta setting changes to 20 ° C that meet the Top value on SNI standards, the occupant's comfort value of 25 ° C is only WWR 30%. Then changes were made again to the Ta setting to 18 ° C, the results obtained were those that were able to meet the Top SNI standards, namely WWR 35%, WWR 40% and WWR 50%. The last modification done is to change the Ta setting to 15 ° C and the whole WWR variable from 35% -65% can reach the Top value ± 25 ° C.

The graph above is a simulation result by locking the WWR variable at 40%, SHGC 0.4 and without shading. The results can be seen if the conditions can reach Top ± 25 ° C in all orientation directions, namely in the Ta setting of 18 ° C and 15 ° C. Based on the explanation above, it can be summarized that the WWR is almost always fulfilled to reach the comfort level of Top 25 ° C, which is between 30% -40%.

The Effect of Decreasing Air Temperature on Energy Consumption Intensity

The level of energy consumption is influenced by the air temperature settings carried out. Decreasing the air temperature to reach air temperature has a direct impact on the energy consumption intensity of the building. The smaller the Ta temperature setting, the performance of the HVAC system will increase, resulting in higher energy consumption in the building but comfortably will have a very good effect to people that used the building. The Figure 6 below is a graph of the simulation results in several variations of WWR can show the level of increase in energy consumption from changes in Ta settings.

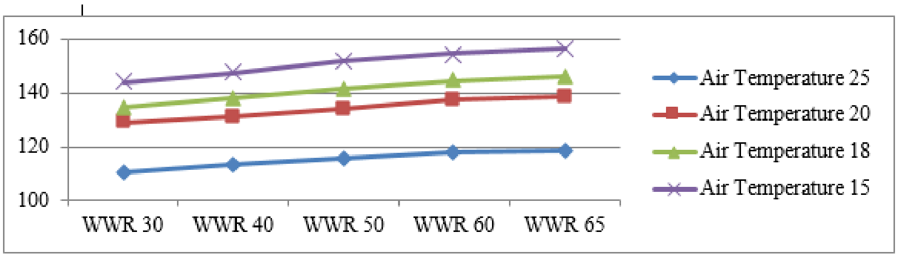

Figure 6. Graph of the Value of Increase in Energy Consumption Intensity After the Decreasing of Temperature Water Settings

Source: Personal Analysis, 2019.

The table 4 shows the simulation results with a fixed SHGC of 0.4, WWR 30% -65% and the Ta setting is reduced from 25 ° C to 20 ° C, 18 ° C and 15 ° C.

Table 4. The Intensity Value of Energy Consumption (kWh / m2) between WWRs is based on a Decrease in Water Temperature Settings

	Energy Consumption Intensity (kWh/m2)				
	WWR 30	**WWR 40**	**WWR 50**	**WWR 60**	**WWR 65**
Air Temperature 25	110.65	113.30	115.62	117.78	**118.77**
Air Temperature 20	129.17	131.30	134.37	137.39	**138.73**
Air Temperature 18	134.57	138.24	141.74	144.62	**145.99**
Air Temperature 15	**144.10**	**147.30**	**151.71**	**154.56**	**156.41**

Source: Personal Analysis, 2019.

Table 5. Difference in Value of IKE or Energy Consumption Intensity (kWh / m2) between WWR

Energy Consump tio n Intensity (kWh/m2)	**Differe nce IKE WWR 30**	**Differe nce IKE WWR 40**	**Differe nce IKE WWR 50**	**Differe nce IKE WWR 60**	**Differe nce IKE WWR 65**	**Averag e Differe nce IKE**	**Increas e Range IKE (kWh/m2)**
***T_a* 25&20**	18.52	18.00	18.75	19.61	19.96	18.97	**18-20**
***T_a* 25&18**	23.92	24.94	26.12	26.84	27.22	25.81	**24-27.5**
***T_a* 25&15**	**33.45**	**34.00**	**36.09**	**36.78**	**37.64**	**35.59**	**33.5-38**

Source: Personal Analysis, 2019.

If seen from the table 5, it can be seen that every decrease in regulation Ta will increase energy consumption. The range of increases in energy consumption per 10% WWR increase in the reduction of 25 ° C to 20 ° C is 18 kWh / m2 - 20 kWh / m2. Then an increase of about 24 kWh / m2 - 27.5 kWh / m2 each increases 10% WWR when the Ta is decrease to 18 ° C from 25 ° C. After that there was an increase in energy consumption of approximately 33.5 kWh / m2 - 38 kWh / m2 in the reduction of Ta from 25 ° C to 15 ° C at every 10% increase in WWR.

Shading Effect Analysis

<u>Analysis of Variations in Shading on the Radiant Temperature Mean Value</u>

In an effort to determine the effect of using shading on TMRT values, a simulation was carried out by locking WWR at 40%, SHGC 04, and Ta setting 25 ° C. while the simulated free variable is VSA 30, VSA 50, VSA 70 and without shading. The existence of this shading is able to reduce the value of surface inside temperature significantly. With that it is also able to reduce the TMRT value of the room.

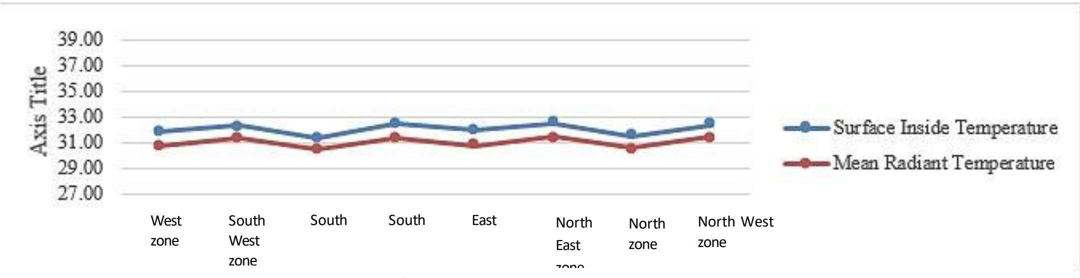

Figure 12. Graph the value of Surface Inside Temperature and Mean Radiant Temperature at VSA 30
Source: Personal Analysis, 2019.

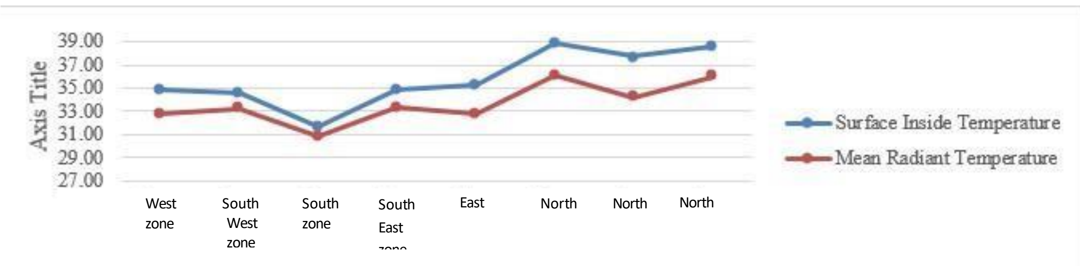

Figure 13. Graph of Surface Inside Temperature and Mean Radiant Temperature When Not Using Shading
Source: Personal Analysis, 2019.

Based on the figure 12 and 13 can be seen that shading can reduce the value of surface inside temperature, the wider the shading will be the smaller surface inside temperature. The wider the shading, the more constant the temperature or temperature is from each zone. This is because the wider the shading will be more able to withstand the heat or radiation of the sun entering the building. On the Table 9 and Figure 14 with less light entering the food, it will further reduce the surface inside temperature and TMRT of the room. The existence of shading can reduce the surface inside temperature of approximately 1 ° C-3 ° C.

Table 9. Value of Surface Inside Temperature between Application Shading

	VSA 30	VSA 50	VSA 70	Non-Shading
East Zone	31.84	32.59	33.61	**34.91**
Southeast Zone	32.33	32.93	33.62	**34.59**
South Zone	31.40	31.43	31.44	**31.62**
Southwest Zone	32.48	33.16	33.88	**34.87**
West Zone	32.00	32.84	33.86	**35.22**
Northwest Zone	32.57	33.58	35.99	**38.85**
North Zone	31.56	32.18	34.80	**37.71**
Northeast Zone	**32.44**	**33.41**	**35.78**	**38.58**

Source: Personal Analysis, 2019.

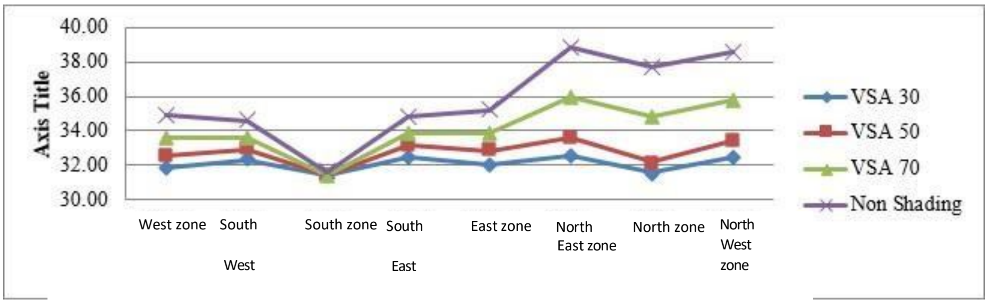

Figure 14. Graph Value Surface Inside Temperature between Shading
Source: Personal Analysis, 2019.

Indirectly from the explanation on figure 14, if the wider the shading will decrease the surface inside temperature, the TMRT value will also decrease by applying shading. The detailed on the figure 15 and table 10.

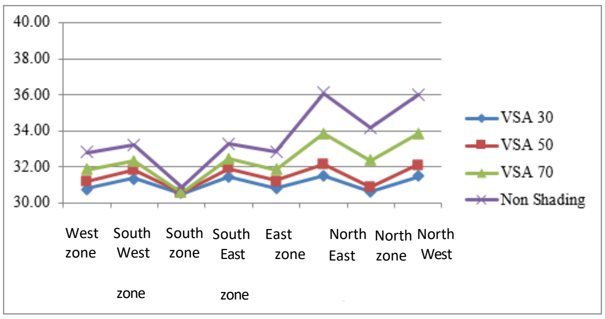

Figure 15. Graph Value of Temperature Radiant Mean between Shading
Source: Personal Analysis, 2019.

Table 10. Value of Temperature Radiant between Shading Applications

	VSA 30	VSA 50	VSA 70	Non-Shading
East Zone	30.80	31.19	31.85	**32.81**
Southeast Zone	31.39	31.82	32.36	**33.21**
South Zone	30.54	30.56	30.59	**30.88**
Southwest Zone	31.45	31.92	32.45	**33.30**
West Zone	30.82	31.24	31.85	**32.83**
Northwest Zone	31.50	32.16	33.87	**36.07**
North Zone	30.63	30.92	32.36	**34.19**
Northeast Zone	**31.47**	**32.13**	**33.85**	**36.03**

Source: Personal Analysis, 2019.

From the figure 15 and table 10, the results of simulations show that the wider the use of shading, the smaller the value of TMRT will be smaller. Besides that, it can be seen that the simulation results show the effect of shading on the value of TMRT of each orientation obtained that is highest in the northwest orientation and lowest in the southern orientation. The range of TMRT values when shading variations are carried out at a temperature of 30.54 ° C-36.07 ° C. From each use of shading can reduce 0.2 ° C-2 ° C.

Table 11. Comparison of Obtained Maximum and Minimum Surface Inside Temperature Values with Mean Radiant Temperature

	WWR Variation	**SHGC Variation**	**Shading Variation**
***Surface Inside Temperature* Minimum**	31.44°C	30.40	**31.40°C**
***Surface Inside Temperature* Maksimum**	40.98°C	39.18	**38.85°C**
***Surface Inside Temperature* Decrease Range**	0.2°C-1°C	1.2°C-4.5°C	**1°C-3°C**
	WWR Variation	SHGC Variation	**Shading Variation**
T_{mrt} Minimum	30.49°C	30.01°C	**30.54°C**
T_{mrt} Maksimum	39.26°C	39.09°C	**36.07°C**
Decrease Range T_{mrt}	**1°C-1.5°C**	**1°C-3.5°C**	**0.2°C-2°C**

Source: Personal Analysis, 2019.

Based on table 11, it can be seen from the simulation results that when varying the type of glass (SHGC) a significant average reduction was achieved, namely with a decrease of 4.5°C for every 0.1 decrease in the SHGC value.

<u>Shading of Operative Temperature Value</u>

In figure 16, it was shown that the use of shading compared to not using shading was able to reduce the operative temperature but not significantly decrease, approximately 1.5 ° C. However, when varied in length, the shading effect is very small and very insignificant. On the Figure 16, The graph trend of the shading simulation results is still the same as the previous simulation. The lowest point is in the southern orientation and the highest point is in the northwest orientation. The lowest Top Value at 28.61 ° C and the highest Top Value at 30.83 ° C.

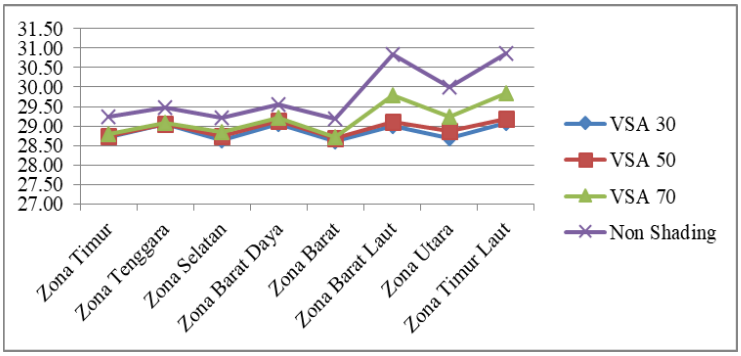

Figure 16. Graph of the Operative Temperature Value between Shading
Source: Personal Analysis, 2019.

Based on Table 12, the size of the Top is closely connected to the building energy consumption. The results obtainedshowed that shading was able to reduce energy between 4 kwh / m2 11.5 kwh / m2. This depends on the length of the short shading used. The longer the shading is used, the lower the Top in the buildingwill be, so the smaller energy consumption will be smaller.

Table 12. Table of Energy Consumption Gain between Shading

	Electricity Intensity [kWh/m2]			
	Non-Shading	VSA 70	VSA 50	**VSA 30**
Lighting	26.58	26.58	26.58	**26.58**
HVAC	58.48	54.81	50.76	**47.04**
Other	28.24	28.24	28.24	**28.24**
Total	**113.3**	**109.63**	**105.58**	**101.86**

Source: Personal Analysis, 2019.

Based on the results of the TMRT and Top simulation, it was concluded that with the setting of water temperature (Ta) fixed at 25 ° C, nothing has been fulfilled to achieve a comfortable Top for occupants of 25 ° C because the lowest temperature value is still ± 28 ° C. However, based on simulations with a fixed Ta value of 25 ° C, it is sufficient to reduce or decrease the Top value by making changes to SHGC because it can reduce by ± 01 ° C-1.7 ° C.

With reference to the comparison table 13, the acquisition of Decrease Range results in theWWR variation gets the smallest value, which is in the range 0.1 ° C-0.6 ° C (every 10% reduction in WWR). This shows that this WWR variation has a big influence in increasing the Top value in the room. The larger the glass used will not only increase the cooling load value but will also create thermal discomfort in the room.

Table 13. Table Comparison of Operative Temperature Values between Variables

	WWR Variation	**SHGC Variation**	**Shading Variation**
$T_{op\ min}$	28.31°C	28.25°C	**28.61°C**
$T_{op\ max}$	32.44°C	32.37°C	**30.83°C**
Decrease Range	**0.1°C-0.6°C (Every decrease 10% WWR)**	**0.2°C-1.7°C (Every decrease SHGC by 0.2)**	**1.5°C (Non shading-Shading VSA 70)**

Source: Personal Analysis, 2019.

While the figure 17 shows a comparison of the values of Ta, Top and TMRT. The Top value is always above the Ta value, so if the Ta setting is 25 ° C, the Top value will be above 25 ° C.

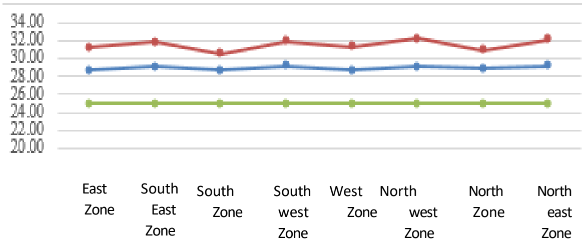

Figure 17. Comparison Chart, Mean Radiant Temperature, Operative Temperature and Standard Comfort 25 ° C
Source: Personal Analysis, 2019.

Table 14. Comparison of Interoperable Temperature Operative Temperature WWR, SHGC and Shading with Lower Temperature Air Arrangements on the Western Wall

	WWR 30	**WWR 40**	**WWR 50**	**WWR 60**	**WWR 65**
Tair 25	28.80	29.19	29.59	29.99	**30.21**
Tair 20	25.63	26.22	26.39	26.66	**26.87**
Tair 18	24.67	25.01	25.43	25.93	**26.10**
Tair 15	23.52	24.13	24.09	24.67	**24.93**
	SHGC 0.2	**SHGC 0.4**	**SHGC 0.8**		
Tair 25	28.52	29.19	30.05		
Tair 20	25.44	26.22	27.29		
Tair 18	24.36	25.01	26.21		
Tair 15	23.07	24.13	24.40		
	VSA 30	**VSA 50**	**VSA 70**	**Non Shading**	
Tair 25	28.61	28.58	28.72	29.19	
Tair 20	25.28	25.26	25.39	26.22	
Tair 18	24.12	24.26	24.56	25.01	
Tair 15	**22.98**	**23.29**	**23.48**	**24.13**	

Source: Personal Analysis, 2019.

Table 15. Difference Comparison of the Intensity Value of Energy Consumption (kWh / m2) between Variables

	Increase Range IKE (WWR)	**Increase Range IKE (SHGC)**	**Increase Range IKE (Shading)**
Tair 25&20	18-20 kWh/m2	16-18 kWh/m2	**18-19 kWh/m2**
Tair 25&18	24-27.5 kWh/m2	22-25 kWh/m2	**24-25.5 kWh/m2**
Tair 25&15	**33.5-38 kWh/m2**	**32-35 kWh/m2**	**34-34.5 kWh/m2**

Source: Personal Analysis, 2019.

Table 14-15 the WWR variation, the more in the intensity of energy consumption per Ta was reduced by 1 ° C by 3.68 kWh / m2. Then there is a variation of the Solar Heat Gain Coeffisient value of the increase in energy consumption per Ta derived by 1 ° C by 3.44 kWh / m2. While for shading variations, the increase in value is 3.57 kWh / m2

(CONCLUSION)

The simulations result said that the Air Temperature setting that applied to building systems is not suitabel because of uncomfort temperature that felt by human. It does not state and suitable with the standard value set by SNI 03-6572-2001 of 25 ° C [15]. We should be lowering the Air Temperature setting until it reaches a standard temperature of 25 ° C that felt by humans.

Table 16. Best variation of building envelope

	WWR	**SHGC**	**Shading**
Northwest	None	0.2	**VSA 50**
Northeast	**None**	**0.2**	**VSA 50**
North	**30%**	**0.2**	**VSA 70**
Southwest	40%	0.4	**VSA 70**
Southeast	40%	0.4	**VSA 70**
West	50%	0.4	**VSA 70**
East	50%	0.4	**VSA 70**
South	**60%**	**0.8**	**VSA 70**

The value of changes in energy consumption which increased significantly occurred in each variable where the air temperature setting was reduced (WWR, SHGC, Shading). In Table 16, if you look at the average results of the rising of energy consumption when the Tair setting is reduced, you can see how much energy consumption raise per air temperature setting that is reduced by 1°C. In the WWR variation, it is able to increase the intensity of energy consumption per air temperature lower by 1 °C by 3.68 kWh/m2. Then, in the SHGC variation, there is a rise in SHGC energy consumption per air temperature that is lower by 1 °C, amounting to 3.44 kWh/m2. Meanwhile, shading variation experienced an increase in value of 3.57 kWh. / m2.

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