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The Use of Venetian-Blind for the Energy Saving in Building in Southeast Sulawesi Indonesia

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Abstract

The aim of this study is to assess the use of alternative less power consumed method to obtain the thermal comfort in building based on the venetian blind in window in Southeast Sulawesi, a tropical region in Indonesia. It conducts an experiment on four selected houses with the different orientation in Kendari, the capital city of Southeast Sulawesi (around-4 South Latitude). For each house, there are two rooms utilized, each 5x5x4 meter-cubic in volume. The window in the first room is equipped with the venetian-blind, while in the other room, it is without the venetian-blind. The data collected are the temperature and the solar heat gain through the window in the room from 8 a.m to 17 p.m in September 25 to October 5, 2015. In addition, a comparison of the data collection on the solar heat gain with those of the calculation using a mathematical model is also performed in this study. The result shows that the placement of the venetian-blind can reduce the room temperature for east and west oriented windows. However, the temperature reduction is only at a certain time range. For north and south oriented windows, the device has almost no effect on the temperature reduction. The solar heat gain through the window in the case with the venetian blind is lower than those without the device. The results from the experiment and the calculation using the mathematical model show a similar pattern, even, the amount is different.

Keywords: *venetian-blind, energy, saving, Southeast Sulawesi, building*

1. Introduction

The problems of the imbalance on the energy supply and the energy consumption, and the environmental catastrophic impacts caused by the use of the conventional fossil energy today have initiated many efforts to make the efficiency in the energy use. One of the approaches on the energy efficiency is to minimize the energy use in buildings. It is believed that the building sector is responsible for about 32 percent of the world energy consumption [1]. One of the important sources for the energy consumption in buildings is the electricity use from the cooling system in the effort to make the thermal comfort for the occupant.

In Indonesia, a developing nation, minimizing the use of the electrical energy to achieve the thermal comforts in a building is not so effortlessly. Indonesia, geographically located in the equator line, has a tropical climate with the average daily temperatures more than 35^{o}C and the high relative humidity (more than 90%) [2]. As a consequence, this climate condition should require considerable energy needs to dissipate the heat in the room to provide the thermal comfort for the occupant.

One of the ways to achieve the thermal comfort with low energy consumption is the use of the venetian-blind in the window of a building. It is believed that the use

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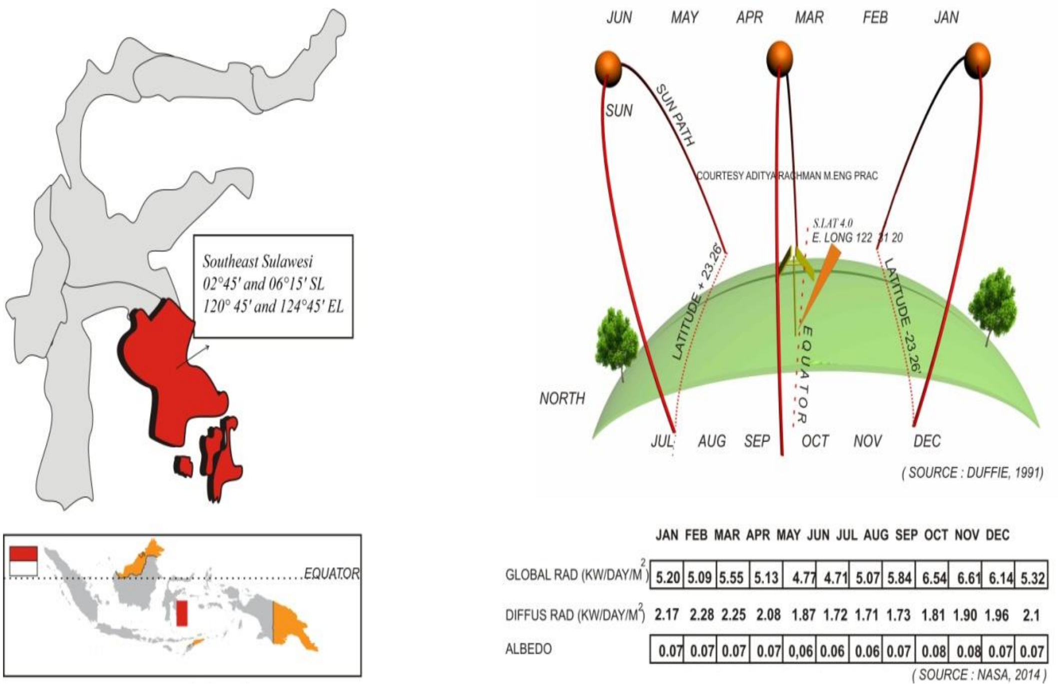
of the venetian blind can save the energy consumption from the cooling system on a building as the device potentially reduces the direct sunlight transmitted into the room [3].

For Southeast Sulawesi, a province in eastern Indonesia, maintaining thermal comfort in buildings is also not so easy. This is because the position of the region is around the equator line. The data from NASA reveals that the daily solar radiation in this region is about 5 KWH /m^2 [4]. The range of the average maximum temperature in this region is around 30ºC-35ºC, and the average minimum temperature is around 22 ºC - 25 º C with the relative humidity of about 50% - 82% [5].



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
GLOBAL RAD (KW/DAY/M^2)	5.20	5.09	5.55	5.13	4.77	4.71	5.07	5.84	6.54	6.61	6.14	5.32
DIFFUS RAD (KW/DAY/M^2)	2.17	2.28	2.25	2.08	1.87	1.72	1.71	1.73	1.81	1.90	1.96	2.1
ALBEDO	0.07	0.07	0.07	0.07	0,06	0.06	0.06	0.07	0.08	0.08	0.07	0.07

(SOURCE : NASA, 2014)

Figure 1. Southeast Sulawesi and Solar Radiation [4] [6]

The information on technical aspects on the use of the less power consumed method based on the venetian blind to achieve the thermal comfort in buildings is so essential to support the effort to make the efficiency in the energy use. The figures regarding to the effect of the venetian-blind in creating thermal comfort in the building with less consumed power use are actually already widely found in many studies in several regions worldwide. However, for the application in Southeast Sulawesi, this information is still less presented. The aspect of the geography should be a major consideration in determining how large the effect of the venetian-blind on the thermal comfort performance, and this can be quite different by regions. This is because the geography can determine how the building is exposed to the sun, which in turn it influences how effective the venetian-blind in creating the thermal comfort performance. The aim of this study is to assess the use of the venetian-blind for achieving the thermal comfort in the building in Southeast Sulawesi.

2. Literature Study

2.2. Thermal Comfort

Thermal comfort is a state of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation [7]. To maintain the standards of thermal comfort for occupants in the building is one of the important objectives on the design of HVAC (Heating, Ventilation, and Air Conditioning) [8]. In ASHRAE Standard 55-2013, for the purpose of thermal comfort of human settlements, the recommended temperatures range between 19.5 and 27.7°C with the relative humidity of about 65% [7].

2.1. Venetian Blind

Venetian-blind, usually placed on the inside and outside of a glass window, is a device to support the interior of houses, offices or other buildings and to filter light [3]. The device is also utilized to adjust the amount of the incoming solar radiation into the room for the energy savings in lighting and in determining the temperature and the visual comfort [9]. Many studies have been initiated to explore the effect of the venetian-blind on the thermal comfort performance in the building.

A study in [10] investigates the influence of venetian-blind on the room temperature on a *trombe* wall in cold weather by using a dynamic numerical model developed for cooling system. The results show that the average air temperature in the room with the venetian-blind is about 5.5°C higher than that of the classic *trombe* wall during the day, while at night, the heat loss from the building with a venetian-blind smaller. A study in [11] investigates the thermal performance of buildings using *trombe* wall with venetian-blind incorporated with a fan, in the winter and summer conditions in Hefei China. The result shows that in winter, the raise on the temperature is higher for the room with the venetian-blind at the slat angle of 45°. In summer, the venetian-blind with the slat angle of 90° assisted with the circulation fan can minimize the effects of the temperature rise (a maximum of around 2°C) and improves the airflow. A study in [12] develops a strategy to obtain a thermal comfort in building using an automatic solar heating control with the combination of ray-tracing and radiosity methods in a room with a venetian-blind. This strategy can reduce solar heat into the room to maintain the thermal comfort. A study in [13] examines the effect of a curved venetian-blind on a glass window on the solar heat transmission into a room. It employs a simulation using a mathematical model on the glass window and the venetian-blind, and an experiment. The result shows that the use of the curved venetian-blind on the glass window can significantly reduce solar heat gain into the room, compared to the plain glass window. A study in [14] develops a three-dimensional model of CFD (Computational Fluid Dynamics) to investigate the flow and the thermal transport into a wall *trombe* with venetian-blind. The model is validated by an experiment. The result shows that the position and width of the venetian blind and the area of the air duct inlet and outlet on the ventilation affect the thermal comfort performance.

2.4. Mathematical Model

In following section, it discusses a mathematical model to project the amount of the solar heat gain through glass window in a room in cases of with and without venetian blind [15]. The amount of the solar heat gain through a glass can be formulated by the following equation:

$$Q' = R\,(\tau + 0.4\,\alpha) \qquad (1)$$

Where, R is the incidence solar energy (watt/m^2), τ is the solar transmissibility and α is the solar absorptivity.

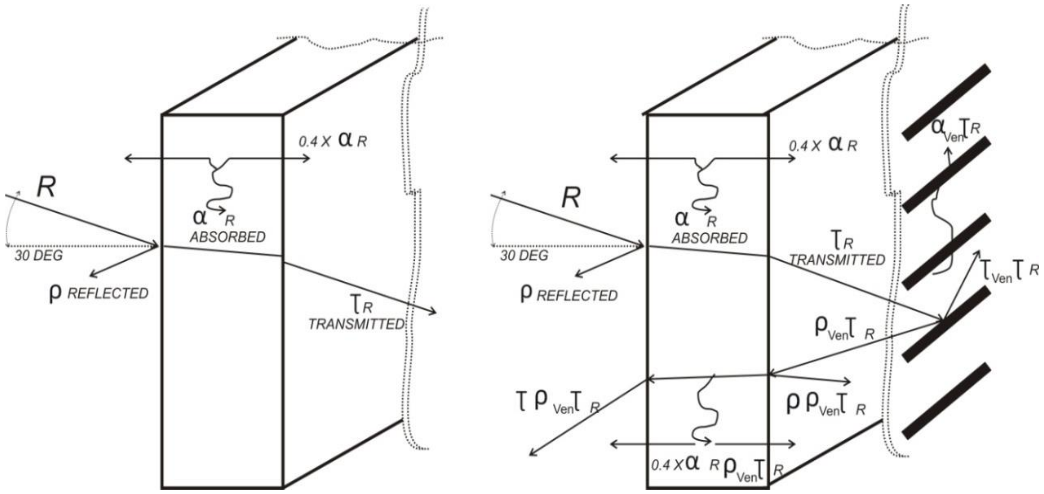


Figure 2. The Heat Gain through Glass with and without Venetian-Blind (Carrier (1974)

The following equation can determine the amount of the solar heat gain through a glass window with a venetian-blind:

$$Q = R\,(0.4\;\alpha + \tau\;(\alpha_{ven} + \tau_{ven} + \rho\,\rho_{ven} + 0.4\,\alpha\,\rho_{ven})) \qquad (2)$$

Where, ρ is the solar reflectivity on the glass, ρ_{ven} is the solar reflectivity of the venetian-blind, τ_{ven} is the solar transmissibility of the venetian-blind and α_{ven} is the solar absorptivity of the venetian-blind.

3. Methodology

The research is conducted in four houses with different orientation in the settlement area of BTN Graha Raya Kendari, Southeast Sulawesi (around -4 South Latitude). For each house, there are two window rooms utilized, each 1 meter square in area. The window in the first room is equipped with venetian-blind, while for the window in the other room, it is without venetian-blind. This room is 5 x 5 x 4 meter-cubic-in volume. The data collected are the temperature and the solar heat gain in the room between 8 a.m and 17 p.m from September 25 to October 5, 2015.

In addition to the data collection, the study also calculates the amount of the solar heat gain through the glass window by using the mathematical model from the equations 1-2. In this calculation, for the glass window, it is assumed that the solar transmissibility is 0.77, the solar absorptivity is 0.15, and the solar reflectivity is 0.08. For the venetian-blind it is assumed that the solar transmissibility is 0.12, the solar absorptivity is 0.37 and the solar reflectivity is 0.51. The detail on the parameters of the glass window and the venetian blind for the calculation can be seen in table 1. In determining the incidence solar energy, it refers to the secondary data of the solar heat gain through reference glass in [15].

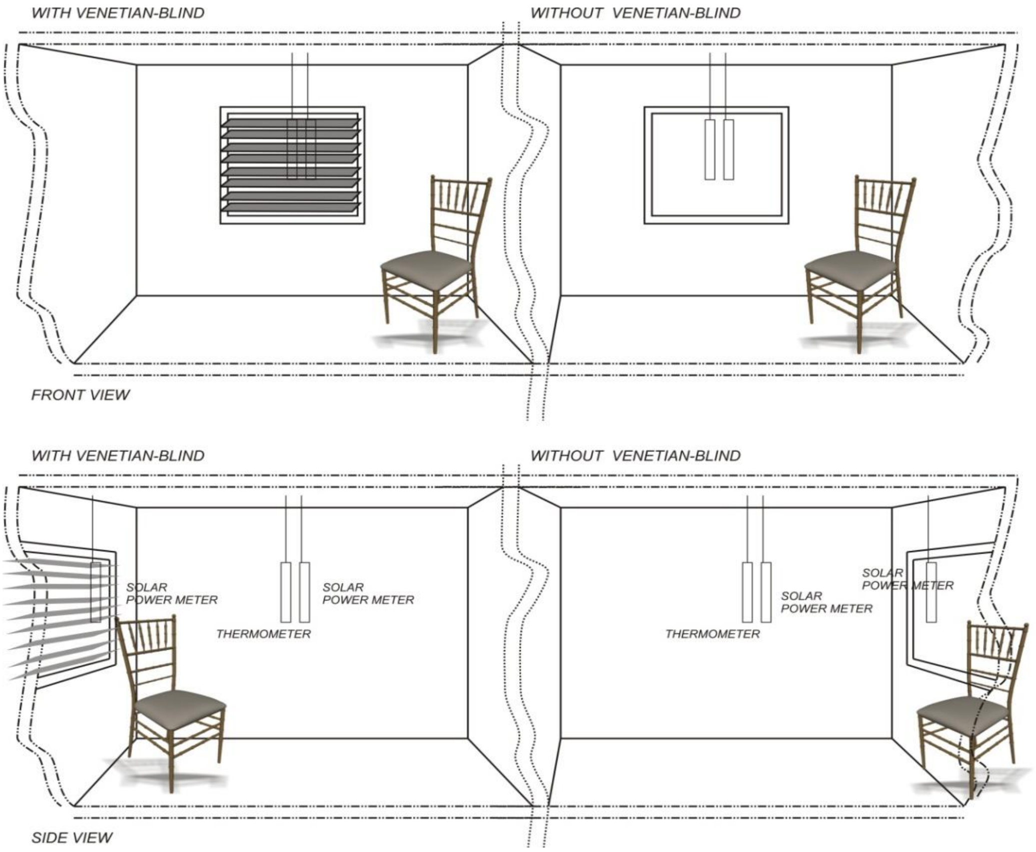


Figure 3. The Model of the Room for Experiment

Table 1. The Parameters of the Glass Window and the Venetian-blind for the Calculation

	Type	Absorptivity A	Reflectibility ρ	Transmissibility τ	Glass Factor
1	*Plate Clear Glass* (6mm)	0.15	0.08	0.77	0.92
2	*Venetian Blind Light Color*	0.37	0.51	0.12	0.59

4. Results and Discussion

Figure 4 shows the result of the averaged values of the data obtained from the experiment on the temperatures on the rooms in cases of with and without the venetian-blind in the variation of time and building orientation. In general, the trend in all figures is similar. The temperatures are low in the morning, then increasing along with the increase of time until the noon, before decreasing in the afternoon.

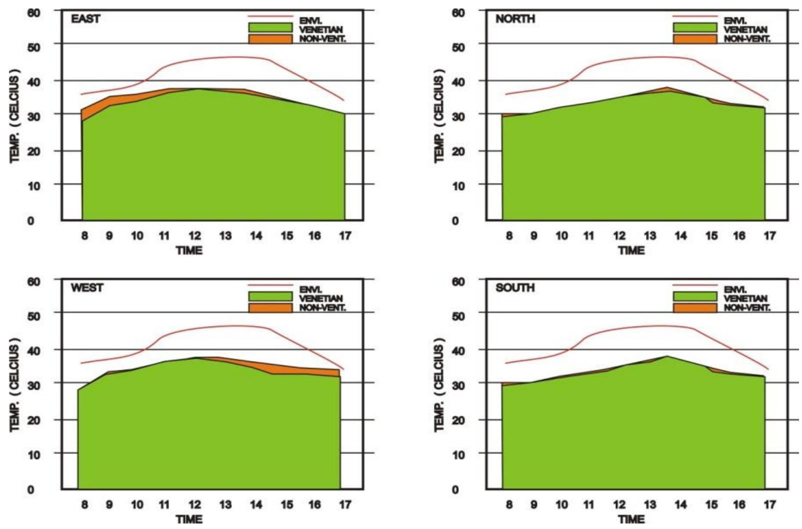


Figure 4. The Results on the Data Collection on the Temperatures in the Room with Venetian-Blind and without Venetian-Blind in the Variation of Time and Orientation

In the east window orientation, in the morning, the room with the venetian-blind has a lower temperature than that without the venetian-blind. The maximum temperature difference between those with and without the venetian blind can reach up to 2°C. During noon to afternoon, the temperatures in the room with venetian-blind and without venetian-blind are almost similar. In the west window orientation, in the morning until the noon, the temperatures in the room for both configurations are similar. At the noon to the afternoon, there is a temperature difference between the rooms with and without venetian blind.

The cases of the windows in south and north orientation, instead of experiencing a similar pattern on the temperatures in the variation of time; their amount is also almost same. In these cases, the placement of the venetian blind has nearly no impact on the temperature reduction in the room.

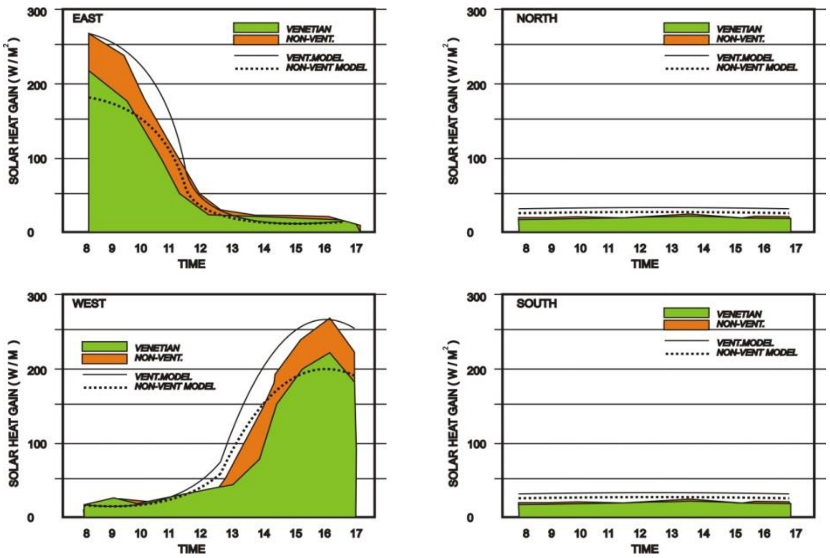


Figure 5. The Results on the Data Collection and the Calculation on the Solar Heat Gain through the Window in Cases of with and Without the Venetian-Blind in the Variation of Time and Orientation

Figure 5 shows the results on the averaged data collection and the calculation of the solar heat gain through the window in cases of with and without the venetian-blind in the variations of time and orientation. In the east-oriented window, the trend of the solar heat gain in the room is decreasing with time (for both the calculation and the data collection). The maximum solar heat gain in the case without venetian-blind is obtained at the morning, about 270 watts/m^2 from the data collection and about 225 watts/m^2 from the calculation. The maximum solar heat gain in the case with the venetian-blind is lower than that without the venetian blind. The maximum solar heat gain in the case with the venetian-blind is approximately 220 watts/m^2 (from the data collection) and around 150 watts/m^2 (from the calculation). On the windows with south and north orientations, the trend of solar heat gain is almost similar. In these cases there is a tendency of constant solar heat gain all days (about 40 watt/m^2).

The results from the experiment and the calculation using the mathematical model have a similar pattern, although the amount is quite different. The discrepancy can be attributed to the assumption of the value of the absorptivity, the reflectibility and the transmissibility of the glass and venetian blind in the calculation of the solar radiation. Indeed, the difference can be attributed by the non-inclusion on the effect of the solar heat gain from the walls on the calculation, at which in the real condition, this should be existed.

In the following section, it attempts to explain the causes from the phenomenon in the results of the data collection in the previous section, relating to the sun’s position and the latitude position of Southeast Sulawesi. Figure 6 shows the sun's position, based on the solar position calendar in [6] and the buildings with different window orientation at around 4^o south latitude in location. The solar position is based on the solar path in September 29th in Kendari, Southeast Sulawesi (about 4^o Southern Latitude).

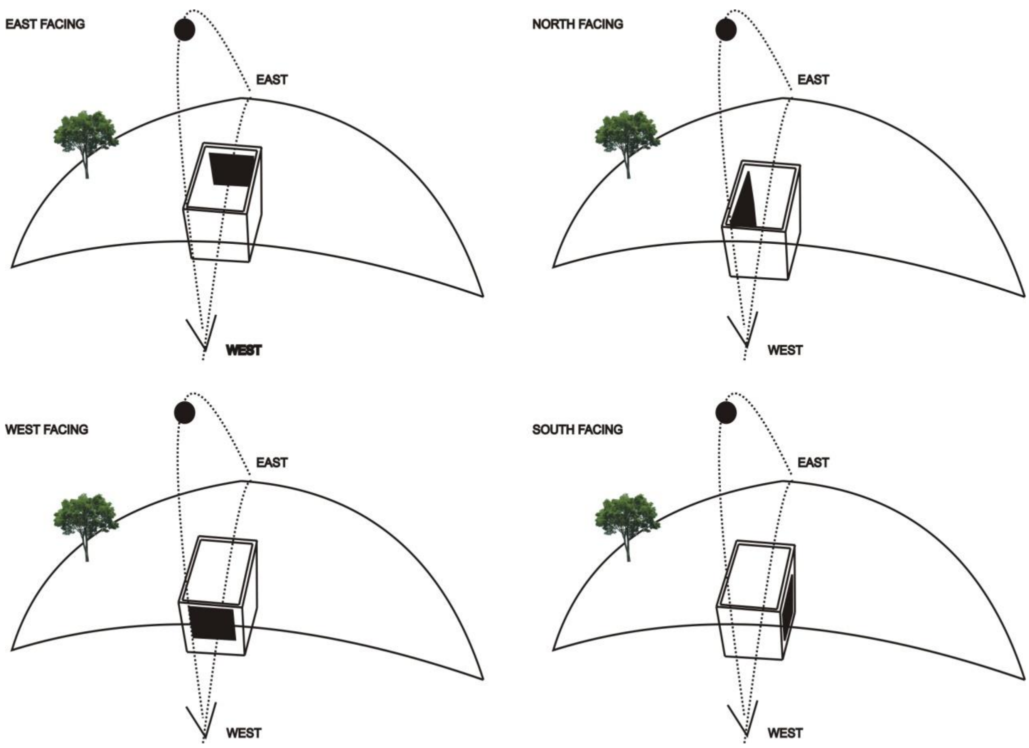


Figure 6. The Pattern of the Relative Solar Movement and the Orientation of the Building

In the east direction, in the morning, the window is fully exposed to sunlight. This can be responsible for the high solar radiation into the room in the morning through the window. In the presence of the venetian-blind, there is a reduction in the sunlight penetration into the room, thus the room are cooler than those without the shading device. At the noon until the afternoon, the presence of the venetian-blind in the window has almost no effect on the reduction of the solar radiation through the window, as the position of the sun in the west.

For the west facing window, in the morning, almost no sunlight exposes. However, in the afternoon, as the position of the sun in the west, the window receives a lot of sun radiation. In this case, the presence the venetian blind has considerable impact to reduce the solar radiation transmitted.

In the windows with north and south orientation, the exposure on the sun is not as high as those in the two former cases. This is due to the sun track is only at east to west with almost zero inclination in north-south direction at the corresponding time (September 29th). In this case, the presence of the venetian-blind has not much effect on the reduction in the solar radiation into the room throughout the day.

For the buildings which face to east and west, the decrease of the solar heat gain through the room by the placement of venetian blind should benefit in reducing the effort to waste the heat by air refrigeration. As the heat gain decrease, the amount of the heat removed by the evaporator on the refrigeration should decrease as well as the room temperature can be set at higher level by the machine. As the heat removed decrease, the electricity required to run the refrigerator machine decrease.

4. Conclusion

This study has assessed the impact on the venetian blind to achieve the thermal comfort in building with low energy consumption in Southeast Sulawesi. The following is the conclusion that can be drawn.

The placement of the venetian-blind has an effect in reducing the temperature in the room for the windows with east and west orientation; even the reduction is only at a certain time ranges. For the window with east direction, the decrease on the temperature is only obtained at the morning to the noon, while for the west window orientation; the temperature drop is obtained at the noon to the afternoon. For the north and south window orientations, the placement of the venetian-blind has almost no effect in decreasing the room temperature. The results from the experiment and the calculation using the mathematical model pose a similar trend, although the amount is quite different. The difference can be attributed to the assumption of the value of absorptivity, reflectibility and transmissibility of the glass and venetian blind and the exclusion on the aspect of the solar heat gain through wall in the calculation stage.

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