International Conference on Social Sciences and Humanities 2008 (ICoSSH'08)

THE EFFECT OF EXTERIOR SHADING DEVICES ON INDOOR CLIMATE

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ABSTRACT

The application of exterior shading devices is very spreading over residential buildings in the hot, humid tropical Malaysian climate for the purpose of blocking the sunlight penetration into interior space and to reduce the amount of heat gain through window. This will have effects on the element of indoor climate such as air temperature, relative humidity, air flow, intensity of light and the extent of sunlight penetration into the interior space as well as thermal comfort. This paper discusses the impact of shading devices on the indoor climate particularly the air temperature and air flow. The investigation was performed on two rooms; one with a shading device and the other one without a shading device. Both rooms are similar in area, window to wall ratio (WWR), as well as their orientation (188°). The measurement of air temperature and air flow was conducted in these to rooms, using environmental data equipment. The analysed data showed that the shading device reduced the amount of heat gain through window and increased the air flow into indoor space, which indicating that the room with a shading device seemed to be more comfortable than the room without a shading devices.

INTRODUCTION

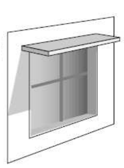
The building envelope and also the shading design would be the most beneficial features to be studied as both of these elements are giving a big impact on the building. The most important factor affecting the architectural environment in the tropical region is solar radiation. Throughout the year, solar radiation would have its influence on either the indoor or outdoor climate of the building. To control the effect of solar radiation on the indoor climate, it is usual to focus on the role played by the building envelope and windows, which act as a filter between the outdoor conditions and indoor conditions.

Windows are the critical point of indoor heat gain where heat transfer can occur by radiation, ventilation (infiltration), conduction and convection. Uncontrolled heat gain through windows causes overheating, thereby causing poor thermal performance.

Exterior shading devices are more effective by 30 - 35% in reducing solar radiation entering a building than interior devices which can only reflect a small part of the radiation and release heat absorbed back into the building (Olgyay, 1963). This is because the exterior shading devices block the solar radiation before it reaches the indoor environment, thus there would be a possible decrease in indoor air temperature. The exterior shading devices can also be used as wind catchers where they help to increase the indoor air velocity provided that they are designed and situated in the accurate place, which otherwise can become a barrier to wind flow (wind breaker) (Hien and Istiadji, 2003). Presently, there are no reliable standard methods to evaluate the effectiveness of sun-shading devices. Indeed, the solar heat gain in buildings depends on a great number of parameters related to the glazing and the shading devices. Moreover, some of the parameters are variable in time, like the position of the incident radiation of the sun compared to the glazing or the configuration of the shading devices (e.g. angles of the slats for a blind)(Jean, 2004).

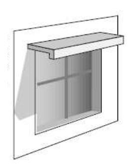
EXTERIOR SHADINGS DEVICES STRATEGIES

A device placed between the sun's rays and the window prevents solar radiation from being transmitted into a room. The primary functions of exterior shadings are to reduce the thermal heat gain in a building as well as to control the levels of direct light. Exterior devices are generally more effective in decreasing heat buildup because they block, absorb or reflect solar heat before it gets into windows. It is either a device attached to the building skin or an extension of the skin itself, to keep out unwanted solar heat. Exterior shading devices include awnings, louvers, shutters, rolling shutters and shades and solar screens. Adjustable shading is particularly useful for east and west facing windows. The low angle of the sun makes it difficult to get adequate protection from fixed shading. Adjustable shading offers greater control over daylight sun and views. Appropriate adjustable systems include sliding screens, louver screens, shutters, retractable awnings and adjustable exterior blinds. Awnings are very effective because they block direct sunlight. They are attached above the window and extend down and out. A properly installed awning can reduce heat gain up to 65% on southern windows and 77% on eastern windows, and light-colored awning does double duty by also reflecting sunlight (US Department of Energy, 1994). Draperies improve the thermal resistance of windows by 40% and reduce heat losses by 30% (Grasso et al, 1990). The screen must be installed on the exterior of a window. Louvers are attractive because their adjustable slats control the level of sunlight entering home and, depending on the design, can be adjusted from inside or outside house. The slats can be vertical or horizontal. Louvers remain fixed and are attached to the exteriors of window frames. Fixed horizontal louvers set to the midwinter sun angle and spaced correctly allow full winter heating and total summer shading.

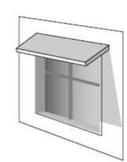


Standard horizontal overhang.

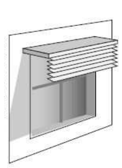
Vertical louvers or fins for east and especially west facades



Drop the edge for less projection.

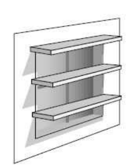


Slope it down for less projection.

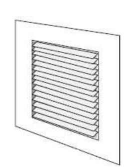


Substitute louvers for the solid dropped edge to let in more light.

Use louvers in place of Solid overhang for more diffuse light while still shading.



Break up an overhang for less projection



Break up an overhang for less projection

Figure 1.0: Different design of exterior shading devices.
Source: Lee, Rubinstein & Selkowitz (1997)

METHODOLOGY

A study was conducted at Block 18 of Taman Utara which is located on the east coast of Penang Island to investigate the effect of exterior sun shading devices on the indoor air temperature and air flow. Referring to Google Earth (2008), the building is situated between latitudes N 5°21`3.96″ and N 5°21`2.52″ and longitudes E 100°18`16.2″ and E 100°18`19.8″. It consists of 17 floors including the ground floor with an area of 1800 m². Measurements of air temperature and air flow were taken at two rooms, one with a shading device and the other one without a shading device. The rooms were from two different flat units located on the fourth floor with an orientation of 188 degrees from the north. The layout of the rooms and the area of the flats are similar. Figure 2.0 shows the locations of the rooms whilst Figure 3.0 shows the orientation of the rooms. On the other hand Table 1 shows the characteristics of the rooms.

Figure 2.0: Locations of the rooms (circled)

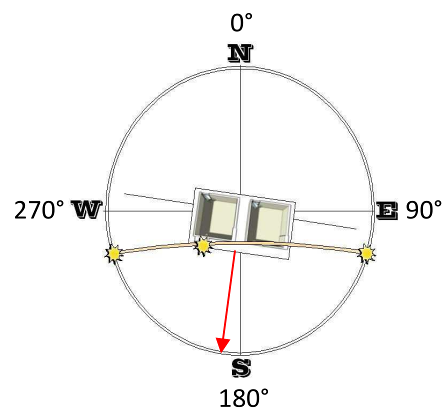


Figure 3.0: Rooms orientation on the south façade (188 degrees from north)

Table 1: the characteristics of the rooms

No	Elements	Room with shading device (85cm ×154 cm)	Room without shading device
1	Area	8.55m²	8.55m²
2	Length	300cm	300cm
3	Width	285cm	285cm
4	Height	260cm	260cm
5	Window	120cm × 150cm	120cm × 150cm
6	WWR	24%	24%
7	Door	80cm × 210cm	80cm × 210cm
8	Orientation	South (188°)	South (188°)
9	Window glass	Pattern soda lime glass	Pattern soda lime glass
10	Window type	Louvres	Louvres
11	Furniture	Rubber mat + wardrobe	Rubber mat
12	Mechanical ventilation (fan, air-conditioning)	----	----

13	Artificial light	40 watt fluorescent tube	40 watt fluorescent tube

The equipments were set up properly and placed safely at the centre of each unit to collect the required data on site for 13 days consecutively. There were also environmental equipments to measure the outside conditions. The measurements were taken at every 3 hours interval in a day. Windows and doors at both rooms were fully opened (90°) during the measurement for the purpose of cross ventilation. The data were analysed using Microsoft Excel. Figure 4.0 shows the typical plan layout of the flats whilst Figure 5.0 shows the set up of instruments in the rooms.

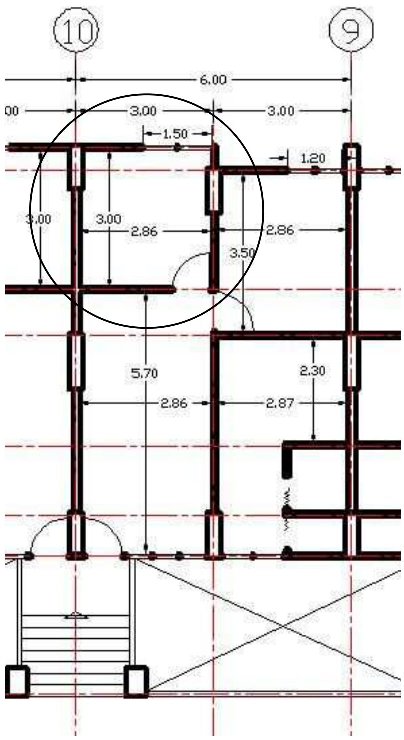
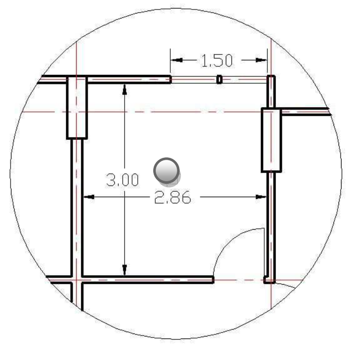


Figure 4.0: Typical plan layout of the flats
Scale 1:100



Finger 5.0: Equipment set up

RESULTS AND DISCUSSION

The analysis of the effect of exterior shading device on the air temperature and air flow performance in the interior space was carried out by comparing the data for the two rooms.

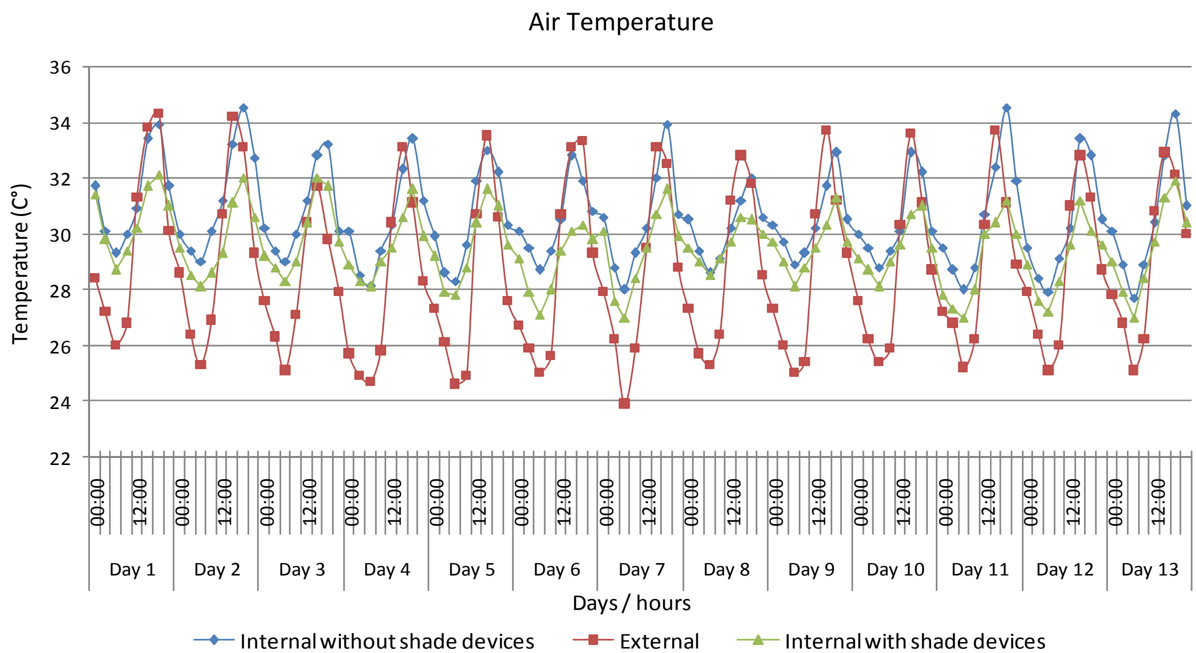


Figure 6.0: Air temperature for 13 days

For air temperature, the graph above (Figure 6.0) shows that the indoor air temperature of the room without a shading device is higher than the outdoor air temperature from 9 pm to 9 am, while the air temperature of the room without a shading device is higher than the outdoor air temperature from 9 pm to 9 am. This possibly happens because there is no direct exposure to solar radiation. The average air temperature difference between the outdoor and the room with a shading device is about 1.1°C to 2.7°C, while the temperature in the room without a shading device is about 2.1°C to 3.5°C. This shows that the temperature in the room with a shading device is lower than the room without a shading device with a difference of 0.8°C to 1.0°C at the particular time mentioned above.

The indoor air temperature of the room without a shading device is lower than the outdoor air temperature from 9 am to 6 pm, while the indoor air temperature of the room with a shading device is lower than the outdoor air temperature from 9 am to 9 pm. This may be happen because of the direct exposure to solar radiation and the influence of heat transfer through external building envelop and the effect of delay time, where the air temperature difference between outdoor air temperature and indoor air temperature of the room without a shading device is about 0.6°C and the temperature in the room with a shading device is about 0.6°C to 2.3°C. It is seen here that the temperature in the room with a shading device is lower than the room without a shading device i.e. about 1.8°C. In general, the air temperature of the room with a shading device is lower than the air temperature of the room without a shading device with an average about 0.7°C to 2.0°C.

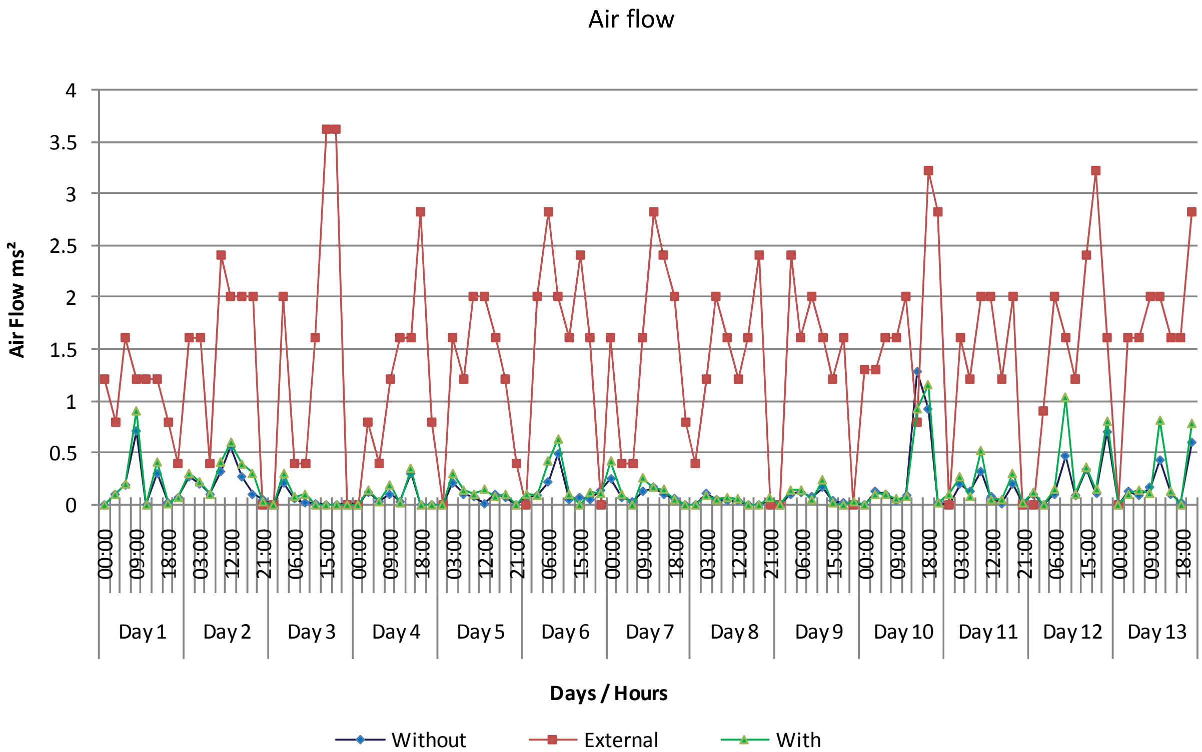


Figure 7.0: Indoor and outdoor air flow

With regard to the air flow, the indoor air flows for both rooms are found to be lower than the outdoor air flow. It can be seen from the graph (Figure 7.0) that whenever the velocity of outdoor air flow is high, the velocity of indoor air flow will also increase. The average outdoor air flow is about 1.41m/s. The average indoor air flow for the room with a shading device is about 0.18 m/s while the average air flow in the room without a shading device is slightly lower than room with a shading device. This may be because the shading device over the window enhances air pressure in front of the window and reduces it on the side which results in a quicker air movement through the window.

It was found that the indoor air flow entirely or partly stopped when the door of the room was closed. It was also observed that there is a relationship between the direction of outdoor air flow and indoor air flow. It was found that when the direction of outdoor air flow moved towards the windows there was an indoor air flow, specifically when the direction of outdoor air was from North, North-east, and North-west. As for other directions of outdoor air flow there was a weak or an absence of indoor air flow.

CONCLUSION

From this study it can be conclude that:

i. The room with a shading device blocks the sunlight from entering into the indoor space except at certain times in a day, while the room without a shading device allows the sunlight to enter the indoor space during daylight hours. Thus the air temperature of the room with a shading device is lower than the air temperature of the room without a shading device with about 0.8°C to 1.0°C, in the evening, while in the morning it is about 1.8°C lower.

ii. This study has also examined the effect of a shading device on the air flow into the interior space. The finding shows that there is a slight difference between the air flow of the room with a shading device and the room without a shading device, where in the average, the room with a shading device is about 0.04 m/s higher.

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