American Transactions on
Engineering & Applied Sciences

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The Sunlight Shading Performance in Traditional Style Apartment: Case Study of Putrajaya, Malaysia

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ARTICLEINFO

Article history:
Received November 03, 2014
Received in revised form February 20, 2015
Accepted February 25, 2015
Available online February 26, 2015

Keywords:
Façade;
SunTool;
House temperature;
Sunshade.

ABSTRACT

This study evaluates the performance of the sunlight shading design on front house's facades which designed with traditional architectural style. The front facades of two case studies in Putrajaya, Malaysia are selected for the simulation; Putrajaya is the administrative city for the federal government, and it is considered the latest new city in Malaysia which characterizes postmodern design which exhibits a range of complex geometric elements blending with colonial, modern and traditional architectural style. The selected case studies are two high apartment's buildings consists of sixteen stories and located in section (KE P16) and 17 stories located nearby artificial lace in present 18 (18R8). SunTool software is used in the survey to calculate the shading area on the façade. The survey will be conducted at a position when the sun path is perpendicular to the house façade, and then compare between the two designs and the used of architectural elements. The study finds that the recessed wall with balcony and sunshade elements that used in the traditional architectural style facade design are efficient to make the façade shading performance better which causes low temperature and provides cool atmosphere during the day time when the temperature is very high outside, and that is the one of the reasons behind the popularity of the Traditional architectural style.

1. Introduction

The aim of this study is to investigate the façade shading performance of the selected buildings with Traditional architectural styles. This study is consider as a guide for architects and designers in order to overcome the heating and brightness problems which caused by the insufficient façade

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shading performance which help to provide guidelines for a sustainable design with an excellent usage of the shading elements for blocking the solar radiations which consider to be very important in the tropical countries such as Malaysia. (Bakhlah & Hassan, 2012). House facade exposed to direct sunlight causes problem of solar radiation. The sun energy will radiate the heat from outside wall transmitted into the interior of the house (Hassan & Ramli, 2010, Feriadi & Nyuk, 2004). It generates extra heat gains inside the house which causes warm temperature to the indoor area. As a result, this creates uncomfortable thermal condition to the occupants.

Many previous studies were conducted on solar radiations in buildings (Olgyay & Olgyay, 1977), however, this research focuses on the Malay Traditional apartment architectural style and analyses the shading elements of the façade design. One of the recent studies was by Ismail and Idris (2002) , and Lim, Ahmad and Ossen (2013) issues on heat gains due to exposure of modern and contemporary high rise building facades to direct sunlight. The other study was by Abdul Rahman (1995) and Omer (2008) on housing design related to thermal comfort with integration of passive design solution to tackle solar radiation.

Figure 1: First case study Traditional 1 apartment.

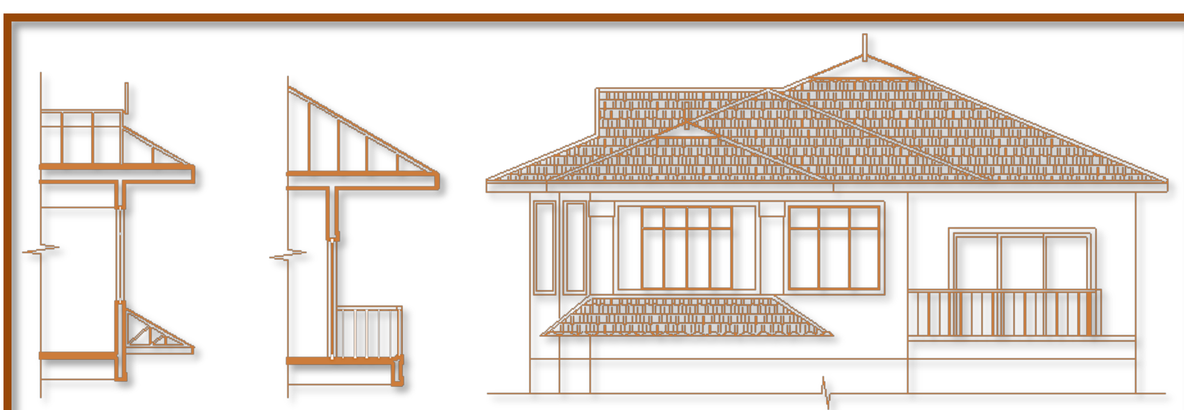

Figure 2: First case study Traditional 1 apartment (left: section AA, Middle: section BB, Right façade)

2. Case of Study

Two apartment buildings with traditional architectural style were selected to be the case studies of this research in order to compare and analyze the shading devices and façade behavior toward the extent of sunlight penetrations in the traditional architecture buildings in Malaysia. The both selected case studies are in Putrajaya the administrative city for the federal government, Putrajaya is considered the latest new city in Malaysia (Hassan, Konsep Rekabentuk Bandar di Semenanjung Malaysia: Kuala Lumpur dan Bandar-Bandar di Sekitarnya, 2005) (Hassan, Putra Jaya: The Direction of Malaysian New Town, 1999). The first case study is an apartments building consists of sixteen stories and located in section (KE P16) in Putrajaya (Figure 1 and 2), while the second case study (Figures 3 and 4) is a 17 stories apartments building located nearby artificial lace in present 18 (18R8).

Figure 3: Second case study Traditional 2 apartment.

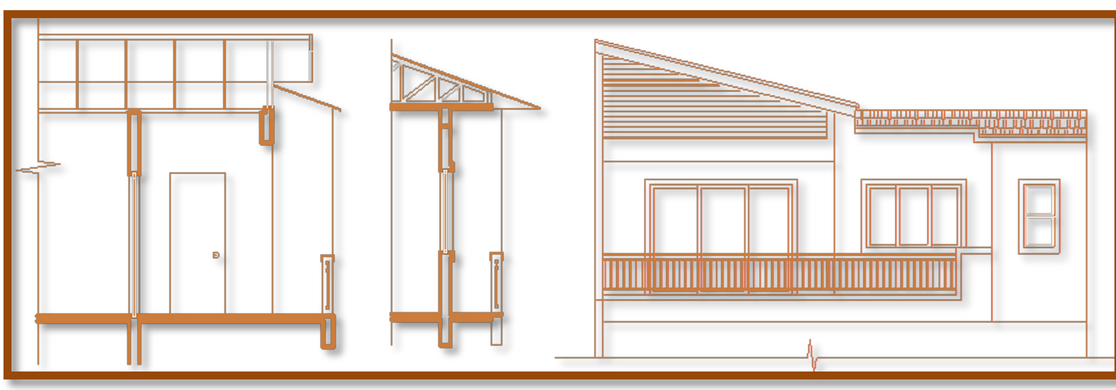

Figure 4: Second case study Traditional 2 apartment (left: section XX, Middle: section YY, Right façade)

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3. Material and Methods

The simulation will be conducted by using SunTool software to calculate the shading areas on the façade. The study aims to get the results of sunlight shading when the building's facade expose to the sunlight at the maximum level at day time; by doing the simulation when the sunlight are perpendicular to the house facade (east facade during morning hours and west facade during evening hours of simulation), then the survey will be able to discuss the efficiency of facade's shading design (Mazloomi, Hassan, Bagherpour, & Ismail, 2010). In order to get the results at the maximum exposure level, the study will be limited to the changing of the sun path to get the perpendicular of the sunlight to the east (90°) and west (270°) Table 1 and Figure (5), and also the other limitation is that there are at certain times and dates that the sun path's azimuth is not possible to have perfectly at 90° (Hassan & Arab, 2013; Arab & Hassan, 2012). In these cases, the closest azimuths nearest to 90° will be used when the simulation is made from 8:00 am to 6:00 pm, which are listed in Table 1.

Table 1: Time, date and azimuth of the sun when the sunlight extent penetration of façade was calculated for cases in Malaysia.

Orientation	Time	Date	Azimuth	Orientation	Time	Date	Azimuth
East 90°	7 am	23 March	90°	West 270°	1 pm	16 September	90.5°
	8 am	25 March	90°		2 pm	29 March	89.8°
	9 am	27 March	89.8°		3 pm	18 September	89.8°
	10 am	28 March	90.1°		4 pm	26 March	89.9°
	11 am	29 March	90°		5 pm	24 March	89.9°
	12 pm	29 March	92.2°		6 pm	22 March	89.9°

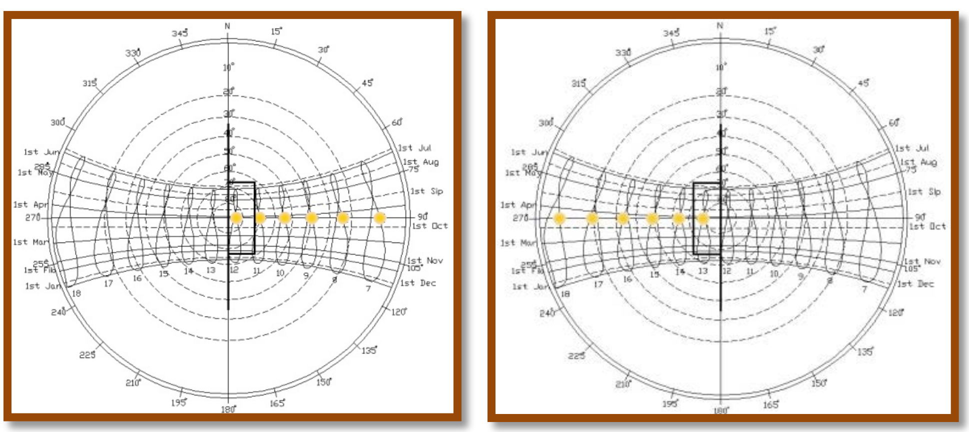

Figure 5: Sun path diagram shows the position of the sun perpendicular to the house facade from 7am to 12pm at orientation of 90° (left) and from 1pm to 6pm at orientation of 270° (right). Source: SunTool Software

So as to get the correct position and orientation, all data about the location, time, date and orientation will be entered into the SunTool software to do the simulation and calculate the percentage of facade's shading area and the extent of sunlight penetration (Figure 6). And then the facade's dimensions such as depth of exterior shading device, height, wall's width and sill height will be keyed in the SunTool software. After drawing the facade and entering all required data, the software will be able to do the simulation and provides the facade shading for the analysis (Hassan & Arab, 2014).

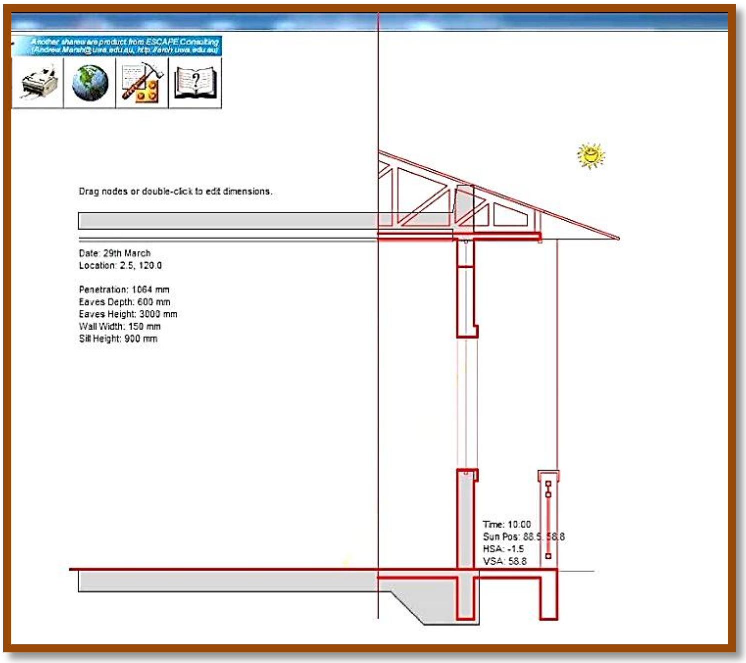

Figure 6: SunTool software (window section)

4. Data Analysis

The main areas of the facade are opaque and glazing areas. The amount of shading area of opaque and glazing areas will be calculated by 'SunTool' programm (Figure7). The amount of shading and exposed area will be calculated based on the following formula:

$$S_{GA} = S_{GH} \times G_W \quad (1),$$

Where S_{GA} = Shaded glazing area, S_{GH} = Shading Glazing Height, G_W= Glazing Width.

$$S_{OA} = S_H \times L - S_{GA} \quad (2),$$

Where S_{OA} = Shaded opaque area, S_H = Shading Height, L = Length of façade.

$$E_{OA} = T_{OA} - S_{OA} \quad (3)$$

Where E_{OA} = Exposed opaque area, T_{OA} = Total Opaque Area.

$$T_{OA} = F_H \times L - T_{GA} \quad (4),$$

Where F_H = Floor Height, T_{GA} = Total Glazing Area.

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$$T_{GA} = G_H \times G_W \quad (5),$$

Where G_H = Glazing Height.

$$E_{GA} = T_{GA} - S_{GA} \quad (6),$$

Where: E_{GA} = Exposed glazing area, T_{GA} = Total Glazing Area.

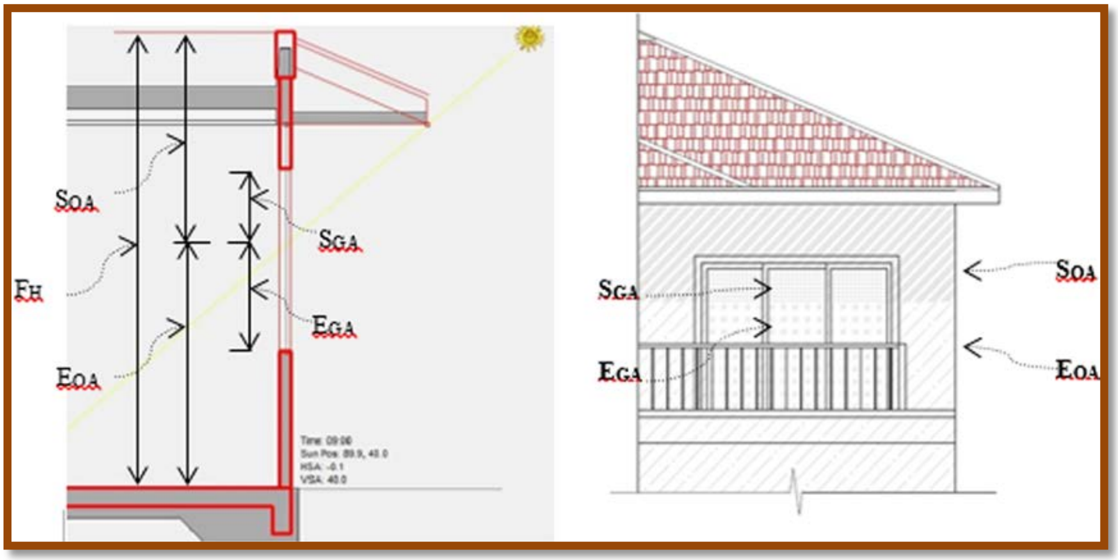

Figure 7: Formulas' abbreviation on facade and section in the calculation of the amount of shading area.

5. Results and Analysis

This study analysis compares the shading area of the last floor's facade of the two traditional style apartments located in Putrajaya, Malaysia, The comparison will be between section AA from the first case study and YY from the second case study (window section) and the other comparison between section BB and XX (door section). Table (2) and Figures (8 and 8) show the results of the shading area percentage of sections AA and BB for the first case study and sections XX and YY of the second case study.

Table 2: The Total shading area of case studied 1 & 2.

Total Shading Area %				
	Traditional 1		traditional 2	
Time	Section A-A	Section B-B	Section X-X	Section Y-Y
8:00 AM	20.04	27.59	45.36	9.24
9:00 AM	29.37	54.59	69.39	16.71
10:00AM	61.62	100.00	100.00	28.07
11:00AM	100.00	100.00	100.00	54.90
12:00PM	100.00	100.00	100.00	100.00
1:00 PM	100.00	100.00	100.00	100.00
2:00 PM	90.06	100.00	100.00	42.14
3:00 PM	46.03	63.56	92.37	27.50
4:00 PM	29.98	41.38	60.58	16.02
5:00 PM	15.99	21.83	38.94	8.66
6:00 PM	4.16	5.47	21.02	2.12

5.1 The comparative analysis of sections AA and YY

Figure (8) shows that the façade of the first case study (Traditional 1) starts with 20.4% shading area in the early morning at 8:00 am, on the next hour one third of the façade is shaded while almost two thirds are shaded at 10:00 am. The design shows an excellent performance between 11:00 am to 1:00 pm with 100% of the façade shaded. The percentage of shading area reduces regularly in the afternoon and evening hours with 46%, 30% and 16% at 3:00, 4:00 and 5:00 pm respectively, the last hour of the simulations shows the minimum shading area percentage with 4.16%. On the other hand the façade YY of second case study (Traditional 2) starts the day with less than 10% shading of the total façade area, in the following hours the percentage increases to gradually with 16.71% 28% and 54.9% at 9:00, 10:00 and 11:00 in order. The results show that all façade area is shaded at 12:00 and 1:00 pm, and after that the shading area retracts from 2:00 to 5:00 pm with 42.12%, 27.5%, 16% and 8.66% respectively, the last hour shows the least shading area percentage with 2.12% only.

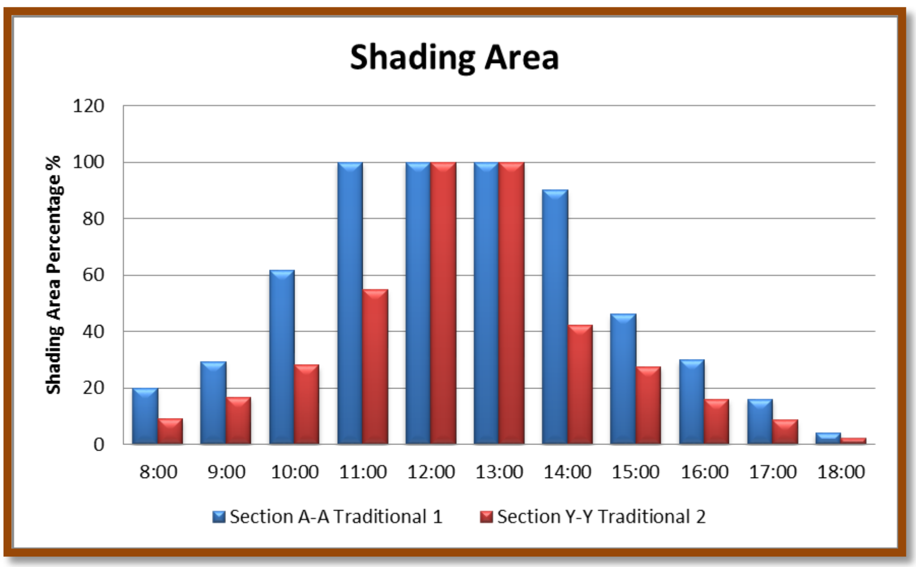

Figure 8: The shading area of sections AA and YY façades

5.2 The comparative analysis of sections BB and XX

The second comparison on this study is to compare the extent of sunlight penetrations of the door sections at both case studies BB and XX. The results show that the traditional 2 design has better performance in shading at all simulation hours. The first case study (Traditional 1) starts the day with 27.59% and 54.59 % of the shading area at 8:00 and 9:00 am respectively. From 10:00 am to 2:00 pm the results show that the façade is 100% shaded and after that the shading area percentage reduces gradually with 63.56%, 41.38% and 21.83% between 3:00 to 5:00 pm in order,

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the last hour of simulations shows the only 5.92% shading area. Whereas the second case study (Traditional 2) start the day with 45.36% and 69.39% of shading at 8:00 and 9:00 am in order, then the simulations show perfect performance from 10:00 am to 2:00 pm with 100% of the façade is shaded, the afternoon hours show reducing of the shading area percentage with 92.37%, 60.58 and 38.94% respectively at 3:00, 4:00 and 5:00 pm. The last hour of the day simulation shows good result relatively with 21.02% shading of the total area.

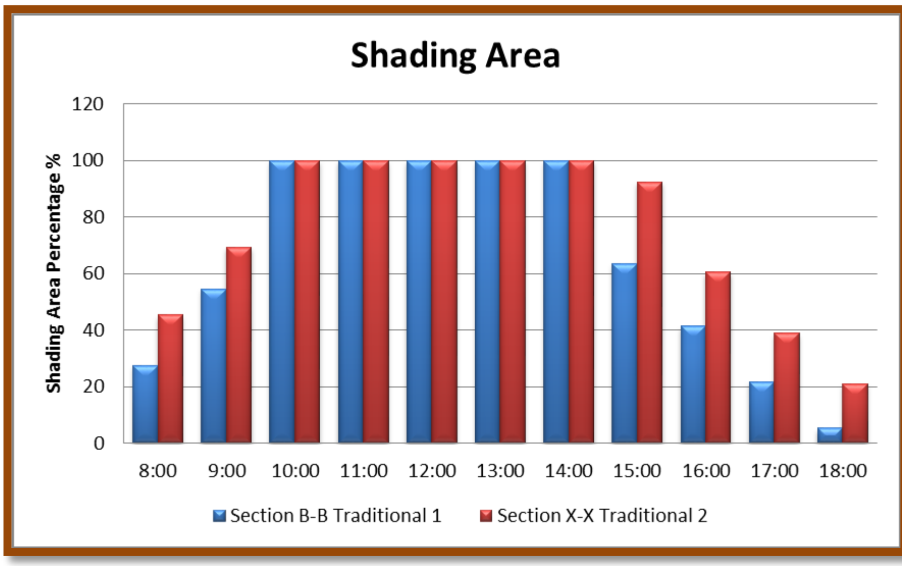

Figure 9: The shading area of section BB and XX façades.

6. Discussion

- This study finds that the early morning hours show shading area between 9% to 20% in window section façade and 20% to 45% for door sections façade.
- Both of the case studies façade show an excellent shadowing performance from 10:00 am until 2:00 pm for door section.
- For window sections the study finds that Traditional 1 style has perfect performance with 100% of the façade area shaded between 11:00 am to 2:00 pm and from 12:00 to 1:00 pm for Traditional 2 style.
- The shading performance in the early morning and late evening hours are not as good as afternoon hours due to the small angle of the sunlight.

7. Conclusion

The study finds that the minimum shading area is at the late evening hours of the simulations in the both traditional 1 and 2 design, and that is because of the low angle of the sun position in the sky during these times (Landry & Breton, 2009), and the findings show as well that the first case study (Traditional 1) has better shading performance in all of the simulation hours for window section façade while the Traditional 2 style case study has better performance during all day hours. However the simulations find that the traditional architectural style have a good shading performance during most of the simulation's hours. The recessed wall with balcony, sunshade elements and roof overhang in the traditional architecture Style, they were very effective preventing the extend of sunlight from getting inside the house deeply and provide good facade shading system except for the first and last hour of simulation because of the angle of sun position.

8. Acknowledgements

This study is under research grant financed by the Universiti Sains Malaysia.

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Note: The original of this article has been submitted to **2nd International Workshop on Livable City 2014 (IWLC2014)**, a Joint Conference with **International Conference on Engineering, Innovation, and Technology (EIT)**, held at Tabung Haji Hotel, Alor Star, Malaysia, during December 9-11, 2014. According to the IWLC2014 Conference Committee, this paper was given Technology Best Paper Award.