THERMAL FACADE SURFACE STUDY ON EARLY MODERN APARTMENTS IN KUALA LUMPUR

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ABSTRACT

This paper discusses thermal surface performance on front facades of high-rise apartments in Malaysia built with early modern style. Early modern style apartments were popular from the 1950s to 1970s using mass produced and fast construction techniques with standardized design by the government to elicit housing shortage problem due to population increase in the city. The apartments built with open corridor system image the frontages and become the main access to entrance doors of the apartment units. The results from the study will provide information on awareness of passive facade design to minimize solar radiation of the apartment facades. The government recently introduces Green Building Index (GBI) as an awareness strategy in architectural building design. By having this awareness, the building design in the future will able to help reducing electricity consumption. There are three early modern apartments selected in the case studies located in Kuala Lumpur. The survey will measure the percentage of the apartments' front façades shaded from direct sunlight. The survey will apply SunTool software. The thermal surface data indicates that all the facades had slightly above 75% under the excellent category of the shading performances. The wide corridor plays the most important role as a sun-shading device to all three apartments' recessed wall facade. The open corridor system has more emphasis on horizontal sun shading device. Less emphasis is on vertical sun shading devices limited to the brick railing fence and parapet walls of the corridor roof on each floor. These horizontal sun-shading devices were only able to give shades to the apartment façades slightly above 50% from evening sunlight.

Keywords: Apartment facade, early modern, thermal surface, Kuala Lumpur

Introduction

This study highlights the importance of understanding solar radiation, which becomes an issue in passive design and energy efficiency in building designs in Malaysia. Solar radiation occurs at the façade and roof surfaces. This study embarks on apartment buildings popularly built with 'open corridor system'. The style was popular by architects from 1950s to 1980s in their building design. At that time, Kuala Lumpur had experienced population booming due to a trend of rural to urban migration by the rural population to find better jobs in the city. The early modern style is an early design form of modern architecture after the end of the popularity of art deco style in the1940s. The construction applied mass produced system and fast construction technique which is necessary to meet the demands of house units by the city population. Apartment buildings have large façade surfaces in comparison to their roof surfaces. It is thus crucial to provide fundamental knowledge on solar radiation to the apartment facades. This study will able to obtain a level of solar radiation by evaluating shading performances of the apartment façades. The higher is the amount of shade, the lesser is the level of solar radiation. The result of this study is significant to understand the level of emphasis and awareness on solar radiation to apartments designed with 'open corridor system', which become less popular after 1990 to present day. If the result is excellent, this system should be pertinent to the present and future apartment design in this country. A design with excellent shade on the building façade is important to provide optimum indoor thermal comfort to the occupants. Bakhlah and Hassan (2012) affirmed that excellent shading elements are necessary to shade building facades from solar radiation of intense sunlight in a tropical region. Apartment facades exposed to direct sunlight causes heat gains on its façade surface, which becomes one of the factors causing solar radiation and urban heat island.

Urban heat island occurs in most cities because it reradiates heats from the built up areas with buildings, open spaces, and roads constructed with sensible heat materials that absorb heats when exposed to direct sunlight. As a result, the cities have comparatively warmer temperature than their greenery surrounding rural areas. Poor design on apartment façades causes solar radiations inside the building. The reason for poor façade design is that it is unable to give optimum shade on its vertical surface area. The outer wall surface will reradiate the heat to the indoor area (Hassan & Ramli, 2010; Stevanovic, 2013; Hassan & Yasser, 2015). It induces more heats inside the house creating warmer temperature than 28^{o}C above the comfort zone. Thus, self-awareness to the importance of shading devices during the design stage by the architects is crucial. This study imparts research findings from the analysis of building simulation using SunTool software. With this finding, this study will able to promulgate significant contributions to the research study with recommendations for excellent facade design as important self-awareness by the architects.

SELECTED case studies

This survey selects three apartments for the case studies. Their façade design exemplifies a typical early modern architectural style that connotes 'Less is more' concept with simple geometrical form and unornamented design. The primary construction uses reinforced concrete space-frame structures, brick walls and cement render finishes (Hassan, Arab & Ismail, 2015). Location of all the apartments is in Kuala Lumpur. Sulaiman Courts is the first high-rise apartment in Kuala Lumpur as well as in Malaysia about a year before the country independence in 1957. A few years after that the government built the second apartment, Pekeliling Flats in 1964. Early modern architecture had signified a popular style from the 1950s to 1970s in Malaysia (Figure 1). Construction of most apartments with this style is until the early 1980s. During this period, the government actively built low-cost apartments to house low-income families who lived in squatter area under relocation program towards 'Zero Squatter' policy in Kuala Lumpur (Sufian & Mohamad, 2009). During that time, the word 'flat' was popularly used to indicate apartment building. Today, this word is barely used replaced with the name 'apartment'. Early modern style applied mass-produced construction technique, a design with modular, and the standard size of the apartment units. This technique had speed up the construction time to cater a problem of housing shortage in Kuala Lumpur (Dewan Bandaraya Kuala Lumpur, 2017; Hassan, 2005). High-rise apartments, offered to buy the apartment unit at affordable price, were currently the choice of accommodation by low-income people in the city (Labin, Che-Ani & Kamaruzzaman, 2014).

Figure 1: Sri Perak Apartment (Flat) in Sentul

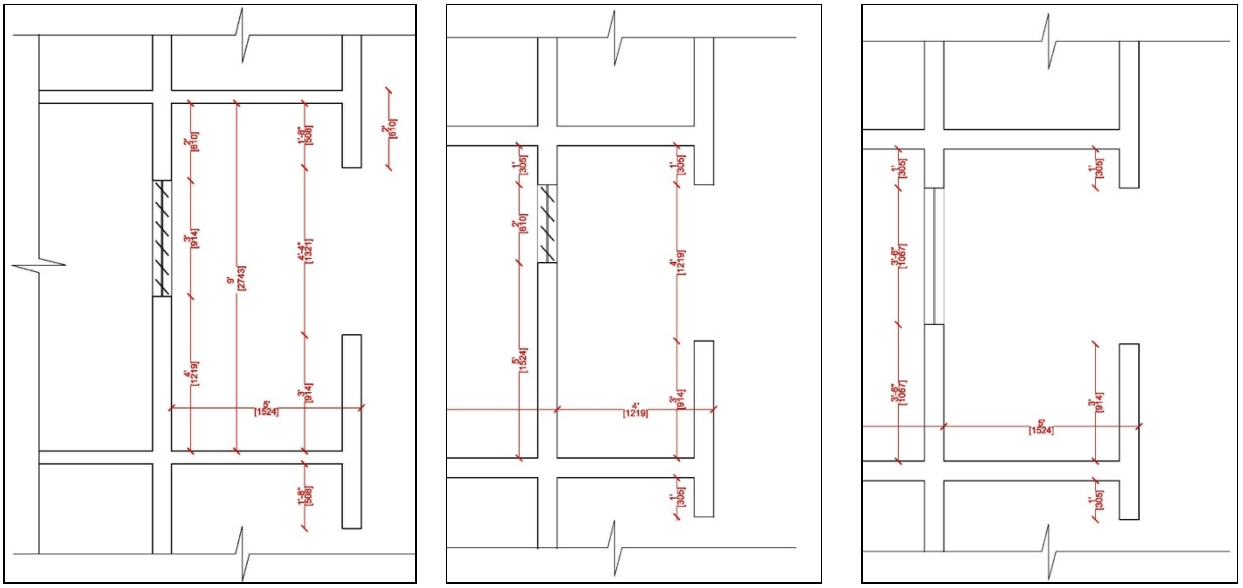
The style was compatible with mass produced and quick construction concept using technological advancement. The design had a simple composition with reference to basic geometric shapes like square, rectangle and circle to draw standardized modular house units in design and production process of working drawing for submission to the local authority's approval. The design simplicity speeds up the design progress and construction (Hassan, A.S. & Al-Ashwal, 2015; Curtis, 2015). These early modern apartments have open corridor system in front of the façade. This type of design is popular during this time. The corridor becomes the main access to the resident or tenant reach to entrance door of his or her apartment unit. British Administration introduced this apartment design slightly before the country's independence, which later nurtured the development of the apartments' style in this country. It was a popular style during Industrial Revolution in Europe for labour class workers, provided with elevators (Hassan, 2004; Ching, Jarzombek & Prakash, 2011; Cruickshank & Fletcher, 1996). Open corridor system became the popular design and one of the best examples is Flat Isokon built in 1932 in Hampstead, London (Burke, 2015; Kostof, 1995). Reinforced concrete structures with brick walls, wooden frame for doors and glass louver windows were the archetypal construction materials. Most apartments had either flat or nearly flat roof.

The federal government projects prefer to build high-rise apartments in Kuala Lumpur due to the scarcity of available land. According to data from Department of Statistics Malaysia (2010), apartment units have the largest percentage of the total house types with 73% in Putrajaya, the new administrative city in Malaysia. The number of apartment units has superseded the number of terrace house type. The government favours building high-rise apartments, able to supply hundreds of house units per hectare to cater the high demand due to the population booming. By the year 2000, more than 2 million people in Malaysia live in high-rise apartments (Department of Statistics Malaysia, 2010). The selected apartments namely Melati, Sri Selangor and Sri Sarawak were selected for the case studies. They were located in Pudu area, Kuala Lumpur. They were amongst the earliest apartments built in this city like Sulaiman Court apartment. The first apartment construction in Pudu area was built in 1958 while the last one was completed in 1965. Figure 2 illustrates Melati Apartment varies from 15 to 18 stories in Loke Yew Road. The location of the apartments in this survey is as follows:

1. Melati Apartment at Loke Yew Road, also known as Loke Yew Apartment
2. Sri Selangor Apartment at Gelugor Road
3. Sri Sarawak Apartment at Kenanga Road

Figure 2: Melati flats at Loke Yew Road in Pudu area

The study only focuses on analysing the shading performance. Figure 3 illustrates three drawings showing foundation to roof detail of the front apartment facades. The details were at a sectional cut of the corridor and its recessed wall. All the buildings have a similar design with open corridor system. They have a slight variation of dimensions of the length, width and height.



Melati Apartment | Sri Selangor Apartment | Sri Sarawak Apartment

Figure 3: Foundation to roof detail of Melati, Sri Selangor and Sri Sarawak Apartment

Research Methodology

The survey will use SunTool software to generate shading simulation on the apartment front facades. This software will provide a series of calculations of the amount of shading area cast on the façade surface. The simulation was only at positions when the facades' angle was perpendicular the sunlight. The simulation will measure the shading performance during morning and evening sunlight simulation when it has the facades perpendicularly facing direct sunlight during morning and evening time. The reason is the apartments selected in the case studies are mass produced buildings with the standardized design built at various building orientations with a lack of reference to the sun path direction.

The SunTool software will help to determine the annual sun path position perpendicular (90°) to the façade's surface, both at the east and west direction. However, there is a limitation in positioning the perpendicular sun path. The limitation of this survey is that not all sun paths (the sun's angle direction) are perpendicular to the facade in any single day times. The other limitation is not all the sun paths have exactly perpendicular to the facades in a case of a location at Kuala Lumpur. Thus, the azimuth with closest to 90° will be applied during the simulation. Each sun path has its angle slightly varies from each other during the daytime. Table 1 (Arab & Hassan, 2016) shows the annual times and dates deduced by SunTool software when azimuth of the

sun path perpendicular to the apartment façades at Kuala Lumpur's latitude (N 3.1°) and longitude (E 101.7°) (Hassan & Arab, 2014; Arab & Hassan, 2012).

Table 1: Times and dates when azimuth perpendicular to the apartment façades

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

With an aid of the SunTool program, it is possible in this survey to pinpoint the effectiveness of the apartment design by measuring the amount of shades cast on the facade surface. Figure 4 shows briefly how the amount of shade and exposed area to the direct sunlight measured with reference to foundation to the roof detail.

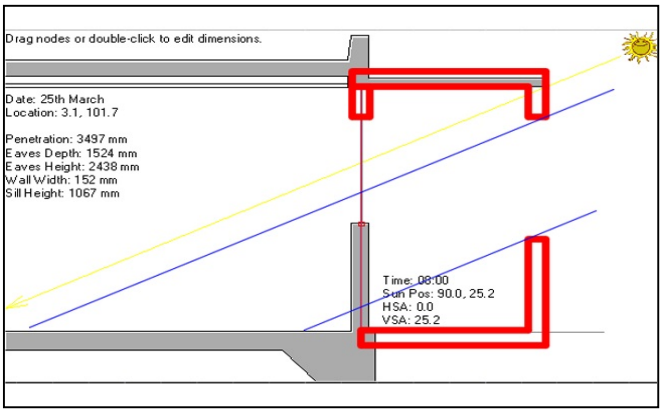


Figure 4: Example of the simulation using SunTool software

Analyses And Findings

This study found that early modern apartments have typically a design with 'open corridor system'. Location of the corridors is in front of the apartment façade commonly with two fire stairways at each end and elevators in the middle of the building. Corridors become an important signage element to the apartment frontage. The design of early modern apartments is popular from 1950s to 1980s for low-income family and to those who had moved from their village to Kuala Lumpur as their new workplace. They were also known as 'the worker's house' (Kosman, 2008; Mohamad Rasdi, 2007) and at that time these buildings were called 'flats'. Dimensions of these low-cost apartments are very basic and minimal to meet the standard of the living requirement by the Municipal Council.

In the case studies, these apartments have their corridor's width varies from 4 to 5 feet which create a recessed wall of the apartment units with a height varied from 8½ to 9½ feet. The corridors have 3 feet height brick railing fence wall functioned as a railing. The extended parapet wall below the brick railing fence at Melati Apartment is 1 feet 8 inches while Sri Selangor and Sarawak Apartment are only 1 feet. In this country, the standard brick wall has ½ feet or 6 inches wide. Each apartment unit has 20 feet wide façade front wall with a series of glass louver window and one entrance door. Frontage wall at Melati Apartment has 4 feet high windowsill and 3 feet high window, Sri Selangor has 5 feet high windowsill and 2 feet high window, and Sri Sarawak has 3½ feet high windowsill and window. Table 2 and Figure 5 shows the result of shading area casted at recessed frontage wall of each apartment unit in all the case studies. In this analysis, 0-25% is categorized as poor, 25-50% as fair, 50-75% as good, and 75-100% as excellent. The most crucial finding is that all the apartment facades have excellent shades from 11 am to 4 pm. However, this analysis finds that the architects who designed all these apartments did not have self-awareness to the importance of vertical shading devices like screen louvers able to provide excellent shades to the apartment facades from late

evening sunlight. Without application of the screen louvers, slightly more than 40% of the apartment facades have direct exposure to the sunlight from 5 pm to 6 pm, which creates solar radiation to the wall surface. Hassan and Mahyuddin (2010) in their study argued that the outdoor temperature at 6 pm was 30.8^{o} Celsius which was 4^{o} Celsius above the average human thermal comfort temperature in Malaysia. Thus, application of the screen louvers is necessary. Early morning low sunlight from 7 am to 10 am is mild sunlight. During this time, it is good to have continuous human skin exposure to direct sunlight, which provides ultraviolet B from the sunray for skin cells to generate vitamin D without having the skin with sunburn problem. The overall results are as follows:

Table 2 Percentage of shading area

Time	Shading Area (%)		
	Melati/Loke Yew	Sri Selangor	Sri Sarawak
8:00 am	53%	51%	51%
9:00 am	54%	53%	53%
10:00 am	67%	58%	68%
11:00 am	100%	89%	100%
12:00 pm	100%	100%	100%
1:00 pm	100%	100%	100%
2:00 pm	100%	100%	100%
3:00 pm	100%	100%	100%
4:00 pm	87%	75%	90%
5:00 pm	58%	54%	58%
6:00 pm	54%	52%	52%
7:00 pm	53%	51%	51%
Average (%)	**77%**	**74%**	**77%**

- All the case studies have their shading performances with above 50% shade (good category) on the façade surfaces.
- All the case studies have excellent shading performance with 77% except Sri Selangor with 74% slightly below 75% mark to be included under an excellent category.
- Melati Apartment has the best result of the overall shading performance, followed by Sri Sarawak and Sri Selangor Apartment. This apartment has the widest corridor and longest extended parapet wall below the brick corridor.
- Sri Selangor Apartment has the lowest performance result in the case studies. It has the narrowest corridor's width and shorter extended parapet wall below the brick railing fence with only 1 feet 2 inches compared to that of Melati Apartment with 2 feet long.
- All apartments have the same height of brick railing wall with 3 feet high, which are the standard height in the corridor design in this country.
- The time from 8 am to 10 am has a cool morning sunlight, which does not affect solar radiation and heat gain to the indoor area of the apartment. The focus of this result's analysis is in the evening sunlight, which induces intense heat to the apartment facades and causes solar radiation.
- All apartment façades have 100% shades from 11 am to 3 pm except Sri Selangor façade at 11 am with 89%.
- At 4 pm, all the case studies have excellent shading performance.
- At 5 pm, all the apartment facades have shades fall under the good category. Nearly half of the surfaces in each apartment have an exposure to direct sunlight. The same condition occurs on the apartment facades at 6 pm.
- From 6 pm to 7 pm, the discussion on the result of this analysis is not necessary. The sun does not create harsh sunlight during this time.

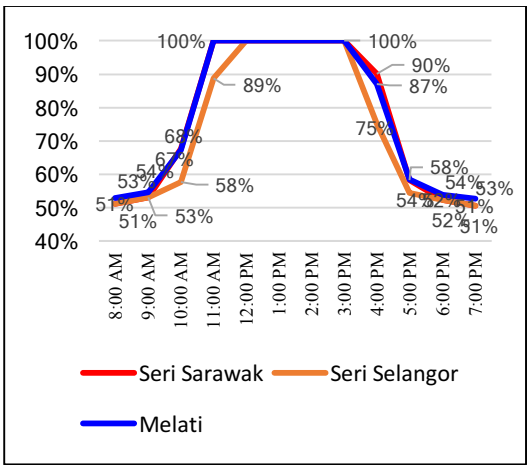


Figure 5: Line chart graph, which illustrates percentage of shading area in each apartment

CONCLUSIONS

This study concludes all the case studies have excellent category of shading performance with an average sunshade of 76%. The contribution of this study is that open corridor system in apartment design provides effective sunshade. The finding of this study recommends apartment with open corridor system as a part of awareness strategy to meet the requirement in Green Building Index (GBI). From 11 to 3 pm, the recessed facades are fully under shade. It is necessary to have the building facades under full shade from intense sunray during this time to prevent solar radiation. The open corridor system also gives excellent shade to the apartment façades at 4 pm. The only necessary evening time that apartment facades do not have excellent shading performance is from 5 pm to 6 pm. Only slightly above 50% of the facades are under shade. The study finds that the open corridor system has more emphasis on blocking high angle sunlight (elevation/altitude) compared to low angle sunlight.

The design has an emphasis on horizontal rather than vertical sun shading devices. The wide corridor plays the most important element as horizontal sun shading device besides functions as circulation access to entrance doors of the apartment units. This horizontal design creates the recessed wall apartment façade. The vertical sun shading elements used in the design is corridor brick railing fence and parapet wall of the corridor roof. The vertical sun shading devices like screen louvers become very important sunshades when the evening sunlight descends at a lower angle (elevation/altitude). From 5 pm to 6 pm, the horizontal sun shading elements are only able to block the apartment façade slightly above 50% from direct sunlight. The finding proposes vertical screen louvers to block the late evening sunlight additionally integrated to the apartment façade to avoid solar radiation to the wall surface. The finding concludes that application of horizontal and vertical sunshades in a tropic is necessary to provide excellent shading performance to the apartment facades. The limitation of this research study is that it is a fundamental study of the effect of solar radiation to the apartment façade. All the values are from a computer simulation survey. The next study will commence on Overall Thermal Transfer Value (OTTV) in its analysis.

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