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Early Modern Apartment Facades in Kuala Lumpur: Overall Thermal Transfer Value

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ABSTRACT

The study dissects the impact of shading on the Overall Thermal Transfer Value (OTTV) through residential building facade with specific reference to the Early Modern apartment facade in Kuala Lumpur. Characterized by its modest mass-produced appearance to cater the low-income groups, special attention is given to the design of the extended open corridor system which becomes the pinnacle of solar shading manipulation on the apartment facade. The selected case study is the Melati Apartment, one of the earliest flats built in Kuala Lumpur, located off the Loke Yew Street. The amount of shading area (%) of the apartment façade is initially simulated and systematically recorded over the course of a day (8 am to 7 pm). While the study records variations in the shading areas alongside time in response to of the length, width and height of the fenestrations and the open corridor system, other parameters like façade orientation, temperature difference, U-values, absorptive factor, and shading coefficient remained empirically similar throughout the study. The procedure proceeds with the calculation of the OTTV which is meticulously undertaken under two different facade conditions which are the fully-exposed and the shaded façades. The study utilizes the subtraction method where the OTTV of the shaded facade is subtracted from the OTTV of the fully-exposed façade in search for OTTV reduction. The result reveals the time period from 11 am to 3pm culminates the highest shading area provided by the corridor, consequently resulting in the lowest OTTV of the residential façade. Conversely, it emerges that in the early morning (8am to 10 ...

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EARLY MODERN APARTMENT FACADES IN KUALA LUMPUR: OVERALL THERMAL TRANSFER VALUE

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Abstract

The study dissects the impact of shading on the Overall Thermal Transfer Value (OTTV) through residential building facade with specific reference to the Early Modern apartment facade in Kuala Lumpur. Characterized by its modest mass-produced appearance to cater the low-income groups, special attention is given to the design of the extended open corridor system which becomes the pinnacle of solar shading manipulation on the apartment facade. The selected case study is the Melati Apartment, one of the earliest flats built in Kuala Lumpur, located off the Loke Yew Street. The amount of shading area (%) of the apartment façade is initially simulated and systematically recorded over the course of a day (8 am to 7 pm). While the study records variations in the shading areas alongside time in response to of the length, width and height of the fenestrations and the open corridor system, other parameters like façade orientation, temperature difference, U-values, absorptive factor, and shading coefficient remained empirically similar throughout the study. The procedure proceeds with the calculation of the OTTV which is meticulously undertaken under two different facade conditions which are the fully-exposed and the shaded façades. The study utilizes the subtraction method where the OTTV of the shaded facade is subtracted from the OTTV of the fully-exposed façade in search for OTTV reduction. The result reveals the time period from 11 am to 3pm culminates the highest shading area provided by the corridor, consequently resulting in the lowest OTTV of the residential façade. Conversely, it emerges that in the early morning (8am to 10 am) and late evening (5pm to 7pm) the OTTV of each facade reaches its highest point during the day due to less shading percentages during these hours. Further analysis unveils the open corridor system's capability to reduce nearly 50% of the average OTTV of the fully exposed façade through shading.

Keywords: High rise Apartments, Early Modern, OTTV, Kuala Lumpur

Introduction

The purpose of this study is to evaluate the Overall Thermal Transfer Value (OTTV) of the Early Modern apartment façade under the influence of different amount of shading at different times over the course of a day. A case study near Jalan Loke Yew in Kuala Lumpur is selected to carry out the study. The early modern apartment style is characterized by its purely simplistic geometric configurations with minimally adorned modular units that embolden its mass-production paragon. Each of these housing units is united by a set of open corridors adjoining to the stairs to vertically link the different levels of the apartment. The embodiment of the extended open corridor system inevitably provides the only opportunity as a shading device for the façade against direct solar radiation during

the daytime. Ultimately, it is detrimental for the building façade to be designed to provide energy efficient and thermally comfortable environmental conditions due to advance solar radiation in response to Malaysia's tropical climate [1].

To calibrate the building's envelope energy efficiency the study employs the principle of Overall Thermal Transfer Value (OTTV) in elucidating on the impact of solar radiation on primarily the apartment façade coupled with the impact of shading areas during specific times in a day [21]. Since its inauguration in 1980, the OTTV calculation method is adopted by several tropical countries in South East Asia including Thailand and Singapore, as a reference to calibrate the amount of thermal transfer values through building façades in

regulating thermal comfort alongside energy consumption [b]. Generally, the OTTV measures heat transfer through building envelope by three methods namely conduction through an opaque surface, conduction through glass window and solar radiation through glass window [22]. In Malaysia, the OTTV is dependent on four parameters which are Window-to-Wall Ratio (WWR), Shading Coefficient (SC), U-values and solar absorption (α) [2], with the recommended OTTV of less than 50 Wm^{-2} [3].

In order to understand the impact of shading generated by the corridor system on the OTTV of the building façade, the study proposes critical analysis of the façade in two stages. The first stage is to carry out the sun shading analysis to measure the percentage of shaded areas (%) respective to the overall façade composition over the course of a daytime. The façade will be simulated from the time period of 8 a.m. to 7 p.m. and the amount of shaded areas for every hour is systematically recorded. The changes in the façade WWR for each hour according to its respective shading percentages will be calculated and recorded during this stage. The second stage is followed by the OTTV calculation of the apartment façade which will be approached in two different façade conditions which are the fully-exposed and the shaded façades. The process continues with the subtraction method where the OTTV of the shaded façade is subtracted from the OTTV of the fully exposed façade to observe the amount of OTTV reduction to be achieved by the open corridor system as the only source of shading device for the early modern apartment.

The findings of this study will provide incisive insights on the importance of shading in controlling the thermal transfer through building envelope to maintain thermal comfort and energy efficiency.

Selected Case Studies

In this study, an apartment which embodies the façade design reminiscent to the typical early modern architectural style was selected as a case study. The style is characterized by an embodiment of simple geometrical forms and unornamented design aiming at amplifying the modernist conception of 'less is more'. The construction utilizes an amalgamation of concrete space-frame structures, brick walls and cement render finishes. Historically, the first high-rise apartment built in this fashion is the Sulaiman Courts a year before the independence in Kuala Lumpur. A few years following its construction, the government decided to build the second apartment known as Pekeliling Flats in 1964.

The Early modern architecture became the popular style particularly in Malaysia from the 1950s to 1970s (Figure 1) where several apartments which manifest the style began to be massively constructed up to the early 1980s. It was during this time that the government was actively constructing low-cost apartments to accommodate the low-income families who lived in squatter homes under a relocation program envisioning towards 'Zero Squatter' policy in Kuala Lumpur [4]. Simultaneously, the word 'flat' was infamous in drawing reference to apartment building.

Today, this word is minimally utilized and it was replaced with the term 'apartment'. The early modern style commonly employed the mass-production construction techniques, typically distinguishable by the design of modular and standardized apartment units. The technique has remarkably expedited the construction process to address housing shortages in Kuala Lumpur [5]. Ultimately, the high rise apartments became an alternative in provision of house units for the low-income earners as their intrinsic shelter [6].



Figure 1: Sri Perak Flat in Sentul, Kuala Lumpur.

The style especially parallels mass-production and rapid construction concepts further enhanced by technological advancement. The mélange often results in simple composition resorting to basic geometric shapes like square, rectangle and circle to illustrate standardized modular house units in design coupled with production process of working drawings to submit for the local authority's approval. In consequence, the design over-simplicity has undeniably hastened the entire progress [7], [8], [9].

In the early modern period, the apartments were typically incorporated with open corridor system at the front facade. The extended corridor serves as the access pathway for the users and residents to connect with the entrance door of the apartment unit. The design was inaugurated by the British Administration slightly before the country's independence which later shapes the development in the apartments' style.

The style characteristically bears the influence from infamous modernist architects during Industrial Revolution in Europe like Le Corbusier, Mies Van der Rohe and Walter Gropius in building high rise flats for laborers, with the use of elevator embedded in the building design [10], [11], [12]. The open corridor system

became the popular signature for the design of apartments such as Flat Isokon built in 1932 in Hampstead, London [13]. Reinforced concrete structures with brick walls, wooden frame for doors and glass louver windows were the ideal construction materials and the apartments were often finally crowned with either flat or nearly flat roof.

The federal government projects on high-rise apartments are mostly concentrated in the capital city of Kuala Lumpur due to the lack of available lands. According to data from the Department of Statistics Malaysia [14], apartment units accounted for the largest percentage of all house types with 73% apartments are located in Putrajaya, the new administrative city for the federal government of Malaysia. The number of apartment units has overshadowed the number of terrace house types as the government is in favor of building high-rise apartments, enabling them to supply hundreds of house units per hectare to address the high demand as a direct result of population booming. By the year 2000, slightly over 2 million people were recorded to have lived in high rise apartments in Malaysia [14].

The Melati Apartment which is located in Pudu area in the city of Kuala Lumpur is selected for the case study. It is known to be amongst the earliest apartments built in this city similar to the Sulaiman Court apartment. The first apartment to be constructed in Pudu area was completed in 1958, while the last was completed in 1965. Figure 2 illustrates the apartments designed from 15 to 18 stories in Loke Yew Road. The location of the apartments in this study is the Melati Apartment (Figure 1) at Loke Yew Road, also referred to as the Loke Yew Apartment

U_w = U value of the opaque part of the wall (W/m^2k)

U_f = U value of the fenestration (W/m^2k)

SC = Shading Coefficient of window

CF = Solar Correction Factor

The absorption factor of a wall α indicates the propensity of a wall to absorb solar energy. For this study, the selected value of α of the brick wall is 0.75 [15]. While SC is defined as the shading coefficient of a fenestration specifically referred to as the ratio of solar heat gain through a particular glass type compared to the solar heat gain through a 3mm clear float glass. The study suggests the proper value of SC chosen is 0.95.

The values yield from this method representing the OTTV of each of the apartment facades without the presence of shading device. To elucidate the extent of shading on OTTV of these facades, further calculation is required by substituting the OTTV parameters that are directly intertwined with shading areas.

The façade orientation selected for the OTTV calculation is based on the facade which receives profound exposure to solar radiation due to its dominant gross wall areas. For Malaysia's geographic location and tropical climate, the West orientation is the predominantly associated with the highest propensity to solar exposure and radiation [16]. Therefore, only the West façade of the apartments is considered for the OTTV calculation to study the impact of shading percentages in mitigating thermal transfer into the apartment facades which contributes to the value of CF equal to 0.94. Window-to-wall ratio WWR is the ratio of window area (glass and frame) to gross wall area [2].

$$WWR = \frac{A_f}{A_i} \quad (2)$$

A_i Total gross area of a wall, m^2

A_f Total gross area of a window, m^2

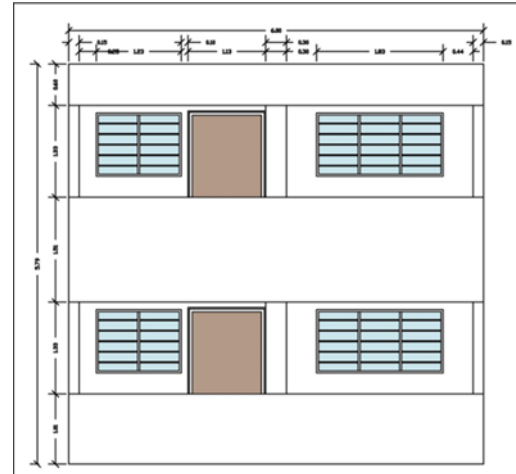


Figure 4: The façade of the Melati Apartment

For the apartment façade the fully exposed WWR is 0.32. The OTTV calculation of the fully exposed façade (100% solar radiation) is shown below:

$$OTTV_w = 15 \times 0.75 \times (1 - 0.320) \times 3.42 + 6 \times 0.320 \times 6.4 + 194 \times 0.320 \times 0.95 \times 0.94 = 93.88 \text{ } Wm^{-2}$$

Secondly, the OTTV calculation is repeated for each of the time period from 8am to 7pm to include the solar shading effects on the OTTV of the façade. Theoretically, the OTTV quantifies heat transfer through building envelope precisely driven by conduction through an opaque surface, conduction through glass window and solar radiation through glass window [24]. Without the presence of direct solar radiation, the thermal transfer process ceases to exist. As a result, only areas that are exposed to solar radiation is considered in the calculation of the WWR. Since the façade of the apartment is subjected to different propensities of shading during daytime the WWR which is a parameter in OTTV calculation is determined according to its respective time period.

To calculate the OTTV of the unshaded areas during the time period from 8am to 7pm, the WWR is re-calculated without taking into consideration the percentage of the shaded areas during these respective

times. This is due to the fact that shading alters the WWR by lowering the gross façade areas exposed to the solar radiation. Therefore, only the areas that are fully exposed to solar radiation is included to calculate the new WWR of the shaded façades of the apartments to quantify the OTTV of these shaded façades at different time periods in the course of a day. The different percentages of shading area provides the extent on the amount of shading that covers the façade which is determined through the shadow heights on the wall. The increase in shading area percentage means more areas are shaded from the upper part to the lower part of the façade as the sun angle rises.

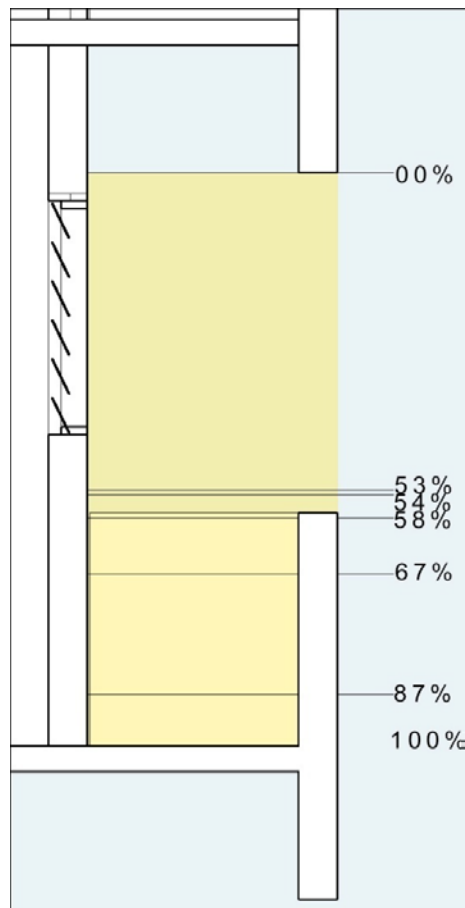


Figure 5: Shadow heights and shading percentages

The shadow heights represent the areas that are shaded in the façade which is crucial in WWR calculation as it only counts the area

that are directly exposed to solar radiation. Ultimately, only the unshaded window and wall areas are utilized in WWR calculation. The values of WWR of the shaded façade areas at different time periods over the course of a day are shown in the table below.

Table 2: Re-calculated Window to Wall Ratio according to shading percentages at different time frames

Time	WWR of Shaded Facade
8 am	0.08
9 am	0.08
10 am	0.05
11 am	0.00
12 pm	0.00
1 pm	0.00
2 pm	0.00
3 pm	0.00
4 pm	0.02
5 pm	0.07
6 pm	0.08
7 pm	0.08
Average	0.03

Each of the newly calculated WWR values of the shaded façade is substituted into the equation to obtain the OTTV inclusive of the impact of shading on the apartment façade at different times in a day which is shown in the table below.

Table 3: The OTTV of shaded façade at different hours from 8 am to 7 pm.

Time	OTTV(shading area)
8 am	52.33
9 am	52.33
10 am	47.13
11 am	00.00
12 pm	00.00
1 pm	00.00
2 pm	00.00
3 pm	00.00
4 pm	41.94
5 pm	50.60
6 pm	52.33
7 pm	52.33
Average	43.67

In providing further understanding on the extent of the open corridor system in providing shade against the solar exposure, each of the OTTV of the shaded area is substituted from the OTTV of the fully exposed façade calculated earlier which gives the value of 93.88 Wm^{-2} . The repercussion of this carrying out this method yields the OTTV reduction values of each time period.

Analyses and Findings

The analysis discovered that the 'open corridor system' is a typical design element in the early modern style apartments [17]. These corridors function as the main circulation system for the residents and users to get access to the entrance door of their apartment unit for each separate floor levels. The corridors mark the frontage of the apartment façade. The apartments constructed from the 1950s to 1980s were designed to accommodate the low-income groups and their family who had migrated from mostly the suburbs to the capital city of Kuala Lumpur in search for a new workplace.

These apartments were also referred to as 'the worker's house' [17], [18] and these buildings were previously known as 'flats'. The dimensions of these low-cost apartments were completely set to the most minimal to meet the standards of living required by the Municipal Council. In the case study, the apartment has the corridor's width of 4 to 5 feet which create a recessed wall of the apartment units with the variable heights ranging from $8\frac{1}{2}$ to $9\frac{1}{2}$ feet. The corridors have 3 feet height brick railing fence wall that serves as a railing. The extended parapet wall of the apartment below the brick railing fence at is set at 1 feet 8 inches.



Figure 6: Frosted Glass Louvered Windows

In this country, the standard brick wall is constructed to be $\frac{1}{2}$ feet or 6 inches wide. Each apartment unit has 20 feet wide façade front wall with a series of glass louver window (Frosted Glass Louvered Windows type – Fig. 6) and one entrance door. The front wall of the Melati Apartment has 4 feet high window sill alongside 3 feet high windows.



Figure 7: Melati/Loke Yew Flat (Example windows)

The study started by evaluating the shading areas (%) of each of the apartment facades during daytime (from 8 am till 7 pm) over the course of a day. The result is summarized as shown in the table.

Table 4: The OTTV of shaded façade and OTTV reduction values according to the percentage of shaded areas at different hours from 8 am to 7 pm.

Time	OTTV of shaded facade	OTTV Reduction	% Reduction
8 am	52.33	41.55	44.3
9 am	52.33	41.55	44.3
10 am	47.13	46.75	49.8
11 am	00.00	93.88	100.0
12 pm	00.00	93.88	100.0
1 pm	00.00	93.88	100.0
2 pm	00.00	93.88	100.0
3 pm	00.00	93.88	100.0
4 pm	41.94	51.94	55.3
5 pm	50.60	43.28	46.1
6 pm	52.33	41.55	44.3
7 pm	52.33	41.55	44.3
Average	43.67	50.21	53.5

The results pinpoint the relationship between shading and the OTTV of different facades of the early modern apartment styles in Kuala Lumpur. It can be observed from the table above the OTTV varies with the presence of shaded areas at different times contribute to varying average OTTV reductions of the apartment facade.

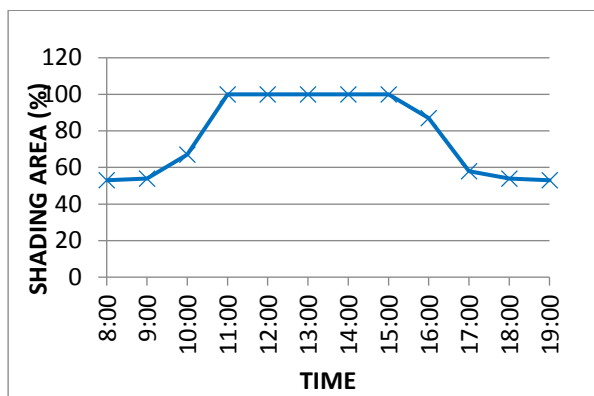


Figure 8: Percentage of Shaded areas at different times during daytime

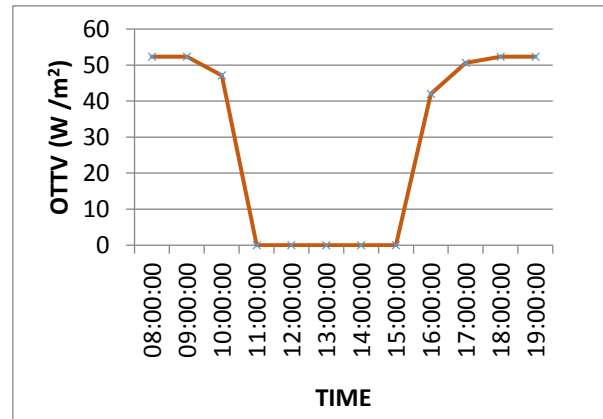


Figure 9: OTTV of shaded façade at different times during daytime

The result highlights the importance of shading in OTTV reduction for the early modern apartment façade. This is evident from the table where at the time period between 11 am to 3 pm the façade culminates the highest shading percentage of 100 %. This condition completely prevents direct exposure to daylight and consequently resulted in OTTV of 0 Wm^{-2} inducing a total of 100 % for the OTTV reduction value. This is due to the fact that OTTV is a process which takes place with the presence of solar exposure on the wall of the façade. Increase in daylight contributes to the increase of solar heat gain and the OTTV [19]. Without solar exposure the process of thermal transfer through the façade wall and fenestrations could not be determined.

A stark contrast can be observed in the OTTV values for the time period between 8 am to 9 am alongside 5 pm to 7 pm. During these times of the day, the OTTV of the façade recorded the highest values of approximately more than 50 Wm^{-2} . Although the OTTV reached the highest during these hours, the values are still within the acceptable residential OTTV range suggested by previous study ranging from 35 Wm^{-2} to 65 Wm^{-2} [2]. This is apparently due to the smaller percentage of shading areas received by the façade at these times of the day. The reason is partly due to the low sun angle during these hours

coupled with the absence of vertical shading device [20].

Further stipulation on the average OTTV generated inclusive with the average shading percentage during daytime, the value of 43.67 Wm^{-2} is achieved. The average OTTV is surely within the comfortable range set by the Malaysian Standards (MS 1525:2007) of less than 50 Wm^{-2} . The average OTTV reduction capability of the open corridor shading system which is 50.21 Wm^{-2} reduces 53.5 % from the OTTV of the fully exposed façade of 93.88 Wm^{-2} , a percentage which reduces more than half of the original OTTV. The shading strategy provided by open corridor system outshines the capability of self-shading strategy which could only reduce 41.37 Wm^{-2} [3].

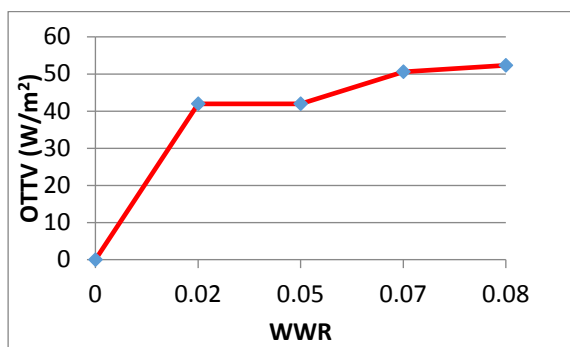


Figure 10 : OTTV at different WWR values

In retrospect, the finding underscores a profound relationship between shading and the value of WWR as a parameter in OTTV calculation. As the value of WWR progresses, the amount of OTTV gradually escalates depending on the amount of shaded area that covers the façade of the apartment. In order to satisfy the requirement set by the Malaysian Standards (MS 1525:2007), the study suggests the maximum value of 0.08 for WWR in order to achieve the requirement of OTTV less than 50 Wm^{-2} . The suggestion on WWR provided by the study seems to echo previous study which suggested the

recommended WWR range is between 0.01 and 0.18 for residential buildings [2].

Conclusion

In conclusion, the study underlines the importance of shading device in mitigating the direct exposure of solar radiation consequently contributing to reduction in OTTV through building envelope. The presence of the open corridor system incorporated in the design of the early modern apartment design substantiates the amount of shading during daytime in order to meet the OTTV requirement set by the standards. Although the average OTTV of the apartment satisfies the requirement, further measures to minimize solar exposure during early morning and late evening hours which include a vertical shading device could be considered in future designs to block the low angle solar radiation [20]. Additionally, the finding reveals the efficiency of the open corridor system as a shading device capable in lowering WWR to achieve the acceptable OTTV set by Malaysian Standards of 50 Wm^{-2} . Therefore, a combination of efficient shading device and thoughtful selection of WWR must be considered as guiding principles by architects in the provision of comfortable and energy efficient façade design in the future.

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