Shading and Extent of Sunlight Penetration on House Facades of the Early Terraced House Type in Petaling Jaya Old Town, Malaysia

Ahmad Sanusi Hassan a* and Mohammed Salem Obaid Bakhlah a

a School of Housing, Building and Planning, Universiti Sains Malaysia, MALAYSIA

ABSTRACT

The aim of this study is to evaluate shading performance and the extent of sunlight penetration on the front house facade of the earliest terraced houses in Malaysia built in 1950s. Two house facades are selected for the case study located in Petaling Jaya Old Town, the first Garden City’s new town in Malaysia. The survey applies sunlight simulation technique using the SunTool programme. The simulation calculates at hourly interval from 7.00am to 6.00pm. The study finds that terraced house facades built in 1950s do not sufficiently design to tackle the house facade exposed to direct sunlight. The emphasis of façade design built in 1950s is more on the architectural style rather than designing efficient shading devices to tackle direct sunlight penetrating to the façade wall and windows. Roof overhang and recessed wall with balcony are the horizontal shading elements commonly used in the house façade design. No vertical shading device was applied to the façade design during 1950s.

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1. Introduction

This study analyses shading areas and sunlight penetration to facades of terraced houses in Petaling Jaya Old Town. The selected facades for the case study are at Section 6, and Section 3 in Petaling Jaya (Figure 1), Selangor about 15 km from Kuala Lumpur. Both houses were
built at southern part of Petaling Jaya (PJS). Section 1 to 8 is also known as Petaling Jaya Old Town because these areas were the earliest settlements built in 1953, 4 years before the country independence. Petaling Jaya is the first Garden City’s new town in Kuala Lumpur as well as in Malaysia built under Decentralised Programme to curb city population’s overcrowding problem in Kuala Lumpur (Hassan, 2005). The selected terraced houses typify an early type of terraced house design in Malaysia. The house design adopts Garden City character with reference to a model of simple cottage design from England introduced by architect Raymond Unwin and Barry Parker (Hassan, 2005; Hall, 1988). The new town is located in the Klang Valley at southwest of Kuala Lumpur Federal Territory borders.

Figure 1: The Case Study 1 at Section 6 (left) and The Case Study 2 at Section 3 (right) in Petaling Jaya South (PJS), Petaling Jaya, Selangor.

The new town was built following the chronic population congestion in Kuala Lumpur due to uncontrolled population migration from rural area to the Kuala Lumpur City which happened dramatically since the early 19th century due to job opportunity as well as the country development towards modernisation. Petaling Jaya is the only new town built before independence under the British administration in Malaya. It was developed in the early decades of the 1950s under the Town and Country Planning Department. The concept of urban planning was adopted from the Garden City concept highlighted by a sociologist idea who was Sir Ebeneser Horward (Hassan, 2005; Hassan, 2009a). Petaling Jaya Old Town had been developed with a city centre located inside the North, East and West Ring Road as well as a small part of Sultan Street. Before independence, the Petaling Jaya City was administered under British by N.A.J. Kennedy's until he was replaced by Abdul Aziz Haji Mohd. Ali, the local Malayan slightly after Malaya’s independence in 1959. According to a data from the
Department of Statistics Malaysia (2003), terraced houses are the most popular house types built in this country, which accounts more than 43% of the house types built in the urban areas in 2000 compared to detached houses, semi-detached houses, mid-rise apartments, high-rise apartments and others.

2. The Case Studies

There are two terraced houses in Petaling Jaya Old Town selected in the case studies which are located about 500 metres to each other. The Case Study 1 (Figure 2) is a terraced house, the address number at No.2, Jalan 6/30, 46000 PJS6, Petaling Jaya whereas Case Study 2 (Figure 3) is located at No.9, Lorong 3/57D, 46000 PJS3, Petaling Jaya. In terms of architectural design, these terraced houses represent atypical terraced house design in Petaling Jaya Old Section which features simple cottage style design (Hassan, 2009b). The design has an influence from the architectural style of residential terraced house type in the United Kingdom popularly built in Garden City’s new towns in early 1900s. The architectural style was introduced by Barry Parker with his interest to the concept of 'English Picturesque Tradition' from modern cottage architecture, featuring heritage from atypical Northern European countryside’s house type (Hall, 1988). He was the architect who had designed terraced houses in Letchworth near London, England the first Garden City in the world. Terraced house design in Petaling Jaya Old Section was a showcase which imitated Garden City’s terraced house types built in the United Kingdom. In terms of architecture, the design was a prototype for Garden City’s housing development as argued by Hassan (2001) when it was first introduced by the British Administration during colonial era in Malaysia (Hassan and Che Yahaya, 2012). It epitomised a style featuring a simplified cottage design which had economic construction cost and less time consumed in construction with simple plan and facade design. The house had simple structural, wall, window and door construction without cosy decorative elements. Barnett (1987) argues;

“Unwin and Parker brought to their design of the Garden City the already well-established concepts of garden suburb and the model village, which in turn were a synthesis of two important design and planning concepts: the picturesque English gardening tradition with its artfully artificial landscape that was developed during the eighteenth century, and the conveniently planned cottage or villa with irregular and picturesque massing, also a late eighteenth-century invention.”
This study found that simple cottage architecture becomes a basis of modern terraced housing development in the United Kingdom and this country. The difference between terraced house style in the United Kingdom and in Malaysia is that some forms of the house elements are slightly modified with reference to the traditional Malay architecture to adjust with the local climate which has a warm and humid climate (Hassan and Ramli, 2010; Zain-Ahmed, Sopian,
Abidin and Othman, 2002) compared to cool and wet climate in the United Kingdom. These elements can be seen on a roof of the house which is designed projected a few feet from the house wall’s perimeter as argued by Bakhlah and Hassan (2012) creating a roof overhang and large window openings for cross air ventilation, and white and light paint colours on the plastered wall surfaces preventing the heat gains from direct sunlight (Zain-Ahmed, 2000).

**Table 1:** Observed time and date, and azimuth of the sun when the shade of facade was calculated for the Case Study 1 and 2 at Petaling Jaya, Selangor at latitude (N 3.1°) and longitude (E 101.4°)

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Time</th>
<th>Date</th>
<th>Azimuth</th>
</tr>
</thead>
<tbody>
<tr>
<td>East 90°</td>
<td>7 am</td>
<td>23 March 2012</td>
<td>90°</td>
</tr>
<tr>
<td></td>
<td>8 am</td>
<td>25 March 2012</td>
<td>90°</td>
</tr>
<tr>
<td></td>
<td>9 am</td>
<td>27 March 2012</td>
<td>89.8°</td>
</tr>
<tr>
<td></td>
<td>10 am</td>
<td>28 March 2012</td>
<td>90.1°</td>
</tr>
<tr>
<td></td>
<td>11 am</td>
<td>29 March 2012</td>
<td>90°</td>
</tr>
<tr>
<td></td>
<td>12 pm</td>
<td>29 March 2012</td>
<td>92.2°</td>
</tr>
<tr>
<td></td>
<td>1 pm</td>
<td>16 September 2012</td>
<td>90.5°</td>
</tr>
<tr>
<td></td>
<td>2 pm</td>
<td>29 March 2012</td>
<td>89.8°</td>
</tr>
<tr>
<td>West 270°</td>
<td>3 pm</td>
<td>18 September 2012</td>
<td>89.8°</td>
</tr>
<tr>
<td></td>
<td>4 pm</td>
<td>26 March 2012</td>
<td>89.9°</td>
</tr>
<tr>
<td></td>
<td>5 pm</td>
<td>24 March 2012</td>
<td>89.9°</td>
</tr>
<tr>
<td></td>
<td>6 pm</td>
<td>22 March 2012</td>
<td>89.9°</td>
</tr>
</tbody>
</table>

3. **Methodology**

Method of the survey applies computer simulation technique using the SunTool software. The simulation will be set at a position of Petaling Jaya at latitude N3.1° and longitude E101.4° closed to the Equator. Limitation of this study is that the simulation will be conducted when the sun position has a sun path perpendicular to the house facade of the selected case studies either during morning (east) or evening (west) hours. The reason is that terraced houses are mass produced house type built with its house facade at various orientations to the sun path; as a result, its house facade simulation will be conducted only at the time at which the house facade is perpendicular to the sun path (Arab and Hassan, 2012). The objective is to measure the simulation results when the house facade has its exposure perpendicular to the sun path (Landry and Breton, 2009). Limitation of this survey exists because the position of the sun path changes from time to time (Mazloomi, Hassan, Bagherpour and Ismail, 2010). In order to get perpendicular angle of the sun path all the day hours to the east (90°) and west (270°) on the house facade, the study has calculated the required sun path using the SunTool Software. Time and date when the sun paths are perpendicular to the house facade are illustrated in Table 1. 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° perpendicular to the house facade (Shahriar and Mohit, 2006). In these cases, the closest azimuths nearest to 90° will be used when the simulation is made in 2012 during daytime in Petaling Jaya from 7.00am to 6.00pm, which are listed in Table 1.

![Figure 4: Simulation in SunTool programme](image)

**Table 2: Calculation of shading and exposed area.**

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{GA} = S_{GH} \times G_{W}$</td>
<td>Where: $S_{GA} =$ Shaded glazing area, $S_{GH} =$ Shading Glazing Height, $G_{W} =$ Glazing Width</td>
</tr>
<tr>
<td>$S_{OA} = S_{H} \times L - S_{GA}$</td>
<td>Where: $S_{OA} =$ Shaded opaque area, $S_{H} =$ Shading Height, $L =$ Length of facade</td>
</tr>
<tr>
<td>$E_{OA} = T_{OA} - S_{OA}$</td>
<td>Where: $E_{OA} =$ Exposed opaque area, $T_{OA} =$ Total Opaque Area</td>
</tr>
<tr>
<td>$T_{OA} = F_{H} \times L - T_{GA}$</td>
<td>Where: $F_{H} =$ Floor Height, $T_{GA} =$ Total Glazing Area</td>
</tr>
<tr>
<td>$T_{GA} = G_{H} \times G_{W}$</td>
<td>Where: $G_{H} =$ Glazing Height</td>
</tr>
<tr>
<td>$E_{GA} = T_{GA} - S_{GA}$</td>
<td>Where: $E_{GA} =$ Exposed glazing area, $T_{GA} =$ Total Glazing Area</td>
</tr>
</tbody>
</table>

All data such as the location of Petaling Jaya, facade orientation at east or west, time and date are keyed to the solar position calculator in the SunTool software (Figure 4) to get the correct position before the simulation will be made. Later, the dimensions of the house facade which are the depth of exterior shading devices, floor height, wall width and sill height are drawn in the SunTool programme. With these solar positions and dimensions of the house...
facade, the software will be able to generate the amount of sun beam and shade on the house facade which provides the results of shading area and extent of the sunlight penetration inside the house.

3.1 Calculating Shading Area

The amount shading area are calculated at hourly interval from 7am to 6 pm when house facades are at a position oriented to east 90° and west 270° perpendicular to the sun path positions. The calculation formulas and the diagrams are shown in Table 2 and Figure 5 respectively.

![Figure 5: Abbreviations on facade and section for Table 2.](image)

The existing wall facade is constructed with two different materials which are opaque element built with brick wall plastered with cements painted in bright colour and window glaze from glass material. The amount of shaded area of these opaque and glazing elements in addition to the extent of sunlight penetration to the indoor area of the house will be simulated in the SunTool programme. The unit of measurement used in this data is the Imperial Units because it was the standard dimension in the terraced house construction widely used in dimensioning the house plans in Malaysia before Metric Units was introduced in 1990. The SunTool programme however provides the measurements in millimetre (Metric units) in the simulations. All the results after that will be converted to the Imperial Units. The data will be then keyed to Microsoft Excel programme to produce graphic line and bar charts for comparative analyses, primarily discussed the results.
3.2 Calculating the Extent of Sunlight Penetration

The simulation survey (SunTool) measures an extent of the sunlight penetration into the indoor area of the selected terraced houses in the case studies which is unblocked by the shading devices of the house facade. In a tropical climate, it is normally to have a house constructed with overhang roofs functioned as shading device (Hassan and Ramli, 2010) illustrated in the house section in Figure 6. However, there are in many cases that the extent of sunlight penetration is not only shaded by the roof overhang but also blocked by an upper window wall. To count the exact extent of sunlight penetration, another line must be drawn parallel to the sun beam at a lower part of the upper window wall as illustrated in Figure 7. A difference of the horizontal distance (x axis) between sun beam and its lower parallel line must
be deducted to get the exact extent of sunlight penetration. These occasions occur in the early morning (7am to 8am) and late evening (5pm to 6pm) due to low sun angle in the sky. The calculation is as follow:

\[ \text{Penetration} = \text{Penetration given by the software (mm)} - \text{Distance between two lines (mm)} \]

4. Analysis and Discussion

For the house facade selected in Case Study 1, it has the total area 414ft\(^2\) which consists of glazed window (180ft\(^2\)) and opaque wall area (234ft\(^2\)) at the ground (storey 1) and first (storey 2) floor level. The facade at the ground floor has window area 120ft\(^2\) and opaque wall area 87 ft\(^2\) while its first floor level has window area 60ft\(^2\) and opaque wall area 147ft\(^2\). For the Case Study 2, its total facade area is 418ft\(^2\) with window 54ft\(^2\) and opaque wall area 364ft\(^2\) at the ground and first floor level. The result shows that the Case Study 1 had larger shading area on its house facade than the Case Study 2. The Case Study 1 had 60% shading area on its house facade starting from 10.00am compared to 35% in the Case Study 2 before both facades were fully under shade at 12.00pm. Similar condition occurred during evening hours starting from 3.00pm, 4.00pm and 5.00pm that the amount of shading area casted on house facade in the Case Study 1 was 43%, 27% and 13% respectively in contrast to that of the Case Study 2 with only 27%, 17% and 9% respectively.

![Figure 8: Shaded and exposed area on the house façade.](image-url)
The results of shading area on house facade (Figure 8) in both case studies show that due to low angle of the sun in the sky at early morning and late evening (Chel, Tiwari and Singh, 2009; Hassan and Arab, 2013), the amount of shading areas accumulated on both house facades in the Case Study 1 and 2 were low (less than 30%) before 8.30am and after 4.00pm. The amount of shading area was smaller than the exposed areas from 7.00am to 9.30am and from 2.45pm to 6.00pm. The shaded areas had however increased gradually due to the increasing vertical sun angle. The results show that from 9.45am to 2.45pm, the amount of shading areas were larger than exposed area. The amount of exposed and shading area was equal at 9.45am and 2.45pm.

Figure 9: Shading area between 2.5ft and 1.5ft projection on the house facades.

Figure 10: Difference of shading area between 2.5ft and 1.5ft projection.

The house facades were completely under shade at 12.00pm. Comparison of shading performance was also carried out between two types of sunshade projection which were built
above the ground floor level of the Case Study 1 with 2.5ft and Case Study 2 with 1.5ft projection (Figure 9 and 10). It can be noted that there were a significant effect to the shaded areas where 2.5ft overhang projection provided larger shaded area than 1.5ft projection. The average difference was 12ft². The maximum difference was 34.64ft² recorded at 1.00pm while the minimum difference was 1.02ft² recorded at 6.00pm. The study found that the house facades built in 1950s only had roof overhangs working as horizontal projection’s shading device, and no vertical projection’s louver for sunshade purpose is used in the terraced façade design. Without the vertical louvers, the façade were exposed to low angle sunlight during evening hours.

![Figure 11: Shading performances on recessed (deep) and non-recessed (shallow) window](image1)

![Figure 12: Shading performances between recessed (deep) and non-recessed (shallow) opaque wall.](image2)
In addition, comparison of shading performance was carried out between 3ft recessed (deep window) and non-recessed window (shallow window) of the house facades. The result (Figure 11) indicates that the amount of shading area on recessed window was larger than non-recessed one. The recessed window was fully shaded starting from 10.00am to 2.00pm while non-recessed window was fully shaded from 12.00pm to 1.00pm. The average shading difference between them was about 20.3ft².

The same condition occurred on recessed and non-recessed wall surface. Figure 12 shows that the recessed opaque wall surface recorded with larger amount of shading area than non-recessed wall surface. The recessed wall was fully shaded from 11.00am to 2.00pm in contrast to non-recessed wall having full shade at 12.00pm. The average difference was about 14.45ft². The maximum difference was 37.68ft² recorded at 2.00pm while minimum difference was 7.38ft² recorded at 7.00am. Both the Case Study 1 and 2 had larger shading area at the first floor than the ground floor level. The reason is the Case Study 1 had recessed wall at its first floor level and the Case Study 2 had shorter overhang projection with only 1.5ft for its ground floor level. In summary, the result shows that the amount of shading area was relatively small with an average of 35% at 3.00pm, 22% at 4.00pm and 11% at 5.00pm in the Case Study 1 and 2. Having sufficient sunshades from 3.00 to 6.00pm is necessary because the evening duration has the warmest air temperature and direct sunlight penetration. In addition, the analysis found that the sky position of the sun plays an important role in creating the amount of shading area as noted by Djamila, Ming and Kumaresan (2011) on the house facade that the larger is the sun angle, the larger is the amount of shading area.

Small amount of the shading area on the house facade at early morning and late afternoon was due to low vertical angle of the sun. The shading area had however a gradual increase due to an increase of vertical angle of the sun (hourly movement of the sun) until it reach to 100% shaded at the afternoon. Due to this reason, the average difference of shading area was small from 7.00am to 10.00am and from 1.00pm to 3.00pm, while it had large average difference from 10.00 am to 11.00am and from 1.00pm to 3.00pm. In case with two types of sunshade projection, the maximum difference of shading area was recorded at 1.00pm when the house facade with 2.5ft overhang projection was at full shade whereas the house facade with 1.5ft projection was partly shaded. On the other hand, the minimum difference was recorded at 6.00pm due to very low sun angle, which caused the overhang projection become ineffective.
The other analysis is the extent of sunlight penetration as illustrated in Figure 13. The extent of sun penetration is measured in feet, recording the distance of the sun penetration from the house facade to the indoor area. There were similar results on the extent of the sun penetration found in the analysis between Case Study 1 and 2 except the ground level which had longer sun penetration in its indoor area due to its short overhang with 1.5ft projection. The study also finds that the extent of sunlight penetration to indoor area through the house facades was another aspect which was influenced by the vertical angle of the sun position in the sky (Hassan and Arab, 2012). The sunlight started with deep penetration to indoor area from the house facade at early morning due to low angle of the morning sunlight. However, it retreated gradually until no penetration inside the house starting from 11.00am to 1.30pm. From 2.00pm to 5.00pm, it started penetration again with gradual increase and lastly at 6.00pm, it penetrated at the deepest extent to the indoor area. The average difference of the extent of sunlight penetration from 8.00am to 11.00am is about 8ft, ranging from maximum 1.6ft to minimum 18.4ft. While the average difference from 2.00pm to 5.00pm is about 10.55ft, ranging from minimum 1.69ft to maximum 23.8ft. The maximum extent was at 7.00am and 6.00pm which was about 52.8ft and 99.1ft respectively whereas the minimum extent was 1.6ft at 11.00am and 2.00pm. The result also shows that there was no sunlight penetration at afternoon when the vertical sun angle was at 90°. The sunlight penetration was influenced by sunshade projection. From the comparison between ground floor’s (1.5ft) and first floor’s (2.5ft) sunshade projection, it can be noted that the difference recorded in the extent of sunlight penetration was equal to the difference in the depth of shading projection.
5. Conclusion

The study concludes that terraced house facades built in 1950s do not efficiently design to tackle the facade exposure to direct sunlight. The study finds that the emphasis of facade design built in 1950s is more on the architectural style influenced by simple cottage design from Garden City movement in England rather than working on efficient shading devices to tackle direct sunlight penetrating to the facade wall and windows. Roof overhang and recessed wall with balcony are the horizontal shading elements commonly used in the house facade design. However these shading design elements were only able to provide less than 50% shading area especially to tackle evening sunlight from 3.00pm to 5.00pm on the house facade. No vertical shading device was commonly applied to the facade design during 1950s. Therefore, having excellent designs of recessed walls, vertical louvers and overhang projections working as sun shading devices are important in the house facade design to tackle the problem.

6. Acknowledgements

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7. References


**Dr. Ahmad Sanusi Hassan** is an Associate Professor in Architecture Programme at the School of Housing, Building and Planning, Universiti Sains Malaysia (USM), Penang, Malaysia. He obtained a Bachelor and Master of Architecture degrees from University of Houston, Texas, USA, and Doctor of Philosophy (Ph.D) degree on sustainable architecture and urban design from University of Nottingham, United Kingdom. At the university, he is currently lecturing in courses related to urban design, studio architecture and history and theory of architecture. He is also teaching architecture courses in Computer Aided Design (CAD), animation and building simulation emphasised in heritage and contemporary architecture study.

**Mohammed Salem Bakhlah** received his Bachelor in Engineering (Architecture Engineering) from Hadhramout University of Science & Technology in 2002. Mohammed received his master degree in building technology from Universiti Sains Malaysia in 2008. Now he is a PhD student at the School of Housing, Building and Planning Universiti Sains Malaysia, Pinang, Malaysia. His research is related to building envelope design for passive heating and cooling strategy for mud brick houses in hot and dry climate. He was awarded a number of merit certificates from Hadhramout University of Science & Technology and from Universiti Sains Malaysia.

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