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A Method to Determine External Horizontal Overhang Projection Considering the Window Solar Angle Properties in Hot and Humid Climate

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ABSTRACT: *A method to determine the optimum overhang projection ratio using total solar energy transmittance (G value) of a window system is presented. The method consists in determining the ideal hourly G value of the window and transmitted heat gains on main cardinal orientations; east, west, north and south. These G-values were utilized to determine the solar radiation intensities for the respective hours of the day. The results were based on the solar radiation data obtained from Subang Meteorological Station, Subang Malaysia, for the year 2001. The results showed that comparison between the window properties and the amount of solar energy transmitted, enable to predict more realistic shading hypothesis than shading device calculations based on incident angle only. The above results suggested optimum overhang ratio of 1.6 (~1.59) for east orientation, overhang ratio between 1.90 and 2.04 for west orientation, overhang ratio between 0.8 and 0.7 for north orientation and between 0.6-0.5 for south orientation. An important benefit of this method is that it gives a series of options of different shading strategies internal or external, to decide based on window systems G-cos value (or solar heat gain coefficient-SHGC) for different orientations.*

Keywords: solar radiation, total solar energy transmittance, incident angle

Introduction

Use of solar path diagram and shading mask to determine the shading device geometry only consider the direct incident solar radiation. Thus, shading is generally design to exclude direct solar radiation penetration in to the building. Due to the fact they only indicate as a fraction to direct solar radiation, “unshaded” or “shaded”. However, the above methods do not determine the amount of solar energy transmitted in to the interior through the fenestration. This implies both short wave and long wave radiation transmission need to be considered in determining shading devices.

The phenomenon of g-value was deployed by Dubois (2000) and Kuhn et.al (2000) as a reference to determine effectiveness of the shading devices. Dubois (2000) developed a method using the g-values of the window glass to determine the shading depth for temperate climate condition and for latitude 59^0 north. The analysis was tested only for south and west orientations. The developed chart was based on Mazria's solar path projection.

Objective

The main objective of this study is to determine shading device geometry using incidence angle and direct beam solar radiation transmittance for east, west, north and south orientations under tropical climate conditions. A normal 3mm thick single pane glass is being used as the reference glazing.

Definition

G-Value as a measure of solar gain

The total solar energy transmittance (g-value) specifies the total fraction of incident solar energy that is transmitted through the fenestration system. The fenestration system implies both the shading device and the window system.

The g-value can be expressed (Dubois, 2000):

$$G_{sys} = \frac{\text{Total Solar Energy Transmittance}}{\text{Incidence Solar Radiation on the facade}} \quad (1)$$

$$G_{sys} = \frac{Q_{sun}}{I_G * A_w} \quad (2)$$

Defining the shading device is made according to the direct radiation. This assumption was made since direct radiation is dominant on clear days when shading is needed and diffuse radiation is desirable as a source of daylight in the building.

However, the diffuse component should also be considered when the shading device is mainly used for glare control.

Method

The incident angle

Intensity of direct solar radiation on any surface for a given atmospheric condition can be determined from the value of intensity of direct normal radiation. If I*bv* denotes the direct solar intensity on a given window surface and the angle between normal to the surface and solar beam is (θ), then Ii is given by;

$$I_{bv} = I_{dn} \times Cos\ (\theta) \qquad (3)$$

I*dn* is the intensity of the direct normal radiation. Assuming for a given incident angle of (θ), the relationship between I*bv* and I*dn* is a constant $(K\theta)$. Thus, it can be expressed as;

$$Cos\ (\theta) = I_{bv} / I_{dn} = K\theta \qquad (4)$$

The window g-value

The solar heat transmission through a glazing is higher when the solar radiation incident perpendicular on the glazing surface. The energy received by the surface decreases when the solar beam moves away from the window normal. The window *g-value* indicates which portion of the incident solar radiation is transmitted and absorbed by the window and become heat in building.

The solar heat gain is expressed by the transmission and absorption coefficients as polynomials in the cosine of the solar incidence angle (figure 1). Transmittance and absorptance properties for glazing are developed by Roos and Karlsson (1998).

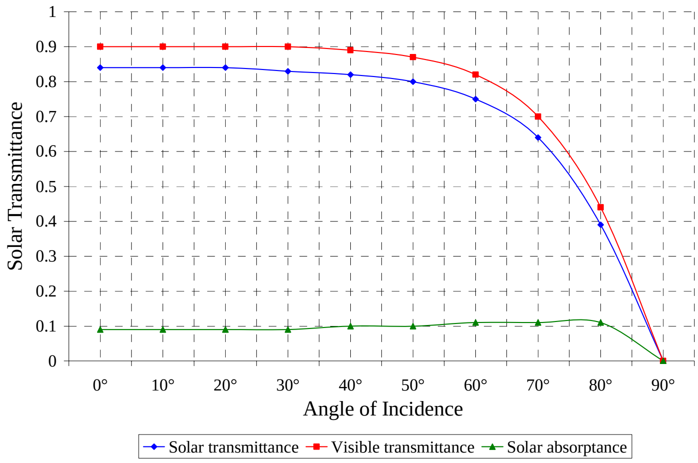

Figure1: The solar transmittance (g-value), visible transmittance and solar absorptance for single clear glass window as a function of the angle of incidence

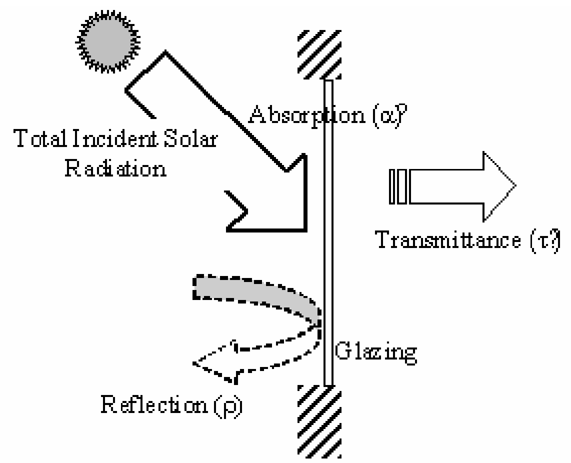

Figure 2: Instantaneous heat balances through sunlit glazing material

Transmission (τ) and absorptance (α) coefficients were determined for direct and diffuse solar radiation as follows:

Hourly solar heat gain on a vertical window surface, *Qsolv* (W/m^2) is given by:

$$Q_{solv} = I_{bv}\,(\tau_b + Ni\alpha_b) + I_{dv}\,(\tau_d + Ni\,\alpha_d) \qquad (5)$$

Since only direct solar radiation is considered,
Direct Radiation:

$$Q_{sol,\,b} = I_{bv}\,(\tau_b N i \alpha_b) \quad (6)$$

Where,

$$g_b = (\tau_b N i \alpha_b) \quad (7)$$

$$\tau = C1 + C2Cos\,(\theta) + C3Cos^2\,(\theta) + C4Cos^3\,(\theta) + C5Cos^4\,(\theta) + C6Cos^5\,(\theta) \quad (8)$$

And

$$\alpha = A1 + A2Cos\,(\theta) + A3Cos^2\,(\theta) + A4Cos^3\,(\theta) + A5Cos^4\,(\theta) + A6Cos^5\,(\theta) \quad (9)$$

For diffuse radiation, Stephenson calculated τdif and αdif to be 0.799 and 0.0544 respectively. Values of the constants *C1, C2, C3, C4, C5 & C6* and *A1, A2, A3, A4, A5 & A6* depends on the glass type and the number of panes. Referred values were obtained from the DOE 2.2 Engineering manual.

The inward flowing fraction *Ni* of the absorbed radiation can be expressed as:

$$Ni = hi / (hi + ho) \quad (10)$$

Where *hi* and *ho* are the heat transfer coefficients of the inside and out side glazing surfaces respectively, given in W/m^2 K. Inward flowing fraction for single glazing is 0.268, reference to ASHRAE fundamentals, (1993). This value is used for present calculations.

Hence, the secondary heat transmission from the absorbed solar radiation can be given as:

$$\tau a = N_i\,\alpha = 0.268 * \alpha \quad (11)$$

Based on the above theoretical assumptions hourly values were derived from the simulation. Then correspondent *g-values* were determined for each set of solar altitude (β) and azimuth (ϕ) angles using the fundamental solar geometrical relationship. However *g-values* for direct solar radiation is taken into consideration as the diffuse component of radiations are independent of the sun position.

$$Cos(\theta) = Cos(\beta) * Cos(\phi - \psi) \qquad (12)$$

Where (ψ), is the orientation of the façade from the same reference direction as the solar azimuth. If the sun is behind the façade $(\phi - \psi)$ >90 or negative (-) value is indicated.

The $g_{\theta -}$ *values* obtain from the above method is the g-value for the reference window. By normalizing the g_θ values with g_0 base value, (which is the maximum transmittance for any given angle, means when the angle of incidence is zero) and the new *g value* can be plotted according to the solar projection and super impose on a solar path diagram.

$$G = g_\theta / g_0 \qquad (13)$$

The nomenclature for G is represented by 'g-value', which implies the fraction of incidence direct solar radiation (I_{bv}) transmitted into the interior through the corresponding glass window. The plotted normalized *g value* is represented by a concentric circle. The inner most circle encompasses the solar position for the g>0.9 value, the second innermost circle for g>0.8 and the third g>0.7 so on. Hence, g>0.7 value implies that 70% of solar radiation from g_0 value is transmitted into the interior through the window pane.

GCos-value

Values obtain for $K\theta$ (Eq. 4) and $g(\theta)$ (Eq.12) from step one and two can be combined into one single value and define it as *GCos-value*. This also can be called as cosine weighted solar angle dependent g-value, Duboi (2000). Hence, for a given incident angle *(x)*, it can be stated as:

$$G_{(x)}\ Cos_{(x)} = \{g\ (x)\} \times \{K\ (x)\} \qquad (14)$$

The *GCos-value* thus specifies the fraction of direct normal solar radiation (I_{dn}) that is transmitted in to the building through the window opening. The calculated *GCos values* using Subang Jaya Meteorological data for east, west, north and south orientations were shown in the following tables (Appendix 1: a, b, c & d). For East and West orientations values were obtain on all twelve months. North orientation data were tabulated for April, May, June, July and August as the direct solar radiation falls on this façade only during these months. South orientation data were collected during the months of January, February, March, September, October, November and December. One day is selected for each month to understand the correlation between each parameter described in above steps. These dates were assumed to be the maximum solar radiation received for respective months. However, for further analysis, months with highest GCos values, maximum incident and transmitted values were selected.

The obtained $G_{(x)}Cos_{(x)}$ values were normalized with $G_{(0)}Cos_{(0)}$ base value, (which is the maximum value for any given angle, when the angle of incidence is zero) and the new *GCos- value* can be plotted according to the solar projection and super impose on a solar path diagram as for *g-value* in step two. Similar to *g-value*, each *GCos* value encompasses solar position at given altitude and azimuth angle. E.g. Maximum values of *GCos*>0.9 delimits the inner most circle, *GCos*>0.8 next inner most circle and *GCos*>0.7 third inner circle so forth.

Direct Solar Gain

The intensity of the solar radiation varies throughout the day and the year depending on the location and the atmospheric conditions. The intensity direct solar radiation (I_{bv}) can be calculated on any surface for given atmospheric conditions using equation, (Eq. 3). Hence, total solar gain due to direct solar radiation can be obtained by;

$$Q_{sol} = I_{dn} \cdot GCos. \ A \qquad (15)$$

Where *A* is the window area.

The values of Q_{sol} is calculated using solar radiation data obtained from Subang Meteorological Station, in Kuala Lumpur and compared with window GCos-values for the main cardinal orientations, (Appendix 1: Table a, b, c, d).

Discussion of Results

The shading depth depends on the required period of the day, where the solar transmission is high. Assuming the building is occupied from 09:00 AM-17:00PM and this period can be accepted as the maximum shading is required. Since the working period is asymmetrical with respect to solar path, critical hours of solar radiation transmission for each orientation differed. The lowest horizontal shadow angle (HSA - 2.3^0) is selected from all cardinal orientations to determine the shading length. Depth of the device is given as a proportion to the window height, (1.82 meter or 6 feet). This dimensionless ratio; external horizontal shading depth to window glazing height, is defined as 'overhang ratio' (OHR).

The following procedure was used to determine the overhang ratio or the projection factor:

1. Determine the critical overheating period of the day, depending on the orientation of the fenestration. E.g. east 9:00- 12:00 hours, west 13:00- 17:00 hours, north and south between 9:00 AM and 17.00 PM hours.
2. From the tables (Appendix 1: a, b, c & d) maximum G-Cos values were identified for respective orientations.
3. Compare the solar radiation intensities obtain for the respective G-Cos values at (2).
4. Select the highest solar intensity and the correspondence G-Cos value and the correspondence overhang ratio.

1. East and West Orientation

Impact of solar radiation incidence on the east façade is critical from 09:00-12:00 hours and 13:00-17:00 hours for the west oriented facades. Beyond this limit the building itself give shade as the sun position is behind the respective facades.

Window angle dependent *g-values* and *GCos-values* are high (>0.9) for east orientation in the morning hours with lowest solar altitude angles and gradually decreased when sun reaches toward noon position. This implies that between 8:00 and 9:00 hours in the morning, most of the incident radiation transmits through the fenestration system (more than 90%). However, solar gain due to direct solar radiation incidence on the vertical surface is low between 8:00 and 9:00 hours compared to higher solar altitude. Vise-versa, although there is high intensity of global solar radiation (> 600 W/m^2) around noon the fraction of radiation transmitted is lower (less than 40%) than at low solar altitude solar positions. Among all the months, January, February and March (table 1) indicated a high *g-value* (>0.9) and *GCos* (>0.8) values for east orientation. This implies that over 90% of g_0*-value* was transmitted into the building. Also, it could be stated as 10% of solar radiation transmittance was reduced from g_0*-value* for that respective solar altitude and azimuth angles. Correspondence overhang ratios for all three days were indicated as 1.74, 1.72 & 1.59 for January, February and March respectively. But the direct solar gain is high on March 21st, compared to January and February. This indicates that only overhang ratio of 1.59 is required to terminate maximum amount of direct solar radiation impinging on the east façade compared to overhang ratios at other low solar altitude angles. This is about 8% reduction compared to the overhang ratio at lowest solar altitude (1.74). Therefore, it can be assumed that an external horizontal shading device with an overhang ratio 1.6 (~1.59) as optimum depth for east facing fenestration. The lowest overhang ratio of less than 0.2 were reported on April, May, June, August, September, October, November and December at 12.00 noon, for east facing fenestration. The overhang ratios for fenestration on east façade range from 0.13 to 1.74 during critical hours (9:00-12:00).

Similarly, for west orientation a high *g-value* (>0.9) and *GCos-values* (>0.9) are indicated for the month of September and October at 17:00 hours (table 1). Also the correspondence overhang ratios were 2.26 and 2.53 which suggested a very deep horizontal overhang. But on these two days and at the particular hour (17:00), the direct solar gain is very low. From all the months March and May indicated high direct solar gain on the west façade. Hence, the results indicated an overhang ratio of between 2.04 and 1.90 is sufficient to eliminate maximum amount of direct solar radiation incident on the west façade during the critical hour (17:00) of the overheated period. The overhang ratio range varies from >0.1 to >2.53 for west orientation.

Table 1: Summary of maximum *g-value* and *GCos-value* obtain for East and West orientations.

Orientation/ Day/Month	Hour	Sol. Alt	Sol. Azi	VSA	OHR	Incid. Angl	g-value	G-Cos value	Qsol (W/m^2)
E-2801	9	28	112.7	30.0	1.74	35.5	0.99	0.81	367
E-2302	9	29.5	103.4	30.2	1.72	32.1	1.00	0.84	274
E-2103	9	32.2	92	32.2	1.59	32.3	1.00	0.84	444
W-2103	17	27.7	268.4	27.7	1.90	27.7	1.00	0.88	213
W-2105	17	24.6	290.6	26.1	2.04	31.7	1.00	0.85	332
W-2409	17	23.9	267.9	23.9	2.26	24.0	1.00	0.91	79
W-2010	17	21.1	257.6	21.6	2.53	24.3	1.00	0.91	121

This implies that considering the glass solar radiation transmittance or the g-value, GCos-value and the solar gain due to direct solar radiation incident on the glazing are important factor in determining the solar shading depth.

2. North and South Orientation

The *g-value* and *GCos* value for North and South indicated lower values than east and west orientations. During the month of May, June and July high *g-value* (>0.7) and *Gcos-values* (>0.2, >0.3 &>0.2 respectively) were obtained for north orientation. Month of June indicated high values than other months, (table 2). Hence the *GCos value* is never higher than 0.4, meaning that the window orientation itself reduces the incident radiation by 60% during the month of June. Evaluating *g-values* for the date 22 June, at 09.00 hrs and 17.00 hours (>0.8) indicated higher than other values. But a constant value (>0.7) is indicated during the shading period, 09:00-17:00. This implies that the solar radiation transmittance is symmetrical during the maximum shading period.

Direct solar gain through south window were obtained on January, February, March, September, October, November and December. Among these months November, December and January obtained a high g-value (>0.8) and *GCos-values* (>0.3) than other months. As in north orientation, GCos-value is never exceeding 0.4. Thus orientation of the window itself reduces the intensity of the incident radiation by 60% during the months where the impact of solar radiation is maximum. Month of December indicated a highest *g* and *Gcos* values for south orientation and values remain constant (g>0.8, *GCos*>0.34) throughout the required shading period. Note that during the month of June and December the sun position is in the north solstice and south solstice respectively.

Projection factor differs from a minimum >0.1 to a maximum >0.8 for north orientation, while range for south orientation is >0.2 to >1.2. But as for the north and south orientation maximum g-value and Gcos values and their corresponding overhang ratios were shown in table 2. According to table 2, best options of overhang ratios for north and south are respectively 0.8>OHR>0.7 and 0.6>OHR>0.5.

Table 2: Summary of maximum *g-value* and *G-Cos value* obtain for North and South orientations.

Orientation/ Day/month	Hour	Sol Alt	Sol. Azi	VSA	OHR	Incid. Ang	g-value	G-Cos value	Qsol (W/m^2)
N-2206	9	32	64.1	55.0	0.70	68.3	0.80	0.35	122
N-2206	17	25.3	294.6	48.6	0.88	67.9	0.81	0.35	58
S-2112	11	53.7	138.2	61.29	0.55	63.81	0.82	0.36	267
S-2112	13	63.1	189.4	63.41	0.50	63.49	0.82	0.37	302

Conclusion

The results showed that window's solar angle dependent properties and its geometrical relationship to the direct solar radiation provide information to make meaningful hypothesis about the external overhang depths. Comparison between the window properties and the amount of solar energy transmitted, enable to predict more realistic shading hypothesis than shading device calculations based on incident angle only. It can be argued that, the obtained values can be defined as optimum geometry of a shading device, compared to the direct solar radiation transmittance.

The above results suggested optimum overhang ratio of 1.6 (~1.59) for east orientation, overhang ratio between 1.90 and 2.04 for west orientation, overhang ratio between 0.8 and 0.7 for north orientation and between 0.6-0.5 for south orientation. These optimum values were obtained for the building occupied period that is from 9:00 am in the morning to 17:00 pm in the evening.

A design method to define the optimum solar shading geometry was presented. Compared to shading mask method to define shading geometry, this method provide additional information on intensity of solar radiation, window solar angle dependent property and the geometrical relationship to the direct solar radiation. These additional information assists to determine the critical overheated periods affecting on a building façade at a given location and orientation. However, energy simulations need to be carried out to justify the shading hypothesis obtained from this experiment.

Another benefit of this method is that it gives a series of options of different shading strategies internal or external, to decide based on shading device gcos-value (or solar heat gain coefficient-SHGC) for different orientations. For example, a shading device (internal or external) with gcos-value with 0.4>gcos>0.3 on south window can be used to get maximum protection from solar heat gains.

The present study was conducted only considering the effect of direct solar radiation. This may give more reasonable results under clear sky conditions. However, considering the diffuse component might give more precise information on the total heat transmittance. Further, in this study uses solar radiation data obtained on a single year. A more precise approach would consist of having more solar radiation data, at least of five years. Also the solar radiation calculations were based on data obtained for horizontal surface. Data obtained on vertical surface will provide more accurate results on overheating period and on shading geometry.

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Appendix 1:

Table a: East Orientation

Day/ Month	Hour	Sol. Alt	Incid. Ang	VSA	OHR	g-value	G-Cos value	SMS sol.rad (W/m^2)	Qsol (W/m^2)
28/01	7	3.5	19.0	3.7	15.49	1.00	0.95	na	na
	8	14	24.1	14.8	3.77	1.00	0.91	269	246
	9	28	35.5	30.0	1.74	0.99	0.81	453	367
	10	41.5	48.6	45.1	1.00	0.97	0.64	553	354
	11	54.2	62.5	60.4	0.57	0.88	0.41	580	236
	12	64.4	76.6	75.6	0.26	0.61	0.14	647	91
	13	68.5	90.8	-89.1	-0.02	0	0	492	0
	14	63.4	105.1	-73.8	-0.29	0	0	586	0
23/02	7	3.7	10.9	3.8	15.21	1.00	0.98	na	na
	8	14.8	18.5	15.1	3.71	1.00	0.95	25	24
	9	29.5	32.1	30.2	1.72	1.00	0.84	325	274
	10	43.9	46.5	45.2	0.99	0.98	0.67	628	422
	11	58	61.2	60.4	0.57	0.89	0.43	678	292
	12	70.6	75.9	75.5	0.26	0.63	0.15	714	109
	13	76.8	90.7	-89.3	-0.01	0	0	828	0
	14	69.6	105.4	-74.2	-0.28	0	0	425	0
21/03	7	4.9	4.9	4.9	11.66	1.00	1.00	na	na
	8	17.2	17.2	17.2	3.23	1.00	0.96	278	265
	9	32.2	32.3	32.2	1.59	1.00	0.84	528	444
	10	47.2	47.3	47.3	0.92	0.97	0.66	625	413
	11	62.1	62.3	62.2	0.53	0.88	0.41	891	366
	12	76.9	77.3	77.2	0.23	0.59	0.13	928	120
	13	86.2	92.2	-87.8	-0.04	0	0	344	0
	14	72.5	107.2	-72.7	-0.31	0	0	372	0

Table b: West Orientation

Day/ Month	Hour	Sol.Alt	VSA	OHR	Incid. Ang	g-value	Gcos-value	SMS sol.rad (W/m²)	Qsol (W/m²)
	11	62.1	-62.2	-0.53	117.7	0	0	891	0
	12	76.9	-77.2	-0.23	102.7	0	0	928	0
	13	86.2	87.8	0.04	87.8	0.14	0.01	344	2
	14	72.5	72.7	0.31	72.8	0.71	0.21	372	78
	15	57.6	57.7	0.63	57.7	0.92	0.49	505	249
	16	42.7	42.7	1.08	42.8	0.98	0.72	567	409
2103	17	27.7	27.7	1.90	27.7	1.00	0.88	242	213
	18	12.7	12.7	4.44	12.7	1.00	0.98	72	70
	11	60.3	-65.4	-0.46	113.5	0	0	703	0
	12	70.5	-80.1	-0.17	99.4	0	0	533	0
	13	72.5	85.2	0.08	85.4	0.26	0.02	505	11
	14	64.3	70.4	0.36	71.3	0.74	0.24	708	168
	15	52	55.7	0.68	57.5	0.93	0.50	572	285
	16	38.5	40.9	1.16	44.0	0.98	0.71	508	359
2105	17	24.6	26.1	2.04	31.7	1.00	0.85	392	332
	18	10.5	11.1	5.08	22.2	1.00	0.93	128	118
	11	65.8	-66.0	-0.44	113.9	0	0	855	0
	12	80.3	-81.1	-0.16	98.9	0	0	803	0
	13	82.8	83.9	0.11	83.9	0.33	0.03	722	25
	14	68.6	68.9	0.39	68.9	0.79	0.28	442	125
	15	53.8	53.9	0.73	54.0	0.95	0.56	211	118
	16	38.8	38.8	1.24	38.9	0.99	0.77	489	377
2409	17	23.9	23.9	2.26	24.0	1.00	0.91	86	79
	18	8.9	8.9	6.38	9.0	1.00	0.99	31	30
	12	74.8	-82.8	-0.13	97.0	0	0	919	0
	13	74.4	82.0	0.14	82.2	0.41	0.05	808	44
	14	63.5	66.8	0.43	67.5	0.81	0.31	625	194
	15	49.9	51.7	0.79	52.8	0.95	0.58	189	109
	16	35.6	36.6	1.35	38.3	0.99	0.78	305	238

2010	17	21.1	21.6	2.53	24.3	1.00	0.91	133	121
	18	6.9	7.0	8.11	12.9	1.00	0.98	44	43

Table c: North orientation

Day/ Month	Hour	Sol.Alt	VSA	OHR	Incid.Ang	g- value	Gcos- value	SMS sol.rad (W/m^2)	Q_{sol} (W/m^2)
	8	18.4	39.5	1.21	67.5	0.81	0.36	244	88
2206	**9**	**32**	**55.0**	**0.70**	**68.3**	**0.80**	**0.35**	**353**	**122**
	10	45.2	63.0	0.51	68.9	0.79	0.33	442	147
	11	57.4	67.2	0.42	69.3	0.78	0.32	405	131
	12	66.8	69.1	0.38	69.5	0.78	0.32	714	226
	13	69.3	69.6	0.37	69.6	0.78	0.31	650	205
	14	62.7	68.4	0.40	69.4	0.78	0.32	450	143
	15	51.6	65.5	0.46	69.1	0.79	0.33	394	129
	16	38.8	59.7	0.58	68.5	0.80	0.34	336	114
	17	**25.3**	**48.6**	**0.88**	**67.9**	**0.81**	**0.35**	**164**	**58**
	18	11.6	27.3	1.93	67.1	0.82	0.37	78	29

Table d: South orientation

Day/ Month	Hour	Sol.Alt	VSA	OHR	Incid.Ang	g- value	Gcos- value	SMS sol.rad (W/m^2)	Q_{sol} (W/m^2)
2112	9	29.9	49.60	0.85	64.90	0.80	0.34	242	82
	10	42.6	57.35	0.64	64.30	0.81	0.35	414	146
	11	**53.7**	**61.29**	**0.55**	**63.81**	**0.82**	**0.36**	**739**	**267**
	12	61.6	63.12	0.51	63.53	0.82	0.37	605	222
	13	**63.1**	**63.41**	**0.50**	**63.49**	**0.82**	**0.37**	**822**	**302**
	14	57.4	62.29	0.53	63.74	0.82	0.36	608	220
	15	47.1	59.15	0.60	64.05	0.81	0.36	380	135
	16	34.9	53.17	0.75	64.63	0.80	0.34	342	118
	17	21.8	41.67	1.12	65.34	0.79	0.33	247	81

Sol.Alt: Solar Altitude Sol.Azi: Solar Azimuth VSA: Vertical shadow angle
OHR: Overhang ratio Incid. Ang: Incident angle
SMS sol.rad: Global solar radiation at Subang Meteorological Station (Kuala Lumpur)

Q_{sol}: Solar gain due to direct solar radiation through window (W/m^2)