International Journal of Engineering, Technology and Natural Sciences
ISSN 2685-3191
Vol. 1, No. 1 Juli 2019

THE EFFECT OF DEPTH SHADING DEVICE ON INNER SPACE ILLUMINATION IN JAKARTA

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ABSTRACT

This research tries to reveal the performance of shading devices towards quantity of natural lighting entering the room. Investigation concerning shading devices (ratio between the depth of shading devices and the height of fenestration) that suitable with illumination standard needs to be done. This research also tries to find out the influence of shading devices orientation on illuminance received by the room. This research examines the performance of three types of external shading devices (egg crate, overhang, side fins) towards natural lighting entering the room. The analysis is performed by Radiance IES software for illuminance performance entering the room. Maximum illuminance reduction for three types of shading device achieved to north direction in R1 reference point. While minimum reduction for overhang and sidefins achieved to south orientation in R2 reference point. Except for eggcrate minimum illuminance reduction achieved to west direction in R2 reference point. It can be concluded that in general the three basic models of shading devices have a strong influence on the direction towards the north and have a small effect on the direction of the south. In addition to the three basic elements of the shading element, the type of eggcrate shading device has the greatest effect of reducing illumination compared to the other two types. While the side fins type has the smallest illumination effect.

Keywords: shading device, illuminance, illumination effect

1. Introduction

Global warming that is unstoppable due to the greenhouse effect on the earth, has recently become a concern of environmentalists. Global warming is not immediately controlled, the impact can be very bad for human life. Various efforts must be made immediately, including preventing uncontrolled deforestation and reducing air pollution which can cause greenhouse effects (Digest, 2007).

Half of the world's population is now estimated to have lived in cities. In 1995 45% of the world's population lived in urban areas, and around 1 billion of the world's 2.6 billion people lived in large cities (Jenck, 1996).

Buildings wrapped in glass that are widely available in big cities like Jakarta will reflect stinging tropical sunlight. This can be seen in various tall buildings along the capital's protocol road. People who cross the building can be exposed to glare and will make the surrounding area hotter because of the radiation. Or cause glare that endangers the driver of the car (R. Siti Fatimah Hidayat, 1996).

About 99 percent of the buildings in the Special Capital Region (DKI) of Jakarta do not fulfill the concept of sustainable construction, so they are wasteful of energy and tend to be environmentally friendly, and produce large exhaust emissions (Antara, 2007).

The use of shading elements to reduce solar thermal radiation can have a detrimental effect. The impact is a reduction in the amount of natural lighting entering the room. Reduction in the amount of natural lighting received by the room because there is a shading mask that appears due to the addition of shading elements (Setiadarma, 1995).

Research revealing how much reduction in the amount of natural lighting coming into space as a result of adding shade elements needs to be done. Furthermore, the city of Jakarta was chosen as the research location because the city of Jakarta is one of the major cities in the world and already has complete climate data.

This study investigates the effect of external shading elements on the amount of natural lighting entering the space. The research problem is emphasized to find out the depth of the external shade elements in accordance with the lighting standards in the inner space located in the city of Jakarta. The study also sought to investigate the orientation of openings in relation to the amount of natural lighting entering the space. It is expected that this study can reveal the relationship between the depth of the external shade device and the amount of natural lighting entering the space, and the direction of its orientation in the inner space in the city of Jakarta.

2. Research Method

This study uses model simulation as the object of research. The model is built through literature studies and initial simulations to determine the limits for the variables to be tested. The material data used in this study was taken from data contained in the software. Climate data is taken from the Jakarta city climate data issued by The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE).

This study uses a space simulation model as the object and uses software as a research tool. The software used in this study is IES radiance (virtual environment 5.6.2) which is used to measure natural lighting.

Simulations are conducted to investigate the effect of the depth of the shading device on illumination on a predetermined workplan in space. This is done by taking reference points 1 and 2 on model space. This simulation is carried out by using software assistance radiance 5.6.2. From the simulation results, it can be determined the depth value of the shading element that matches the illumination target on the workplan.

In developing the model that will be examined the author refers to the method developed by J.W. Griffith at the Libbey-Owens-Ford Company (How to Predict the Interior Daylight Illumination, Toledo, Ohio, 1976). It is assumed that the top of the window is parallel to the ceiling and the bottom is at the height of the table (3 ft above the floor). Assuming the ceiling height is 10 ft.

The procedure for analyzing the research above is done to examine three points in a space that represent a particular area. Namely: 1. Maximum point, within 5 ft of the window, 2. Midpoint, is the midpoint between the window and the back wall, 3. The minimum point, is 5 ft from the back wall. Each prediction point represents the floor area.

In this study only checks on midpoints and minimum points were taken as research samples. Two reference points were taken into consideration because they have been checked (pre-simulated) in the direction with minimum illumination (west) and with the highest depth of shading element (2.8m).

Pre-simulation results are reported for illumination on the workplan in the west direction. The results reported are in the form of illumination points on workplan in the middle of space (3.00 meters), and distances with windows starting at 1.00 meters, 1.50 meters, 2.00 meters, 2.50, meters, 3.00, meters, 3.50, meters, 4.00 meters, 4.50 meters, 5.00 meters and 5.50 meters. The values reported in lux are as follows:

Table 2.1 Illumination Value at Workplan 2.8 meters depth of image westward

	5,50	5,00	4,50	4,00	3,50	3,00	2,50	2,00	1,50	1,00
Westward Without Shading Devices										
3,00	828	856	940	1057	1261	1505	1857	2382	**3147**	4131
Westward Eggcrate 2,8										
3,00	328	333	332	343	369	411	482	559	**662**	811
Westward Overhang 2,8										
3,00	492	507	535	539	596	675	794	950	**1116**	1351
Westward Sidefin 2,8										
3,00	731	721	750	823	938	1129	1367	1715	**2198**	2929

Source: Radiance IES 5.6.2 Simulation Output

The conclusion from the pre-simulation that has been done is that at a point with 1.5 meters from the lowest illumination window is 662 lux. This level of illumination is still above the desired illumination target. This point can be ignored on illumination sampling on the work plan, because there is no longer possible lower illumination value. Therefore, the point chosen as the reference point in this study is R1 with a distance of 3 meters from the window, and R2 with a distance of 4.5 meters from the window.

Variable width of space for this study was selected 6 meters. While the depth of space is chosen 6 meters. The reason for choosing is that the distance of natural lighting to enter the deepest side of the room is 2.5 times the height of the window. This study uses a window with a height of 2 meters. So that the maximum penetration distance of natural lighting into space is 5 meters. The ceiling height of the model is 3 meters. The upper limit of the window with a 0.1 meters ceiling. While the lower limit is 0.9 meters high from the floor. Window width is considered continuous without bulkhead.

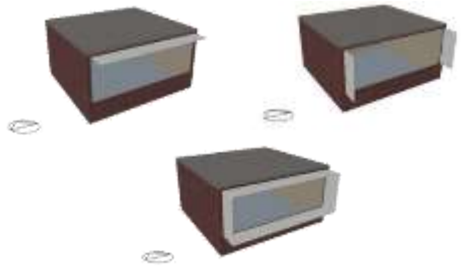
This study seeks to determine the effect of geometry in the form of depth of the shadowing element for its performance against natural lighting factors that enter into a space.

Eight kinds of depth from the shadowing element will be tested on the type of horizontal, vertical, and eggcrate shading elements to a space of 36 m² (6 x 6 meters). Furthermore, the results of this test will be recorded and analyzed to determine the effect on illumination on the workplan entering the room.

The model of the inner space is assumed to be a room 6 meters long and 6 meters wide and 1/2 brick wall with a flat roof. Window height is of 2 meters with a width of 5.8 meters. The height of the window from the floor is 0.9 meters (the height of the lower end).

Horizontal (overhang), vertical (sidefins), and eggcrate shading elements were tested for the ratio of depth to window height to the effect of illumination on the workplan received by the room. In addition to the influence of the depth of the shadowing elements, the effect of the shading element orientation on eight wind direction (north, east, south, west, northeast, southeast, southwest, northwest) was also tested for illumination on the workplan in the room.

Picture 2.1 Model of Shading Device (Overhang, Sidefins, dan Eggcrate) in 6x6m space



Source : Analysis Based on Griffith and Koenigsberger

The inner space is conditioned as follows: The internal illumination of space is at level 500 lux. The location of the reference point is at a depth of 3 meters and 4.5 meters from the location of the window. The workplan height is 0.9 meters. The whole room and the shadow elements are assumed painted in white.

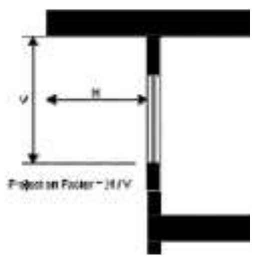
The desired illumination target is in the range of close to 500 lux. It is assumed that the function of the inner space is as an office space that requires an illumination level approaching the range of 500 lux. This level is chosen to meet the needs of light for jobs that require moderate accuracy. Climate data used in this study is hourly climate data for the Jakarta region or at locations 6.18˚S latitude and 106.83˚E longitude. The condition of the sky dome is assumed to be bright. This assumption is made to get the maximum illumination value.

The analysis of this study is based on data obtained from simulations with IES radiance software (virtual environment 5.6.2) on tests performed on the shadowing element. The shadow element simulation is carried out on eight wind direction (east, southeast, south, southwest, west, northwest, north, northeast).

The study was conducted by taking March 21 as the date of the study. The time of the study was chosen at 12.00 WIB by reason of the perpendicular angle of sunlight and would cause the level of illumination to be evenly distributed in each orientation tested. The simulation results are in the form of illumination levels (lux) on the workplan at two predetermined reference points (R1 and R2). For illumination research, simulations are carried out in a steady state by taking a sample at 12.00 WIB.

This study assumes white as the color of the space model in which it is studied. White is chosen because this color has the highest reflectance value (R = 1) so it will maximize illumination on the workplan. The state of the sun is chosen in bright conditions (clear sky) with reasons to maximize sunlight falling on the window area.

The ratio of the horizontal depth of the external shadow projection is divided by the sum between the opening heights and the distance from the upper side of the opening to the base of the farthest point from the projection of the external shadow, in a unit.



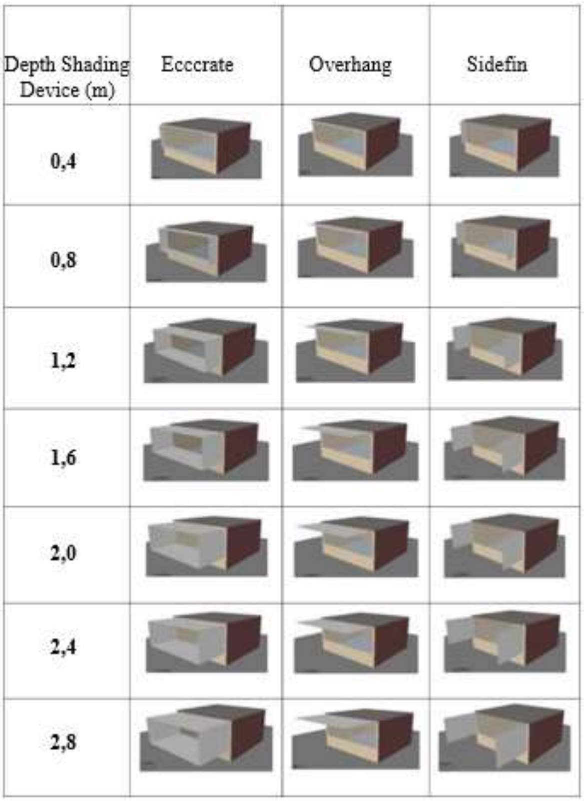
Picture 2.2 *Projection Factor* (Shading Device Ratio to Fenestration)
Source :
http://www.archenergy.com/guam/glossary.htm

The ratio (R) of the shading element in this study is the comparison between the depth of the shading element and the height of the window (window height). The height of the window used in the study was 2 meters.

$$R = \frac{D}{H}$$

Description:
R : Shading Element Ratio
D : The depth of shading element
H : Height of window

Table 2.2 Depth of Shading Device That Will be Simulated



Source : Analysis

Table 2.3 Depth of Shading Device and Ratio to Window (window height of 2 meters)

Shading Device (m)	Ratio to Phenestration (R)
0	0
0,4	0,2
0,8	0,4
1,2	0,6
1,6	0,8
2,0	1,0
2,4	1,2
2,8	1,4

Source : Analysis

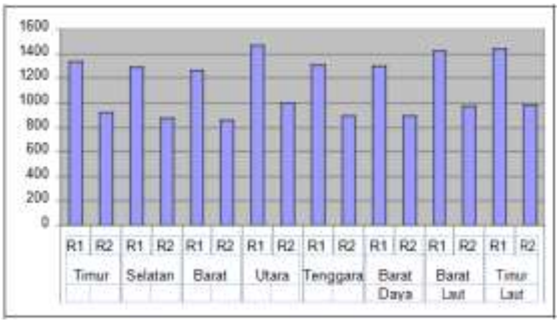
3. Results and Discussion

The study was conducted on the effect of the shading elements on the amount of natural lighting entering the room. The study also investigated the effect of building orientation on the amount of natural lighting entering the room. The measurement results of natural lighting that enter the room with certain shadowing elements compared to the amount of natural lighting that enters the room without the shadowing element (base case model/ratio 0). This comparison will show the performance of the shadowing elements against natural lighting.

Analysis is based on the natural illumination (lux) illumination values that enter the room and fall on the workplan (0.9 m above the floor). Reference points according to research conducted by Griffith were taken on the workplan with a distance of 3 meters from the window (midpoint) and 1.5 meters from the wall of the room farthest from the window (minimum point). The study was conducted by assuming the dome standard of the sky in the clear sky model and taking time at 12.00 WIB.

The illumination target is 500 lux (close to 500 lux) in accordance with the illumination standards required for office space. While the reference point is taken at two points. Point R1 (reference 1) in the middle of space (with a distance of 3x3 meters) and point R2 at a distance of 1.5 meters from the back wall (3x1,5 meters) according to the reference point taken in the research conducted by Griffith (How to Predict Daylight Illumination). Data obtained from the IES radiance output on March 21 at 12.00 WIB is presented in a table form that is associated with the depth of the shadowing elements at reference points 1 and 2 for the types of eggcrate, overhang, and side fins shadow elements.

Table 3.1 Illumination in Inner Space Workplan without Shading Device on March 21 at 12.00 (lux)



Source : Radiance IES 5.6.2 Simulation Output

On the condition without the shadowing element the direction of the north orientation gets the highest illumination level, namely at R1 1471 lux and at R2 1002 lux. The minimum illumination level occurs in the direction of the western orientation with the illumination level on R1 is 1261 lux and R2 856 lux.

Table 3.2 Depth of Eggcrate Shading Device and Illumination at Reference Points 1 and 2 on March 21 at 12.00 WIB (lux)

	Timur		Selatan		Barat		Utara	
	R1	R2	R1	R2	R1	R2	R1	R2
0.0	**1332**	**922**	**1295**	**876**	**1261**	**856**	**1471**	**1002**
0.2	1141	806	1057	761	1142	796	1218	854
0.4	959	683	902	648	959	678	1038	721
0.6	805	586	759	548	790	573	851	609
0.8	684	492	645	475	678	495	711	527
1.0	581	432	551	416	583	433	611	453
1.2	486	380	466	363	487	377	516	397
1.4	410	325	397	319	411	332	435	344
	Tenggara		**Barat Daya**		**Barat Laut**		**Timur Laut**	
	R1	**R2**	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**
0.0	**1307**	**894**	**1296**	**895**	**1427**	**974**	**1442**	**978**
0.2	1088	774	1086	773	1198	837	1198	840
0.4	921	660	919	655	1001	705	1000	712
0.6	775	564	760	561	838	605	832	606
0.8	654	481	648	479	703	516	715	515
1.0	547	418	553	416	603	447	600	445
1.2	471	365	465	368	510	394	508	392
1.4	397	323	397	322	425	335	430	336

Source : Radiance IES 5.6.2 Simulation Output

The gradual addition of depth to the element of the eggcrate shadow will result in a decrease in the level of illumination received by the room. This occurs in all orientation directions with almost the same level of reduction.

For eggcrate shadow element type, maximum illumination reduction occurs in the direction of north orientation at reference point 1 (orientation with maximum illumination) which is 1471 lux - 435 lux = 1036 lux. While the minimum illumination reduction occurs in the west orientation direction at reference point 2 (856 lux - 332 lux = 524 lux).

Table 3.2 Depth of Overhang Shading Device and Illumination at Reference Points 1 and 2 on March 21 at 12.00 WIB (lux)

	Southeast		Southwest		Northwest		Northeast	
	R1	R2	R1	R2	R1	R2	R1	R2
0.0	**1307**	**894**	**1296**	**895**	**1427**	**974**	**1442**	**978**
0.2	1153	801	1124	809	1246	881	1239	878
0.4	1008	727	1017	728	1098	782	1107	787
0.6	922	666	913	670	994	707	984	710
0.8	851	628	845	622	908	655	918	657
1.0	797	588	796	584	845	620	852	616
1.2	758	564	760	559	796	576	812	590
1.4	704	536	697	539	752	561	760	566

	East		South		West		North	
	R1	R2	R1	R2	R1	R2	R1	R2
0.0	**1332**	**922**	**1295**	**876**	**1261**	**856**	**1471**	**1002**
0.2	1089	777	1167	831	1197	833	1264	893
0.4	970	692	1046	734	979	693	1123	795
0.6	859	632	940	667	940	685	1007	728
0.8	805	586	862	611	876	629	931	667
1.0	761	552	812	591	817	601	866	624
1.2	707	525	757	558	713	533	808	595
1.4	674	506	714	529	675	507	762	570

Source : Radiance IES 5.6.2 Simulation Output

The gradual addition of depth to the overhang shadowing element will result in a decrease in the level of illumination received by the room. This occurs in all directions of orientation with relatively the same level of reduction.

For overhang shadow element type, maximum illumination reduction occurs in the north orientation direction at reference point 1 (orientation with maximum illumination), which is 1471 lux - 762 lux = 709 lux. While the minimum illumination reduction occurs in the direction of the south orientation at the reference point 2 (876 lux - 529 lux = 347 lux).

Table 3.4 Depth of Sidefins Shading Device and Illumination at Reference Points 1 and 2 on March 21 at 12.00 WIB (lux)

	East		South		West		North	
	R1	R2	R1	R2	R1	R2	R1	R2
0.0	**1332**	**922**	**1295**	**876**	**1261**	**856**	**1471**	**1002**
0.2	1317	907	1287	869	1235	837	1440	966
0.4	1302	883	1280	860	1204	812	1403	932
0.6	1288	865	1273	851	1176	791	1370	922
0.8	1269	845	1267	837	1152	779	1368	909
1.0	1254	843	1249	826	1140	764	1357	898
1.2	1251	817	1241	814	1136	758	1342	887
1.4	1230	824	1224	812	1129	750	1320	871
	Southeast		**Southwest**		**Northwest**		**Northeast**	
	R1	**R2**	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**
0.0	**1307**	**894**	**1296**	**895**	**1427**	**974**	**1442**	**978**
0.2	1274	872	1270	865	1399	942	1400	966
0.4	1250	845	1244	845	1368	917	1370	931
0.6	1228	833	1220	826	1346	896	1352	909
0.8	1216	816	1206	816	1333	881	1339	890
1.0	1204	808	1188	806	1327	879	1327	877
1.2	1184	802	1187	794	1304	868	1326	866
1.4	1180	786	1186	789	1303	850	1300	849

Source : Radiance IES 5.6.2 Simulation Output

The addition of depth to the shadowing elements of side fins will result in a decrease in the level of illumination received by the room. This occurs in all orientation directions with approximately the same level of reduction.

For sidefins shadow element type, maximum illumination reduction occurs in the north orientation direction at reference point 1 which is 1471 lux - 1320 lux = 151 lux. Minimum illumination reduction occurs in the south R2 orientation, which is 876-812 lux = 64 lux.

Of the three shading element types, the eggcrate type gives the maximum illumination reduction value of 1036 lux which occurs in the north. On average this type also gives a decrease in illumination values greater than the other two types. While the type of sidefins gives the smallest value decrease in illumination of 64 lux in the south direction R2. The type of sidefins also gives a smaller decrease in illumination compared to the other two types of shadowing elements.

Table 3.5 Minimum-Maximum Illumination Reduction and Orientation for Basic Shading Device Models on March 21

Shading Device Model	Maximum Illumination		Minimum Illumination	
	North R1 1471 lux		West R2 856 lux	
	Maximum Illuminance Reduction		Minimum Illuminance Reduction	
	Orientation	Lux	Orientation	Lux
Eggcrate	North R1	1471-435=1036	West R2	856-332=524
Overhang	North R1	1471-762=709	South R2	876-529=347
Sidefins	North R1	1471-1320=151	South R2	876-812=64

Source : Radiance IES 5.6.2 Simulation Output

On March 21 the position of the sun is in the equator line (in the middle of the hemisphere). This research was conducted at 12.00 WIB for illumination sampling. From these conditions it can be concluded that the illumination will be spread evenly throughout the direction of the room (the difference in orientation does not have a large effect on illumination).

The maximum reduction for eggcrate, overhang, and sidefins is reached in the north direction R1. While the minimum reduction for overhangs, and sidefins is achieved in the southern orientation R2. Except for the minimum illumination eggcrate reduction is reached in the west direction R2.

It can be concluded that in general the three basic models of shadow elements have a strong influence on the direction towards the north and have a small effect on the direction of the south. In addition to the three basic elements of the shading element, the type of eggcrate shadow element has the greatest effect of reducing illumination compared to the other two types. While the sidefins type has the smallest illumination effect.

4. Conclusion

This study uses three types of basic models of external shading elements consisting of eggcrate, horizontal (overhang) and vertical (sidefins) types. This study tested its performance on natural lighting (illumination on the workplan). The illumination target on the workplan in this study is in the range of 500 lux (standard office space) with the model space color assumed to be white. With this illumination target, it is expected to find the ideal ratio of the depth of the shadowing element to penestration.

Eggcrate shading device type reaches a value close to the illumination target (500 lux at reference point 2) at a ratio of 0.8 (west, south, east, southeast and southwest) and a ratio of 1.0 (north, northwest and east sea).

Overhang shading device type reaches a value close to the illumination target (500 lux at reference point 2) at a ratio of 1.4 (for west, north, south, east, southeast, southwest, northwest and northeast).

Sidefins shading device type reaches a value close to the illumination target (500 lux at reference point 2) at a ratio of 1.4 (for west, north, south, east, southeast, southwest, northwest and northeast).

In this study the maximum illumination reduction occurred in the north, while the minimum illumination reduction occurred in the south direction. Except the minimum reduction for eggcrate occured in the west direction.

Thank-you note

My gratitude goes to all who helped the research process and the writing of this journal to completion. I also thank the University of Technology Yogyakarta for funding this journal.

REFERENCES

Anonim. (1982). Architects Handbook of Enery Practice, *Simplified Energy Evaluation Technique*, The American Institute of Architects, Washington.

Austin Stack, John Goulding, J. Owen Lewis, (2003). Shading System, Solar Shading for European Climates, Energy Research Group, University College Dublin, School of Architecture, Richview, Clonskeagh, Dublin 14, Ireland.

Meyer, William T. (1976). *Energy Economics And Building Design*, McGraw Hill Book Company, United States of America, University Graphics Inc, Caledonia.

M. Susan Ubbelohde, Christian Humann. (1993) *Comparative Evaluation of Four Daylighting Software Programs,* University of California, Berkeley, CA

O.H. Koenigsberger, T.G. Ingersoll, A. Mayhew, S.V. Szokolay. (1973). *Manual of Tropical Housing and Building*, Part One : Climatic Design, Bombay, Orient Longman, Longman Inc, New York.

Phillips, R.O. (1992). *Sunshine and Shade in Australasia*, Sixth Edition, CSIRO Division of Building Construction and Engineering, Australia.

Pidwirny, Michael, Dr., Maret (2005). Department of Geography, Okanagan University College, *Fundamentals of Physical Geography*, http://www. physicalgeography.net

Satwiko. Prasasto. (2004). *Fisika Bangunan 1-Edisi 1*, Andi Offset, Yogyakarta.

Satwiko. Prasasto. (2004). *Fisika Bangunan 2-Edisi 1*, Andi Offset, Yogyakarta.

Satwiko. Prasasto. (2005). *Arsitektur Sadar Energi: Pemanfaatan Komputer dan Internet Untuk Merancang Bangunan Ramah Lingkungan*, Andi Offset, Yogyakarta

S.V. Szokolay. (1987). *Thermal Design of Buildings*, Canberra, RAIA Education Division, Canberra Published and Printing, Canberra

V. Olgyay and A. Olgyay. (1969). *Design With Climate Bioclimatic*, *Bioclimatic Approach to Architectural Regionalism*, Princeton, Princeton University Press, New Jersey

Witte, Michael J, Henninger, Robert H, Glazer, Jason. (2001). *Testing and Validation of A New Building Energy Simulation Program*, U.S Department of Energy, Washington