DIMENSI INTERIOR, VOL. 12, NO. 1, JUNI 2014: 51-56
ISSN 1693-3532

DOI:10.9744/interior.12.1.51-56

http://dimensiinterior.petra.ac.id

Balcony and Jalousi Effectiveness Review to Promote Daylight in Interior for Tropical Country

Purnama Esa Dora Tedjokoesoemo
Interior Design Department, Faculty of Art and Design, Petra Christian University
E-mail: esa@petra.ac.id

ABSTRAK

Perkembangan kota pada akhirnya akan mempengaruhi gaya hidup manusia yang tinggal didala.m.nya. Bangunan tinggi, yang lebih menguntungkan secara ekonomi, membutuhkan dukungan area terbuka untuk interaksi sosial. Ketiga prinsip desain yang berkelanjutan tidak dibuat hanya untuk mendukung aspek pertumbuhan ekonomi saja, tetapi juga untuk mempertimbangkan interaksi sosial dan ekologi didala.m.nya. Sejak era Kolonial Belanda, balkon dan jalusi telah dikenal sebagai elemen arsitektural yang dapat menyediakan area tambahan untuk berinteraksi; hemat biaya dan menyediakan fungsi pembayangan untuk area dibawahnya. Penelitian ini menginvestigasi bagaimana efisiensi elemen-elemen ini akan mempengaruhi pemanfaatan pencahayaan ala.m.i ke dala.m. ruang untuk menghemat energi. Penelitian kuantitatif ini dilakukan dengan menggunakan software IES-VE 2012 dengan fasilitas yang telah ada didala.m.nya yaitu Suncast, Flucs-DL, and Radiance untuk menghitung kedala.m.an penetrasi pencahayaan ala.m.i dan potensi silau. Simulasi ini dilakukan untuk negara tropis (Singapura).

Kata Kunci**:** pencahayaan alami, desain pasif, balkon, jalusi, energi.

ABSTRACT

City growth will eventually affect its people lifestyle. Higher buildings, which serve higher economic value, will need to be supported with open area for social interaction. The three principal of sustainable design is not only to embrace the economic growth, but also to consider social interaction and ecology in it. Since the colonial era Balconies and jalousies are well known as architectural elements that provide more space for interaction, economically possible to make use of, and provide shading for the space underneath. This research will investigate how these elements efficiency will affect the introduction of daylight into interior space to save energy. This quantitative research was conducted with IES-VE 2012 software with embedded suncast, Flucs-DL, and Radiance software in it to calculate the depth of daylight penetration and glare potential. The simulation was set in tropical country (Singapore).

Keywords: *daylight, passive design, balcony, jalousie, energy.*

INTRODUCTION

High rise building has become one of the effective options to overcome the increasing population in limited land available. With the emerging issue of green building and sustainability, the effort to reduce energy consumption has been highlighted and supported. As the use of energy in this building may be huge, passive design strategy needs to be considered as an important approach to reduce energy consumption.

Balcony provides shading and maximizes occupants' living quality. Balcony provides access to outdoor view and relaxing function. Balcony also plays a decisive role in the energy behavior of the buildings since they may intervene and influence almost all of the mechanisms of how buildings interact with its environment [1]. However, balcony may not able to hinder sunlight in higher angle. To overcome this problem, movable screen device usage can be considered. This research will look into the potential of balcony and screen device, in form of jalousie, to introduce daylight into the interior underneath in high-rise buildings as passive design strategy.

RESEARCH METHOD

The method for this research is a quantitative research with the use of IES-VE 2012 as the main software. The design simulation tools used in this research are Suncast for SC calculation and Flucs-DL and Radiance embedded in it for further study of daylight penetration.

The simulation conducted in elimination method to come with one orientation suggested for the most efficient balcony depth with maximum daylight penetration and minimum heat gain. In this research, heat gain reflected with lower shading coefficient (SC) value according to RETV formula as per follow:

$$RETV = 3.4(1-WWR)U_w + 1.3(WWR)U_f + 58.6(WWR)(CF)(SC)$$

where

RETV : residential envelope transmittance value (W/m^2)
WWR : window-to-wall ratio (fenestration area/gross area of exterior wall)
U_w : thermal transmittance of opaque wall (W/m^2 K)
U_f : thermal transmittance of fenestration (W/m^2 K)
CF : correction factor for solar heat gain through fenestration
SC : shading coefficients of fenestration

Source: http://www.bca.gov.sg/performancebased/others/retv.pdf

Figure 1. RETV formula

IES-VE 2012 is the main software used in this study. IES-VE is a flexible integrated system for performance assessment that brings productivity and excellence to every aspect of sustainable building design. The design simulation tools employed within IES-VE 2012 for this research are Model IT, Suncast, Flucs DL, and Radiance.

Research Methodology

Benchmark and balcony model will be tested in suncast for 8 orientation. This is to achieve the best 2 balcony depth. After that, 2 best balcony depth will be added by jalousie and re-run in suncast to see any improvement in heat reduction and RETV value. The lowest RETV gained in particular façade and balcony depth will be re-run at daylight study by FLucs DL and Radiance.

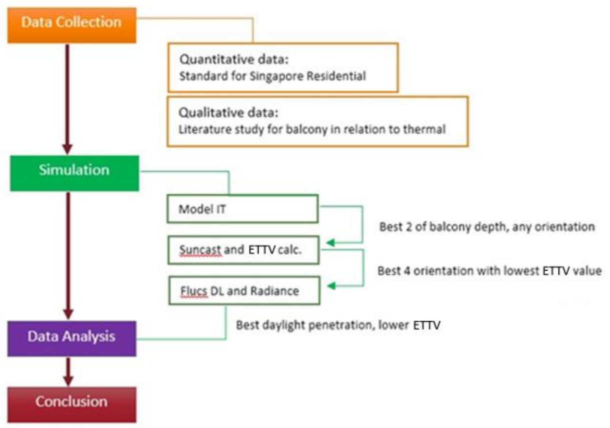

Figure 1. Research Methodology Flow Chart

As for the simulation will be run for a year period, starting from 1st of January to 31st of December, the analysis set at 22nd each month for a year to take the sun position at its highest position and referring to BCA standard for RETV date calculation table [2]. G value by percentage gathered from Suncast simulation, then inputted and calculated manually using SC_2 formula. Inputted values for RETV calculation in suncast are as follows (equation see figure 1):

- WWR (window to wall ratio) 30% inputted 0.3
- U_w (thermal transmittance of opaque wall) inputted 2.0332 W/m^{2}K as represent of brick 200 mm + plaster
- U_f (thermal transmittance of fenestration) inputted 2.0588 W/m^{2}K as represent of low-e double glazing (6 mm+6 mm) (2002 regs)
- CF (correction factor) inputted from 90^0 for all orientation (see BCA guideline)
- SC (shading coefficient) inputted for SC_1 is 0.3870 as represent of low-e double glazing (6mm+6mm) (2002 regs), while SC_2 will be gathered from Suncast simulation.

Some assumptions to the simulation unit has been made as per follow:

- Single residential unit simulated is located in high rise building in 10 x 10 m rectangular shape unit
- Units' height are uniform in 3.0 m and each unit has false ceiling in 2.7 m height
- Unit simulated start from 2nd storey in which 1st storey is 6.5 m height from ground level (as in URA standard)
- Opening to balcony area material is in closed condition
- Screen device will be assumed as jalousie

This study will be limited in variant of balcony and balcony depth as regulation provided by URA. Balcony type used is normal rectangular balcony and the depth of balcony will be capped to 2.0 m depth in maximum.

SIMULATION INPUTS

1. Modelling

The study para.m.eter inputted for simulation with the assumption and modelling is single unit 10 x 10 m area and 2.7 m floor to ceiling height. Horizontal louvers as jalousie are modeled in sa.m.e length as balcony. Balcony length is 4 meter, depth will be vary based on the scenario tested, and the floor slab thickness is 15 cm as in concrete balcony. Each louvers width is 20 cm. Distance between fin set as 15 cm:

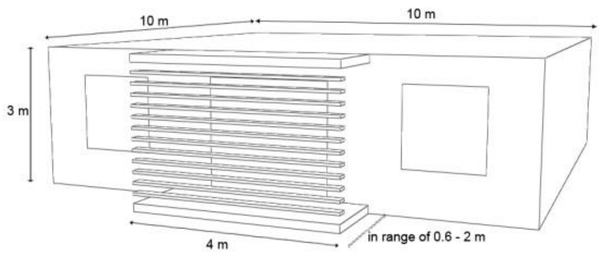

Figure 3. Single Unit Model Dimension

The scenario used for this research is based on sa.m.ple model in Figure 1 and differentiate based on depth of balcony and availability of jalousie. The scenarios for depth of balcony are 0.6 m, 1.0 m, 1.5 m, and 2.0 m. These dimension taken based on building material and modular design consideration. For the 0.6 m, the size taken with consideration of human circulation area minimum of 0.6 m in Asia [3].

This study is conducted in 3 para.m.eters as follows:

- The depth of balcony
- 8 orientation of façade
- Screen device availability

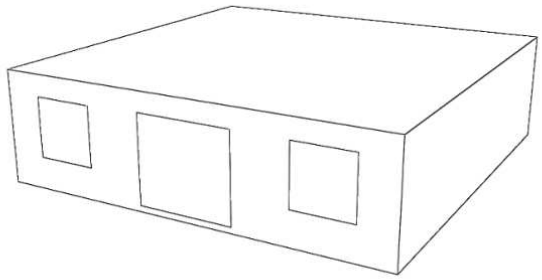

Figure 4. Benchmark Unit with No Shading Device

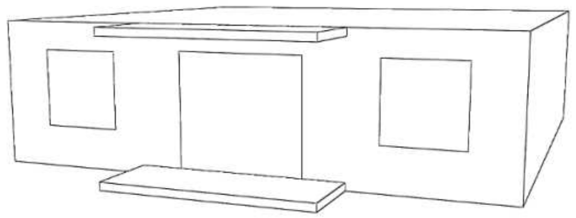

Figure 5. Sa.m.ple Unit with Balcony
(and overhang resulted from unit upon)

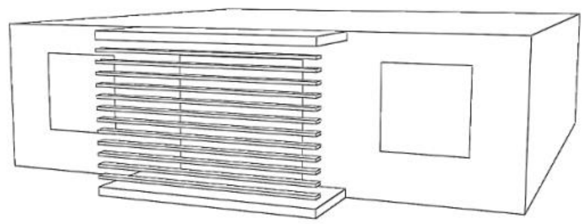

Figure 6. Single Unit with Balcony and Jalousie

2. Flucs DL and Radiance

Materials set for daylight study are inputted as follow:

Table 1. Material Assigned for Daylight Study

Construction	Specification	Material
Wall	Reflectance 70%	White gault brick
Glass	Transmittance 70%	Default
Floor	Reflectance 0.4	Crea.m. PVC tile
Roof	Reflectance 0.10	Default

In Flucs DL, the CIE overcast sky model is chosen to represent uniform Singapore climate and sky [4]. Simulations run at 22 March, June, and December. From this simulation we will get daylight uniformity value, minimum and maximum luminance level, and area above threshold. The threshold set for residential living room area set in 120 lux to represent general room with average relaxing load activity [5].

Meanwhile, to know the peak daylight depth penetration, simulations in radiance run in sunny sky model at 22 March/ September, June, and December at 12 a.m. According to Singapore BCA, simulation for daylight analysis should be run in overcast sky condition (sunny sky model) at 13 a.m. in working level height. But for glare analysis, simulation should be run at 10 a.m. or 4 p.m. [2].

Based on the result from suncast, since 3 lower heat gain are basically in area of East façade, the simulation time inputted in this study is at 10 a.m. and 12 a.m. For further analysis for equinox comparison, West run at 1 p.m. and 4 p.m. at 4 sa.m.e date with sunny sky model. The penetration depth marked are in those achieve 120 lux or more and calculated in working plane 0.85 m above ground.

LITERATURE REVIEW

1. Balcony

The word "balcony" is defined as a platform projecting from the wall of a building and surrounded by a balustrade or railing or parapet. Balconies are extensions of the roofed areas of apartments above ground level that are intended to offer the residents quick and easy access to the external environment. Although they may be found in buildings at all latitudes, their presence is more pronounced in buildings situated in areas where the environmental and particularly the climatic conditions are mild for long periods of the year [1].

Source: http://www.areasg.com/listings/aalto-meyer-road, accessed: 14 November 2012

Figure 7. Balcony Used in High-Rise Residential Unit

The role of balconies is enhanced to the extent that the external environmentis attractive for long periods of time and they possess properties which are more conducive to a feeling of comfort than those exist in the interior of buildings. Balconies may represent an important factor in the functional organization of apartments situated above ground level, and a conspicuous morphological feature in the faces of the buildings to which they belong. They also play a decisive role in the energy behavior of the buildings since they may intervene and influence almost all of the mechanisms of how buildings interact with its environment [1].

2. Singapore Climate and Sun path

For this research in context of tropical country, Singapore city is chosen as the simulation location as its massive develop.m.ent in green building and the huge numbers of its high rise buildings. To conduct this research, there are 4 critical dates that should be considered: March 21st, June 22nd, September 23rd, and December 22nd. These dates are the dates where sun positioned in its critical time. On March 21st and September 23rd sun is in equinox and positioned in its highest angle. During this period of time, the duration of the day is longer relative to the night as the sun across the sky [6].

While on June 22nd and December 22nd, sun in Singapore will be in its summer solstice and positioned in its lower angle. During the summer solstice, the duration of the day will be much shorter relative to the summer solstices and September equinox. As the earth proceeds into the March equinox, the altitude of the sun will gradually be higher. The duration of the day will increase to eventually 12 hours at the equinox [6].

3. Singapore Code for Built Environment by URA

The Urban Redevelop.m.ent Authority (URA) is Singapore's government agency who's responsible for the urban planning of Singapore. To promote high-rise greenery, URA introduced the balcony GFA (Gross Floor Area) incentive scheme in 2001 to encourage balconies to be incorporated in residential and hotel develop.m.ents. For balconies to enjoy the 10% GFA incentive above the Master Plan GPR control, at least 2 sides of the balcony edges should be open and unenclosed [7].

Based on URA, balcony depth for stacked building under URA provision is limited to 2.0 m maximum in accordance to PES covering depth. Screen device encouraged by URA to be installed in the balcony shall meet these requirements [7]:

a) The proposed balcony screens allow for natural ventilation within the balcony at all time
b) The proposed balcony screen is capable of being drawn open or retracted fully

4. Heat Gain

RETV, is similar to ETTV, its differences laid in the local usage of it. RETV tends to be more localozed for residential unit. However, both serve the sa.m.e consideration towards basic components for calculation. RETV is the expression value for heat gain through exterior wall and window for commercial building that stands for Residential Envelope Transmittance Value. The RETV takes into consideration three basic components of heat gain through the external walls and windows of a building:

- Heat conduction through opaque walls
- Heat conduction through glass windows
- Solar radiation through glass windows

For the purpose of energy conservation, the maximum permissible RETV has been set at 25 W/m^2 calculated through RETV formula [8]. Heat gain will relatively affect daylight penetration in respect to logic of bigger opening will introduce more daylight, but will also bring more heat without proper treatment. This research attempt to figure the balance between depth of balcony that will effectively reduce heat gain and maximize daylight penetration.

5. Daylight Penetration

In Singapore, day lighting design has been the predominant concern as regards the new demands of providing healthy and energy efficient buildings. Utilizing day lighting has been recognized as a useful strategy for energy conservation and creating a pleasant visual environment. However, to introduce day lighting to a room, careful considerations are needed; otherwise adverse effects can be produced. The principle of day lighting design is to maximize the utilization of daylight, avoid glare problems, and minimize the cooling load imposed by solar radiation [9].

RESULT AND DISCUSSION

A. SC Value

The simulation elimination started with simulation to find the best SC_2 value. The benchmark unit result for Suncast simulation show that without any shading device (balcony and jalousie) the annual SC_2 value is 1 which means 100% heat hits the respective façade. The first step for this research is to simulate units with balcony only.

From these 4 scenarios available, writer narrows the result to get the best 2 balcony depth in each balcony orientation. These best 2 balcony depth will then simulated to the next phase. From the simulations run, balcony depth of 1.5 m and 2.0 m show the best result.

Table 1. Annual SC_2Value for Each Balcony Depth in 8 Balcony Orientation

Orientation	SC_2 Value Annual			
	Balcony Depth w/o Jalousie			
	0.6	**1**	**1.5**	**2**
North	0.89	0.79	0.76	0.76
NE	0.84	0.74	0.67	0.62
East	0.91	0.75	0.65	0.59
SE	0.84	0.88	0.62	0.6
South	0.82	0.81	0.75	0.75
SW	0.91	0.82	0.74	0.69
West	0.83	0.73	0.63	0.57
NW	0.9	0.82	0.76	0.71

The next step is to run the simulation with the addition of jalousie as shading device in front of the balcony for those 2 most effective balcony depths. Annual SC_2 value obtained from this step will be then compared to those that use no jalousie to see the effectiveness of jalousie.

Table 4. Annual SC2 Value Comparison for 2 Most Effective Balcony Depth in 8 Balcony Orientation

Orientation	SC_2 value annual			
	Balcony Depth w/o Jalousie		Balcony Depth w/ Jalousie	
	1.5	**2**	**1.5**	**2**
North	0.76	0.76	0.75	0.76
NE	0.67	0.62	0.55	0.56
East	0.65	0.59	0.45	0.45
SE	0.62	0.6	0.51	0.52
South	0.75	0.75	0.74	0.75
SW	0.74	0.69	0.56	0.58
West	0.63	0.57	0.51	0.51
NW	0.76	0.71	0.59	0.6

Table 5. Annual RETV Value Comparison for 2 Most Effective Balcony Depth in 8 Balcony Orientation

Orientation	RETV			
	Balcony Depth w/o Jalousie		Balcony Depth w/ Jalousie	
	1.5	2	1.5	2
North	9.93	9.93	9.88	9.93
NE	10.25	9.90	9.42	9.49
East	10.86	10.38	9.25	9.25
SE	9.94	9.81	9.18	9.25
South	10.03	10.03	9.97	10.03
SW	11.13	10.76	9.79	9.94
West	11.04	10.53	10.01	10.01
NW	11.12	10.76	9.90	9.97

From simulation run, balcony depth of 1.5 m show better RETV value than 2.0 m balcony depth. Eastern balcony orientations (South East, East, and North East) generally show the lowest value of annual SC_2 which means lower RETV as well.

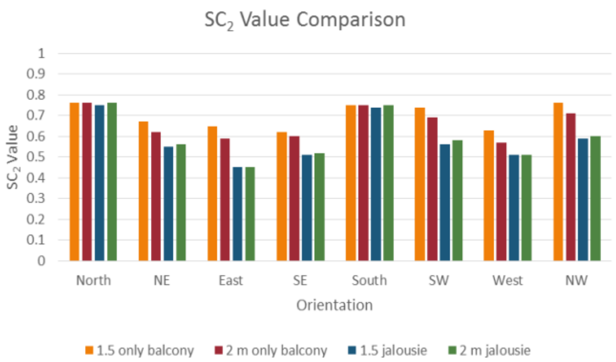

Figure 8. SC_2 (shading device only) Comparison Chart

B. Daylight Analysis

Daylight tested in Flucs DL using CIE overcast sky model show uniform result for every orientation. The results show that in uniform climate condition like Singapore, the a.m.ount of daylight into a room and uniformity value is not highly affected by orientation. However, the availability of shading device reduces the daylight penetrated into the room. The availability of balcony slightly increases daylight uniformity.

To compare these 3 orientations by their depth of penetration, these models run in radiance with sunny sky condition to represent the best scenario possible. The simulation conducted for 22 March, June, and December at 10 a.m. and 12 a.m. to represent critical time for these 3 orientations. For the best case assumption, depths of daylight penetration and area coverage calculated for area above 120 lux illuminance level are presented as follows:

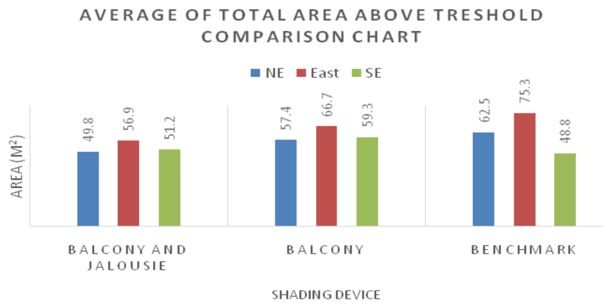

Figure 9. Average Total Area Comparison Chart

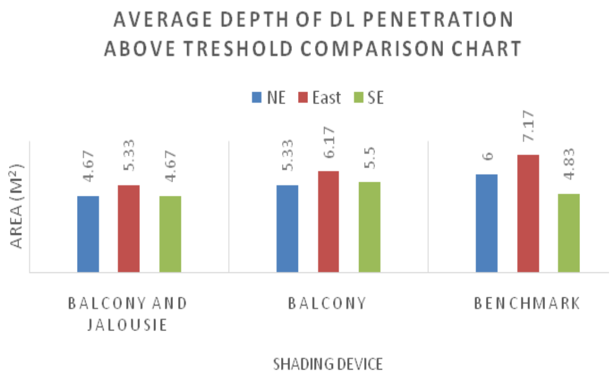

Figure 10. Average Depth of Penetration Area Comparison Chart

The result showed that East opening orientation has the best daylight penetration in any scenario, compared to North East and South East. The average depth of daylight penetration obtain in East façade opening is the highest in any shading device availability in this 3 lowest heat gain façade.

The depth of daylight penetrates into the room with both shading, jalousie and balcony, installed is reduced by 25.6% compared to benchmark. Whereas, without jalousie, but balcony only, daylight penetration was reduced by 14% compared to benchmark.

Table 2. Best Case Depth of Daylight Penetration in East Orientation

Shading Device	Date	Time (day)	Area Above 120 lux	Depth of Penetration Above 120 lux
Jalousie and Balcony	22-Mar	10:00	75.88 m^2	7 m
		12:00	44.82 m^2	4 m
	22-Jun	10:00	70.43 m^2	7 m
		12:00	41.12 m^2	4 m
	22-Dec	10:00	69.13 m^2	6 m
		12:00	40.17 m^2	4 m
Balcony	22-Mar	10:00	89.92 m^2	8 m
		12:00	51.53 m^2	5 m
	22-Jun	10:00	82.39 m^2	8 m
		12:00	48.44 m^2	4 m
	22-Dec	10:00	80.6 m^2	8 m
		12:00	47.39 m^2	4 m
Benchmark	22-Mar	10:00	98.14 m^2	9 m
		12:00	59.27 m^2	6 m
	22-Jun	10:00	94.19 m^2	9 m
		12:00	54.01 m^2	5 m
	22-Dec	10:00	93.63 m^2	9 m
		12:00	52.58 m^2	5 m

Radiance simulation results showed that deeper daylight penetration obtained in March (equivalent to September) at 10 a.m.. East orientation enables it to gain more morning daylight from month of March and September, due to higher solar angle in equinox and its position to equinox. Horizontal shading device work more effective in East orientation.

This analysis also has been tried at West façade, which confirm that solar angle plays an important role in daylight gain through shading device. Opening placed in West and East orientations showed better performance in daylight gain compared to the sub-cardinals. The difference is in time of daylight penetrating the room. The East façade will gain daylight in morning to noon (approximately from 6 a.m. to 12 p.m.), while the West façade will gain daylight from noon to evening (approximately from 12 p.m. to 6 p.m.).

CONCLUSION

Balcony is defined as a platform projectin from the wall of a building and surrounded by a balustrade or railing or parapet. Balcony, as architectural element, plays a decisive role in the energy behavior of the buildings since they may intervene and influence almost all of the mechanisms of how buildings interact with its environment [1]. This study proves that balcony has an effect to heat reduction as it will provide shading to particular area of façade. To increase this shading area, the installation of jalousie can be provided.

In area where the sun angle is high, horizontal shading (jalousie) has an important role to reduce heat. Without any shading devices, the best orientation for opening is North and South. But, after shading devices are installed, East façade perform best. This is due to solar altitude is higher in month of March and September that correspond to its position in equinox that refer to East and West building orientation.

Jalousie is effective to reduce heat gain and decrease the depth of balcony needed in relation to decrease the material used. The optimum balcony with jalousie depth is 1.5 m. Additional depth will not affect the RETV but yet will reduce the penetration of daylight even more. Jalousie enables East façades to perform better in heat reduction yet still maintain daylight penetration into the room. The best case scenario showed in March/ September at 10 a.m. with 7 m depth of penetration above 120 lux.

The application of 1.5 m depth balcony reduce heat gain, which expressed by the reduction of RETV value as much as 20.55%. On the other hand, the additional application of jalousie reduce heat significantly as much as 32.3%. The RETV reduction may not be the sa.m.e as ETTV reduction due to different formula and coefficient used in its formula. However, the SC_2 reduction may imply the reduction of heat gain with the sa.m.e reduction a.m.ount of G value.

REFERENCES

[1] Papa.m.anolis, N. 2004. *An Overview of the Balcony's Contribution to the Environmental Behaviour of Buildings.* Eindhoven, Plea 2004- The 21st Conference on Passive and Low Energy Architecture.

[2] Building and Consturction Authority. 2010. *BCA Official Website.* [Online] Available at: http://www.bca.gov.sg/Envsuslegislation/others/GM_Certification_Std2010.pdf. [Accessed 18 November 2012].

[3] Panero, Julius, M. Z. January 1980. In: *Human Dimension and Interior Space: A Source Book of Design Reference Standards.* s.l.: Watson-Guptill Pubns.

[4] Rao, K.. 1988. Solar Radiation and External Temperatures of Buildings. In: B. B. Lim, ed. *Control of the External Environment of Buildings.* Singapore: Singapore University Press, pp. 19-32.

[5] Badan Standardisasi Nasional. 2000. *Konservasi Energi Pada Sistem Pencahayaan.* SNI 03-6197-2000 ed. Jakarta: Badan Standardisasi Nasional.

[6] Lee Jin You, L. J. H. L. G. Y. L. G. H., L. S. A. a. L. W. K., n.d. *NUS Faculty of Science Department of Mathematics Official Website.* [Online] Available at: http://www.math.nus.edu.sg/aslaksen/gem-projects/hm/0304-1-66-sun_and_architecture.pdf. [Accessed 18 November 2012].

[7] Singapore Urban Redevelop.m.ent Authority (URA). 2007. *Revised Guildelines for Blaconies and Private Enclosed Spaces (PES),* Singapore: URA.

[8] Singapore BCA (Building Construction Authority), n.d. *Code on Envelope Thermal Performance for Buildings.* Singapore: Singapore BCA (Building Construction Authority).

[9] Wong, N. H. A. D. I.. 2004. Effect of External Shading Devices on Daylighting. *Lighting Research and Technology,* 36, 4 (2004) (1 December 2004), pp. 317-333.