

UNIVERSITY MALAYA

**Original literary work declaration**

Name of Candidate : Tiew Si Yee (I/C No: 830421085050)

Registration/Matrix No. : BGB 080005

Title of Thesis (“this Work”) : “CLIMATIC IMPACT ON URBAN  
HERITAGE BUILDING: CASE STUDY ON A BRITISH COLONIAL RESIDENCE  
– JKR 989 IN KUALA LUMPUR”

Field of Study : SUSTAINABLE, CONSERVATION

I do solemnly and sincerely declare that:

- (1) I am the sole author / writer of this Work;
- (2) This Work is original;
- (3) Any use of any work in which copyright exists was done by way of fair dealing and for permitted purposes and any excerpt or extract from, or reference to or reproduction of any copyright work has been disclosed expressly and sufficiently and the title of the Work and its authorship have been acknowledged in this Work;
- (4) I do not have any actual knowledge nor do I ought reasonably to know that the making of this Work constitutes an infringement of any copyright work;
- (5) I hereby assign all and every rights in the copyright to this Work to the University of Malaya (“UM”), who henceforth shall be owner of the copyright of this Work and that any reproduction or use in any form or by any means whatsoever is prohibited without the written consent of UM having been first had and obtained;
- (6) I am fully aware that if in the course of making this Work I have infringed any copyright whether intentionally or otherwise, I may be subject to legal action or any other action as may be determined by UM.

Candidate’s Signature

Date

Subscribed and solemnly declared before:

Witness’s Signature

Date

Name :

Designation :

## **Tuntutan pihak ketiga**

Projek Ilmiah ini disediakan bagi memenuhi syarat keperluan bagi pengijazahan Sarjana Sains Senibina oleh Universiti Malaya. Pihak Jabatan Senibina, Fakulti Alam Bina, Universiti Malaya, tidak bertanggungjawab atas sebarang tuntutan dari pihak ketiga yang berhubung kait dalam penyediaan Projek Ilmiah ini.

11 November 2011

This Academic Project is prepared here in fulfillment of the requirements for the Degree of Master of Science Architecture by the University of Malaya. The Department of Architecture, Faculty of the Built Environment, University of Malaya makes no responsible for any claim from the third party with regards to the production of this Academic Project.

11 November 2011

## **Acknowledgement**

In the course of completing this thesis, I would like to express my deepest gratitude and appreciation to Pn Seri Nila Inangda and Pn Ati Rosemary for equipping and sharing with me her knowledge in her perspectives of windows design. I have also own a great deal to the management of Badan Warisan Malaysia for giving me permission to conduct field measurement, the staffs in rendering me the data regarding to the particular issue and the visitors of Badan Warisan Malaysia who willing to give assistance in answering the questionnaires which I provided. They have all given off their time and most importantly, have contributed to the completion of my assignment. Besides that, I have had the enthusiastic support and generous assistance of many individuals. It is indeed a pity that constraints of space prevent me from naming them individually but I would like to take this opportunity of thanking each and every one of them from the bottom of my heart.

## Abstrak

Malaysia adalah sebuah negara yang panas dengan purata suhu antara 24°C dan 33°C dan kelembapan relative antara 70% dan 90%. Oleh itu, faktor bahangan haba merupakan masalah yang paling serius dalam pembangunan terutama jenis kediaman. Walaupun penyaman udara boleh menyelesaikan masalah ini, namun ia banyak menggunakan tenaga elektrik dan juga menyebabkan masalah alam sekitar. Selain itu, kebimbangan 'sick building syndrome' telah membangkitkan kesedaran kepentingan pengudaraan semulajadi dalam bilik. Tindakan membuka tingkap adalah sambutan yang paling hangat dan mudah untuk mengawal bahangan haba di dalam bilik. Justeru itu, size tetingkap adalah sangat penting kerana jika size tetingkap tidak direka dengan betul, cahaya matahari akan menerusi secara langsung melalui tingkap dan menyumbang haba lebihan ke dalam bilik. Rumah tempatan di kawasan tropika perlu dilindungi dan dikaji untuk mengenal pasti strategi reka bentuk tingkap untuk pengudaraan semula jadi dan 'daylighting'. Kajian ini menyediakan penilaian prestasi reka bentuk tingkap di kawasan bandar dan penilaian kesan 'microclimate' terhadap keselesaan terma dalaman bagi penduduk dengan berdasarkan kajian di kediaman terpilih jenis 'British Colonial' di Kuala Lumpur, Malaysia. Hasilnya mencadangkan kediaman jenis British Colonial di Bandar perlu dilindungi dan reka bentuk tingkap optimum untuk kediaman di kawasan Bandar. Penilaian telah dijalankan berdasarkan pengiraan tetingkap nisbah dinding 'Window to Wall Ratio', pengukuran lapangan dan ujian simulasi yang menggunakan AIOLOS. Seni bina bangunan dan tingkap kediaman yang dipilih dianalisis dan data yang dikumpul daripada setiap rumah terpilih telah digunakan dalam pengiraan tetingkap nisbah dinding-'Window to Wall Ratio'. Pengesahan hasil tetingkap nisbah dinding 'Window to Wall Ratio' kemudiannya diperiksa oleh pengukuran lapangan dan simulasi dengan menggunakan perisian

AIOLOS. Penyelidikan ini menunjukkan bahawa keadaan haba kediaman yang dipilih adalah lebih tinggi daripada keperluan piawaian Malaysia. Di samping itu, bangunan yang sedia ada di sekeliling bangunan kajian mengenakan kesan mendalam terhadap 'microclimate' JKR 989 yang secara langsung mempengaruhi prestasi tingkap bangunan itu.

## Abstract

Malaysia is a hot and humid tropical country that has yearly mean temperature between 24°C and 33°C and relative humidity between 70% and 90% throughout the year. Thus, overheating is a paramount problem in residential buildings. Although air conditioning can solve this problem, it will consume a large amount of electricity and also causes environmental problems. Moreover, the concern of sick building syndrome has resulted in a resurgence of interest in naturally ventilated rooms. The action of opening a window is the most intuitive and simple response to controlling overheating in a room. Even so, if the window opening dimension is not properly designed, direct sunlight through the window will contribute by far the largest heat gain in houses. The survival of vernacular houses especially in the tropics should be reviewed to identify window design strategies that had been applied for natural ventilation and daylight. This study provides an evaluation on the window design performance in urban area and evaluation of impact of microclimate on indoor thermal comfort of the inhabitants based on case study on a selected British Colonial residences in Kuala Lumpur, Malaysia. The result suggests optimum window design for similar residences in urban area. The evaluation was conducted based on the calculation of window to wall ratio, field measurement, and simulation test using AIOLOS. Architecture and window design approaches of the selected residences were analyzed and the data collected from each residence were applied in the calculation of window to wall ratio. The validations of the window to wall ratio were then examined by field measurement and simulation using AIOLOS software. The research reveals that the thermal condition of the selected residence was higher than Malaysia standard requirements. In addition, existing surrounding buildings imposed a deep impact on the microclimate of JKR 989 which directly influenced the windows performance of the building.

# Table of Contents

<b>Original literary work declaration</b>	<b>ii</b>
<b>Tuntutan pihak ketiga</b>	<b>iii</b>
<b>Acknowledgement</b>	<b>iv</b>
<b>Abstrak</b>	<b>v</b>
<b>Abstract</b>	<b>vii</b>
<b>Table of Contents</b>	<b>viii</b>
<b>Table of Figures</b>	<b>xiv</b>
<b>List of Tables</b>	<b>xviii</b>
<b>Table of Abbreviation</b>	<b>xx</b>
<b>CHAPTER 1.0      Introduction</b>	<b>1</b>
1.1    Research issues	5
1.2    Problem statements	6
1.3    Objectives	7
1.4    Significant of study	7
1.5    Scope of study	7
1.6    Research Limitation	8
1.7    Research Problem	9
<b>CHAPTER 2.0              Background Study</b>	<b>10</b>
2.1    Thermal comfort and acclimatization	13

2.1.1	Thermal comfort principle	
2.1.2	Evaluation of thermal comfort	
2.2	Ventilation as building requirements	19
2.2.1	Ventilation openings	
2.2.2	Air exchange	
2.2.3	Effect of air speed on comfort	
2.2.4	Natural lighting and ventilation (Building by Laws 1984)	
2.3	Microclimate impact on building envelope	23
2.3.1	Urban Heat island	
2.3.2	Internal heat gain	
2.3.3	The role of building envelope in controlling heat gain inside the building	
2.3.4	Window design factors	
2.4	Energy	35
2.4.1	Renewable energy sources	
2.4.2	Non-renewable sources	
2.4.3	Energy crisis	
2.5	The disadvantages of air conditioning system	38
2.6	Natural ventilation	40
2.6.1	Cooling process of natural ventilation	
2.6.2	Passive cooling concept	
2.6.3	Convective cooling models	
2.6.4	Passive cooling strategies	
2.6.5	Passive cooling in traditional architecture	
2.6.6	Exterior shading	
2.6.7	Passive cooling in modern buildings	
2.7	Critical barrier	58
2.7.1	Internal obstruction	



2.8	Daylighting	60
2.8.1	Daylight factor	
2.9	Bioclimatic architecture	61
2.9.1	Principles of bioclimatic design housing	
2.9.2	Investigate case studies	
2.9.3	Design elements and strategies of bioclimatic design	
2.10	Simulation software	65
<b>CHAPTER 3.0 Research Methodology</b>		<b>67</b>
3.1	Selection of sample for calculation of Window to Wall Ratio	69
3.2	Collection of data	74
3.3	Selection of typical year data	74
3.3.1	Air Temperature	
3.3.2	Relative Humidity	
3.3.3	Air velocity	
3.4	Window to Wall ratio calculation	77
3.5	Case study - field measurement	78
3.6	Case study - computer simulation	79
3.7	Analysis	82
<b>CHAPTER 4.0 Window to Wall Ratio</b>		<b>83</b>
4.1	Calculation 1: JKR 511, Persiaran Mahameru	84
4.1.1	History background of the residence	
4.1.2	Architectural style	
4.1.3	Ventilation system	

4.1.4	Results of Window to Wall Ratio	
4.2	Calculation 2: JKR 989, Jalan Stonor	89
4.2.1	History background of the residence	
4.2.2	Architectural style	
4.2.3	Ventilation system	
4.2.4	Results of Window to Wall Ratio	
4.3	Calculation 3: JKR 1331, Jalan Semarak	95
4.3.1	History background of the residence	
4.3.2	Architectural style	
4.3.3	Ventilation system	
4.3.4	Results of Window to Wall Ratio	
4.4	Calculation 4: JKR 1716, Jalan Ledang	99
4.4.1	History background of the residence	
4.4.2	Architectural style	
4.4.3	Ventilation system	
4.4.4	Results of Window to Wall Ratio	
4.5	Calculation 5: JKR 541, Jalan Belfield	103
4.5.1	History background of the residence	
4.5.2	Architectural style	
4.5.3	Ventilation system	
4.5.4	Results of Window to Wall Ratio	
4.6	Summary of Window to Wall Ratio	106
<b>CHAPTER 5.0</b>	<b>Case Study</b>	<b>108</b>
5.1	Case study procedure	110
5.1.1	Exterior surrounding	
5.1.2	Instrumentation	

5.2	Measurement process of indoor thermal condition in Zone 1 (Resource Centre) of JKR 989	114
5.2.1	Description of investigated room	
5.2.2	Temperature	
5.2.3	Humidity	
5.2.4	Daylight	
5.3	Measurement process of indoor thermal condition in Zone 2 (Meeting room) of JKR 989	126
5.3.1	Description of investigated room	
5.3.2	Temperature	
5.3.3	Humidity	
5.3.4	Daylight	
5.4	Measurement process of indoor thermal condition in Zone 3 (Glass room) of JKR 989	137
5.4.1	Description of investigated room	
5.4.2	Temperature	
5.4.3	Humidity	
5.4.4	Daylight	
5.5	Measurement process of indoor thermal condition in Zone 4 (Kitchen) of JKR 989	147
5.5.1	Description of investigated room	
5.5.2	Temperature	
5.5.3	Humidity	
5.5.4	Daylight	
5.6	Summary of field study 1	152
5.7	The evaluation of micro climate impact on indoor thermal comfort	154
5.7.1	Measurement result of micro climate data of JKR 989	
5.7.2	Measurement result of indoor thermal comfort factors	
5.7.3	Predicted Mean Value & Predicted Percentage of dissatisfaction	
5.7.4	Summary of evaluation study on micro climate impact on	

5.8	Computer simulation	163
5.8.1	Simulation inputs and assumption	
5.8.2	Simulation procedure	
5.8.3	Air flow	
5.8.4	Process simulation	
5.8.5	Simulation results of macroclimate	
5.8.6	Airflow result with different window design	
5.8.7	Results of air exchange rate for different types of window design	
5.8.7.1	Optimization analysis	
5.8.8	Summary of simulation test	
<b>CHAPTER 6.0</b>	<b>Analysis and Discussion</b>	<b>176</b>
6.1	Window to wall ratio	177
6.2	Field measurement	178
6.2.1	Air temperature	
6.2.2	Humidity	
6.2.3	Daylighting	
6.3	PMV & PPD	181
6.4	Computer simulation	182
6.5	Comparison field measurement with simulation test	185
<b>CHAPTER 7.0</b>	<b>Conclusion &amp; Recommendations</b>	<b>186</b>
	References	191
	Appendixes	

## Table of Figures

Fig. 2.1	Body heat loss and air temperature	16
Fig. 2.2	Thermal comfort for human	18
Fig. 2.3	Source of heat enter into the building	25
Fig. 2.4	Sample components of window	27
Fig. 2.5	Sample opening windows	31
Fig. 2.6	U factor	33
Fig. 2.7	Visible light transmittance	34
Fig. 2.8	Energy usage at home	36
Fig. 2.9	Natural ventilation strategies	41
Fig. 2.10	Pressure effect from wind	41
Fig. 2.11	Partition designed to minimize resistance for effective cross Ventilation	41
Fig. 2.12	Cross ventilation rule of thumb-effective for upto 5 times the Ceiling height	42
Fig. 2.13	Pressure effect from stack ventilation	43
Fig. 2.14	Passive cooling strategies	48
Fig. 2.15	Basic comfort zone	48
Fig. 2.16	Expanded comfort zone	49
Fig. 2.17	Passive cooling strategies	51
Fig. 2.18	Sketch of a house with vaulted roof	51
Fig. 2.19	Ventilated and micro ventilated roof system for passive cooling	52
Fig. 2.20	Section drawing of JKR 989 showing the ventilation that occurs	53
Fig. 2.21	Taj Mahal in Agra, India built around 1648AD with high roof	53
Fig. 2.22	LEO building in Putrajaya	57
Fig. 2.23	Overview of potential barriers to the application of natural ventilation in buildings	58
Fig. 2.24	Top lighting sample	60
Fig. 2.25	Side lighting sample	60
Fig. 3.1	JKR 511 main entrance	72
Fig. 3.2	Overall view JKR 989	72
Fig. 3.3	Overall view of JKR 1331	73
Fig. 3.4	Overall view of JKR 1716	73
Fig. 3.5	Overall view of JKR 541	73

Fig. 3.6	Graph of temperature Kuala Lumpur in 2004-2008	76
Fig. 3.7	Graph of relative humidity Kuala Lumpur in 2004-2008	77
Fig. 3.8	Graph of wind velocity Kuala Lumpur in 2004-2008	77
Fig. 4.1	Section of JKR 511	85
Fig. 4.2	Floor plan JKR 511	86
Fig. 4.3	North West elevation	87
Fig. 4.4	South East elevation	87
Fig. 4.5	North East elevation	87
Fig. 4.6	South West elevation	87
Fig. 4.7	Floor plan of JKR 989	92
Fig. 4.8	South East elevation	93
Fig. 4.9	North West elevation	93
Fig. 4.10	SouthWest elevation	93
Fig. 4.11	North East elevation	93
Fig. 4.12	Floor plan of JKR 1331	96
Fig. 4.13	South West elevation	97
Fig. 4.14	South East elevation	97
Fig. 4.15	North West elevation	97
Fig. 4.16	North East elevation	97
Fig. 4.17	Floor plan JKR 1716	100
Fig. 4.18	North East elevation	101
Fig. 4.19	North West elevation	101
Fig. 4.20	South East elevation	101
Fig. 4.21	South West elevation	101
Fig. 4.22	Section of JKR 541	103
Fig. 4.23	Floor plan JKR 541	104
Fig. 4.24	South elevation	105
Fig. 4.25	North elevation	105
Fig. 4.26	East elevation	105
Fig. 4.27	West elevation	105
Fig.5.1	South West facade of JKR 989	109
Fig. 5.2	Floor plan JKR 989	110
Fig. 5.3	Zoning in JKR 989	111
Fig. 5.4(a)	Royal Chulan Hotel in front of JKR 989	112
Fig. 5.4(b)	Apartment on East JKR 989	112

Fig. 5.4(c)	Office tower under construction which behind JKR 989	112
Fig. 5.4(d)	Upcoming 42 storey apartments next to JKR 989	112
Fig. 5.5 (a)	HOBO data logger to measure temperature, humidity&daylighting	113
Fig. 5.5 (b)	BABUC used to measure temperature, wind velocity, humidity& Daylighting for internal space	113
Fig. 5.6	Floor plan JKR 989	114
Fig. 5.7(a)	Resource centre with windows closed	115
Fig. 5.7(b)	Resource centre with windows opened	116
Fig. 5.8(a)	Librarian working space	116
Fig. 5.8(b)	Summary of window types in Resource centre	117
Fig. 5.9(a)	Graph shows temperature zone 1 (windows closed)	118
Fig. 5.9(b)	Graph shows RC temperature with windows opened	119
Fig. 5.10(a)	Graph shows relative humidity resource centre windows closed	120
Fig. 5.10(b)	Graph shows RH for RC with windows opened	121
Fig. 5.11(a)	Graph shows illuminance RC JKR 989 with windows closed	124
Fig. 5.11(b)	Illuminance data RC with windows opened	125
Fig. 5.12	Floor plan JKR 989	126
Fig. 5.13(a)	Door to meeting room	127
Fig. 5.13(b)	Meeting room with windows closed and opened	127
Fig. 5.13(c)	Location of measurement equipments in meeting room	128
Fig. 5.13(d)	Section of meeting room	128
Fig. 5.13(e)	Summary of window types in meeting room	128
Fig. 5.14(a)	Graph shows temperature meeting room with windows closed	129
Fig. 5.14(b)	Graph shows temperature meeting room with windows opened	131
Fig. 5.15(a)	Graph shows humidity meeting room with windows closed	132
Fig. 5.15(b)	Graph shows humidity with windows opened	133
Fig. 5.16(a)	Graph shows illuminance meeting room with windows closed	135
Fig. 5.16(b)	Graph shows illuminance meeting room with windows opened	136
Fig. 5.17(a)	Floor plan of JKR 989	137
Fig. 5.17(b)	Exterior and interior view of glass room	137
Fig. 5.17(c)	Location of measurement takes place	137
Fig. 5.18	Summary of window types in glass room	138
Fig. 5.19(a)	Graph shows temperature glass room with windows closed	139
Fig. 5.19(b)	Graph shows temperature glass room with windows opened	140

Fig. 5.19(c)	Cross ventilation in glass room	141
Fig. 5.20(a)	Graph shows humidity glass room with windows closed	142
Fig. 5.20(b)	Graph shows humidity with windows opened	143
Fig. 5.21	Interior of glass room	144
Fig. 5.22(a)	Graph shows illuminance glass room with windows closed	145
Fig. 5.22(b)	Graph shows illuminance glass room with windows opened	146
Fig. 5.23	Floor plan of JKR 989	147
Fig. 5.25	Summary of window types in kitchen	148
Fig. 5.26	Graph temperature kitchen	149
Fig. 5.27	Humidity Graph Kitchen	150
Fig. 5.28	Graph Illuminance kitchen JKR 989	152
Fig. 5.29	Floor plan of JKR 989	154
Fig. 5.30(a)	Graph of microclimate- temperature of JKR 989	155
Fig. 5.30(b)	Graph of microclimate- relative humidity of JKR 989	156
Fig. 5.31(a)	Graph of air temperature for meeting room, JKR 989	157
Fig. 5.31(b)	Graph air velocity of meeting room, JKR 989	158
Fig. 5.31(c)	Graph relative humidity of meeting room, JKR 989	159
Fig. 5.31(d)	Daylight meeting room, JKR 989	159
Fig. 5.32	Graph Predicted Mean Value- predicted percentage of Dissatisfied for different sessions	161
Fig. 5.33	Interior of zone 2	165
Fig. 5.34	Rear elevation of JKR 989	166
Fig. 5.35	Information to be inserted in AIOLOS in order to do simulation	168
Fig. 5.36(a)	Macroclimate air temperature	168
Fig. 5.36(b)	Macroclimate air velocity	168
Fig. 5.36(c)	Macroclimate air direction	168
Fig. 5.36(d)	Air changes without window	169
Fig. 5.36(e)	Air flow without window	169
Fig. 5.37	Schedule of windows	170
Fig. 5.38	Section of meeting room JKR 989	175
Fig. 6.1	Rear elevation of JKR 989	183
Fig. 6.2	Olgay's bioclimatic chart, converted to metric, modified to warm Climates	184



## List of Tables

Table 2.1	Summary of standard ventilation requirements of ASHRAE and UBBL	20
Table 2.2	Type of windows	28
Table 2.3	Window design requirement	35
Table 2.4	Comparison between architecture techniques and passive Techniques for passive cooling	55
Table 2.5	Summary for types of obstruction and their solution	59
Table 2.6	Characteristics of different types of buildings	62
Table 2.7	Summary of types of screens used for case studies	65
Table 4.1	Standard requirement of WWR	83
Table 4.2	Summary of window to wall ratio for windows in JKR 511	88
Table 4.3	Summary of window to wall ratio for windows in JKR 989	94
Table 4.4	Summary of window to wall ratio for windows in JKR 1331	98
Table 4.5	Summary of window to wall ratio for windows in JKR 1716	102
Table 4.6	Summary of window to wall ratio for windows in JKR 541	106
Table 5.1	Range of thermal comfort parameters	109
Table 5.2	Zone 1 existing features	114
Table 5.3	List of illuminance requirement of a house	122
Table 5.4	Zone 2 existing features	126
Table 5.5	List of illuminance requirement of a house	134
Table 5.6	List of luminance requirement	134
Table 5.7	Zone 3 existing features	137
Table 5.8	List of illuminance requirement of a house	144
Table 5.9	List of luminance requirement	144
Table 5.10	Zone 4 existing features	147
Table 5.11	List of illuminance requirement of a house	150
Table 5.12	List of luminance requirement	151
Table 5.13	Detail of climate	156
Table 5.14	Result of PMV & PPD	160
Table 5.15	Summary of maximum, minimum and mean indoor and outdoor Measurement result	162
Table 5.16	Macroclimate air temperature	168
Table 5.17	Air flow & air exchange rate in zone 2	169

Table 5.18	Summary air flow rate and air exchange rate for different design of windows in JKR 989	171
Table 5.19	Optimization analysis result	173
Table 5.20	Summary of window design for optimum ventilation	173
Table 6.1	Summary result of natural ventilation and daylighting for 5 calculation	177
Table 6.2	Summary of measurement for different zones	179
Table 6.3	Result of PMV and PPD	182
Table 6.4	Detail of climate	183
Table 7.0	Comparison of indoor and outdoor temperature and relative Humidity JKR 989	189

## List of Abbreviations

AL	-	Air Leakage
ASHRAE	-	American Society of Heating, Refrigerating and Air- Conditioning Engineers
CFM	-	Cubic feet per minute
CORE	-	Centre for Conservation Studies and Records
JKR	-	Jabatan Kerja Raya
LSG	-	Light to Solar Gain
PMV	-	Predicted Mean Value
PPD	-	Predicted Percentage Dissatisfied
RC	-	Resource Centre
SHGC	-	Solar Heat Gain Coefficient
UBBL	-	Uniform Building By Law
VLT	-	Visible Light Transmittance
WWR	-	Window to Wall Ratio
ZEB	-	Zero Energy Building