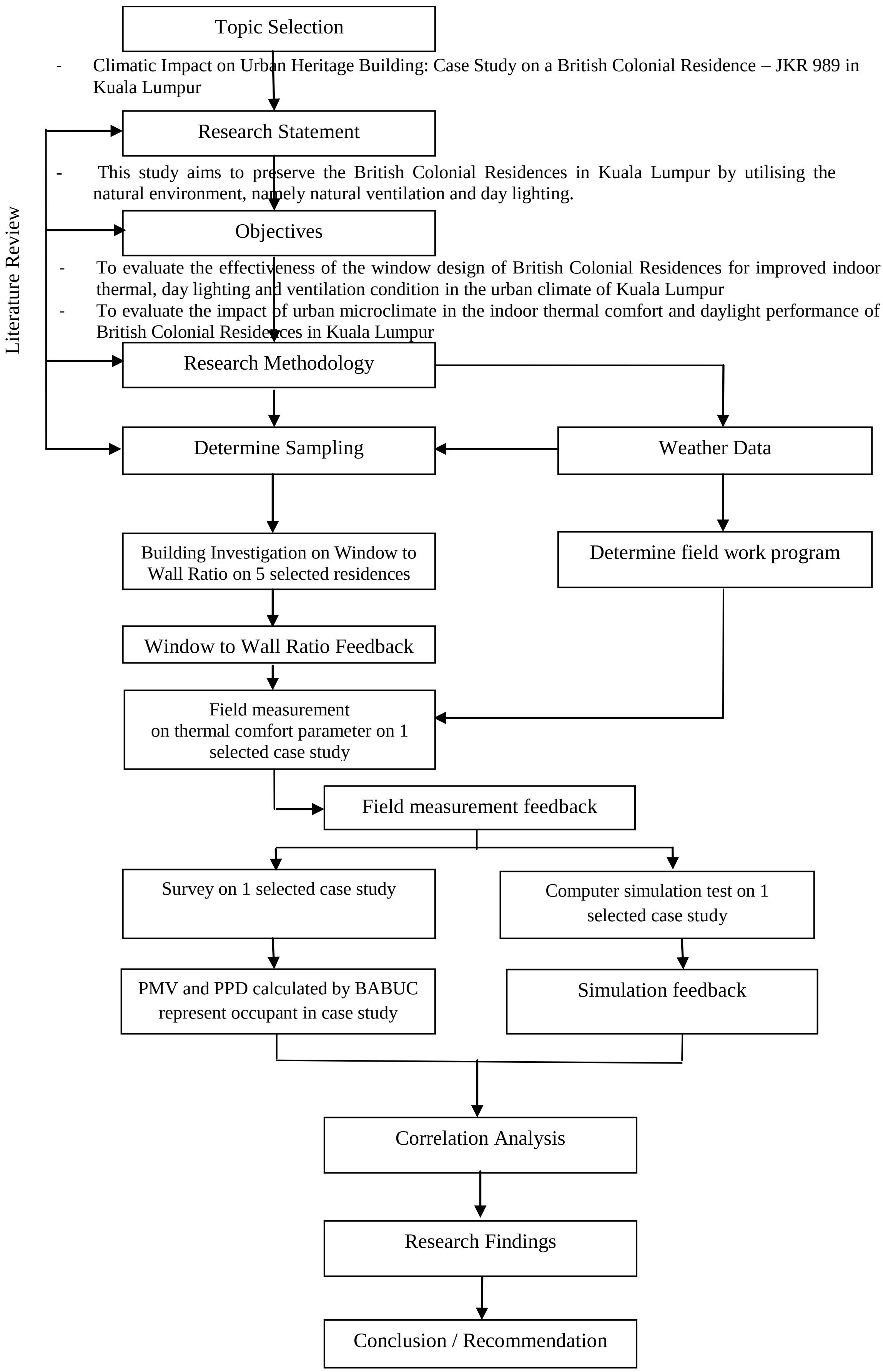
CHAPTER 3.0

Research Methodology



In this research, data collection was being divided into calculations of window to wall ratio, field measurements and a simulation test. Calculations of window to wall ratio were done on five selected British Colonial residences in Kuala Lumpur. This Window to wall ratios were calculated on every windows of each wall of each selected residences. The calculation result of one selected residence was then justified with field measurement on thermal comfort parameters followed by simulation test on the same selected residence.

Simulation test is conducted with AIOLOS in order to calculate the airflow rate in selected zones in the selected residence as case study. The result of the simulation test was then compared with field measurement in order to evaluate the thermal comfort level of the occupants using AIOLOS.

This study was started by focusing on five selected British Colonial residences in Kuala Lumpur, Malaysia. These buildings have sensitive approach to energy consciousness for indoor comfort conditions (Ghafar, 1997). Justification of British Colonial Residences for investigation is being divided into selection of buildings from all the old buildings recorded in *Kajian Inventori Warisan Seni Bina Malaysia 1992/1993.* Buildings which are more than fifty years old are considered as old buildings. Criteria for selection included the following: i) the availability of measured drawings for the buildings found in UM CORE (University Malaya Conservation and Building Record) and Resource Centre in *Badan Warisan Malaysia*, ii) public building, residential building, single storey building, buildings which were built using bricks, buildings with climatic responsive design and built during the British colonial period. Although Malay traditional houses were classified under the category of vernacular architecture, were not included in this study due to the material used which is timber. As suggested by Malik (2005) that

> *"The Malay Traditional Village House is a good reference to passive design elements but are not suitable in modern times and urban scene due to building regulation restrictions. The introduction of the Colonial House is the start of an urban design and a sign of changing design priorities."*

Therefore British Colonial building was selected as sample for case study to represent climatic responsive design residences in urban set up.

3.1 Selection of samples for calculations Window to Wall Ratio

The calculation of Window to Wall Ratio (WWR) on five (5) typical colonial residences which are JKR 511, JKR 989, JKR 1331, JKR 541 and JKR 1716 are situated within Kuala Lumpur and JKR 989 is located within the Kuala Lumpur business central district. Selection for the calculation was based on the following:

a. British Colonial Buildings

Historic buildings represent a very sensitive part of built-up areas. Architecturally, most of the British colonial buildings have special features including louvered windows, shaped gables, shading devices, internal courtyards, high ceilings, porticos, verandas and air-wells, which are promoting natural ventilation and day lighting and responsive to local climate.

> *"It is important to understand that British Colonial Buildings not only possess an original identity in their own style but also that they were generally constructed by trained contractors. These builders introduced*

some of the best building techniques for their time." extracted from *British Colonial Architecture in Malaysia 1800-1930* by A. Ghafar Ahmad, 1997,pp.4.

b. government quarters

During the British occupation in Malaya, many colonial buildings mostly public / government buildings were built in the major towns of Georgetown, Kuala Lumpur, Ipoh, Taiping, Seremban, Johor Bahru and Kuching as there was a tremendous influx of British officials.

"As a result of the formation of the Federated Malay States, there was a tremendous influx of British officials to the colony. Government departments expanded rapidly and to the arrivals of administrators, were added the waves of doctors, engineers, educators, those considered of lesser standing such as merchants, planters, importers. All these people had to be housed, their children educated, their souls taken care of, and their leisure time given outlet. Although the design of the buildings made the necessary concessions to the climate, their buildings remained, on the whole, copies of those of the homeland, with some elements of Imperial India." Extracted from Malaya 1900-1930: a Retrospect of the Country through Postcards by Ng, 1983, pp. 68

c. single storey buildings

Different height of a room will influence the airflow pattern and thermal comfort of a building. Changing height of a building, while keeping length and width unchanged, will produce an increase in depth of the downwind wake without variation of shape. In addition, the wind velocity increases at higher levels.

d. Least changes to the buildings

Major changes to the building will damage the original features of traditional architecture which led to thermal comfort conditions in buildings. These buildings are chosen as they have minimum experience of change along the time line.

e. Climate responsive design

Some of the old buildings constructed were very rigid and have yet to adapt to the climatic conditions. The buildings selected in this research are an example for providing physical comfort to the inhabitants by passive means, minimize energy consumption.

> *"During the British period, there was a tremendous influx not only of British officials. As a result, many residences (eg. Bungalows and villas) were built to house these people, and these residences can be found in towns, cities and on plantation estates. Some of these buildings have borrowed the western tradition, particularly in the style and method of construction with, of course, adaptations to the local climate."* extracted from *British Colonial Architecture in Malaysia 1800-1930* by A. Ghafar Ahmad, 1997,pp.45 and Mooore, 1990.

> *"Many of the colonial and the indigenous Malay buildings had by necessity been designed to respond to the hot humid tropical climate of Malaysia. The climate demanded roofs that were able to discharge the rainfall quickly, deep overhangs or eaves to give shading to the windows and protection to the walls and good cross ventilation to keep the interior cools."* extracted from Post Merdeka Architecture Malaysia 1957-1987 by Pertubuhan Arkitek Malaysia, 1988, pp. 16. (Chan, 1987)

f. similar typology

There are various types of British colonial architecture in Malaysia, such as forts, churches, palaces, clock towers, prisons, government offices, institutional and commercial, residential, schools, railway stations, hotels and guests' house, miscellaneous buildings/monuments. Classification identifies the similarities in physical elements between buildings of the same function and style.

Only five (5) buildings stated in Figure 3.1, Figure 3.2, Figure 3.3, Figure 3.4 & Figure 3.5 fulfilled all the above mentioned criteria based on the list Kajian Inventori Warisan Seni Bina Malaysia 1992/93. Three out of five houses have similar design but different orientation, which are JKR 989, JKR 1331 and JKR 1716.

- JKR 511, Persiaran Mahameru, KL (Class I quarter), built in 1901, oriented to North East

Figure 3.1: JKR 511 main entrance
Source: UM CORE, 2006

- JKR 989, Jalan Stonor, KL (Class III quarter), built in 1925, oriented to South East

Figure 3.2: Overall view JKR 989
Source: Author, 2009

- JKR 1331, Jalan Semarak, KL (Class III quarter), built in 1939, oriented to North East

Figure 3.3: Overall view of JKR 1331
Source : UM CORE, 2006

- JKR 1716, Jalan Ledang, KL (Class III quarter), built in 1931, oriented to North West

Figure 3.4: Overall view of JKR 1716
Source: UM CORE, 2006

- JKR 541, Jalan Belfield, KL (Class IV quarter), built in 1906, oriented to South

Figure 3.5: Overall view of JKR 541
Source: UM CORE,2006

Site observation

Building Investigation

Site visit was done to observe the overall window design of the residences. The building orientation, window orientation, direction of wind flows, width and height of room, dimension of windows, shading device, existing features at surrounding were noted. Photographs of the residential environment were taken, sketches of the pattern of wind flow and the location of window were drawn. An interview session were held with the occupants/building users to understand the technical part of the bungalows.

3.2 Collection of Data

Climatic data of five years (between 2004 and 2008) was collected from the Meteorology department to determine the months of the year which have the highest temperature and humidity in order to conduct the field measurement. Petaling Jaya station data was selected for this research as the only principal station (PJ/Subang/KLIA) that recorded solar radiation, temperature, maximum wind speed and direction, relative humidity and cloud cover data. Field measurement was done during months which have constant changes in mean temperature and relative humidity. Air temperature, humidity, wind velocity and direction were measured.

3.3 Selection of Typical Year Data

Five year weather data of Kuala Lumpur between year 2004 and year 2008 were obtained from the Malaysia Climatology Department to determine field work programme and the period to carry out simulation test.

For thermal analyses of local climate data, thermal conditions of one typical year data set of weather conditions are required before one typical month set is selected. Several kinds of typical weather data are currently available and the criteria for constructing a typical year weather data vary from one database to another.

The weather data obtained from the Department of Climatology Malaysia contain hourly weather observations. The weather data are supplemented by solar radiation estimated on an hourly basis from earth sun geometry, hourly weather elements, and particularly the cloud amount information.

A typical meteorological year is based on an empirical approach that selects individual month from a long period (30 years or more). Data sets occurring with the maximum frequency may be chosen to be included in the typical year. Since there is only a limited amount of weather data available in Kuala Lumpur station, Petaling Jaya Weather Station was selected to provide the related information. In this study, year 2008 weather data has been tested as a typical year data because it is the latest weather data available and has minimum amount of missing data. This reduces the amount of reconstruction and manipulation of data. To ensure that year 2008 weather data can be used as a typical year data, the testing steps listed below were taken to test the data set.

3.3.1 Air Temperature

Refer to graph 3.6 shown mean air temperature between year 2004 and year 2008. Maximum mean air temperature between year 2004 and year 2008 is 28.5°C on February, June and September. Minimum mean air temperature between year 2004 and year 2008 is 26°C on November. Mean air temperature between year 2004 and year 2008 is 27.4°C on January, July and October.

3.3.2 Relative Humidity

Refer to graph 3.7 shown mean relative humidity between year 2004 and year 2008. Maximum mean relative humidity between year 2004 and year 2008 is 85% on November. Minimum mean relative humidity between year 2004 and year 2008 is 70% on August. Mean relative humidity between year 2004 and year 2008 is 78% on January, February, March, May, June and July.

3.3.3 Air Velocity

Refer to graph 3.8 shown mean air velocity between year 2004 and year 2008. Maximum mean air velocity between year 2004 and year 2008 is 10m/s on March and September. Minimum mean air velocity between year 2004 and year 2008 is 7m/s on December. Mean air velocity between year 2004 and year 2008 is 8.65m/s on March, April, June and July.

As a result, the Northeast Monsoon and Southwest Monsoon have less effect on the temperature, humidity and air flow of climate in Kuala Lumpur. Therefore, the field measurement result will not affected by the monsoon season. From these data, simulation test and field measurement will be taken on May, June and July as these two months had constant changes on air temperature, relative humidity and air velocity compared to other months in the year.

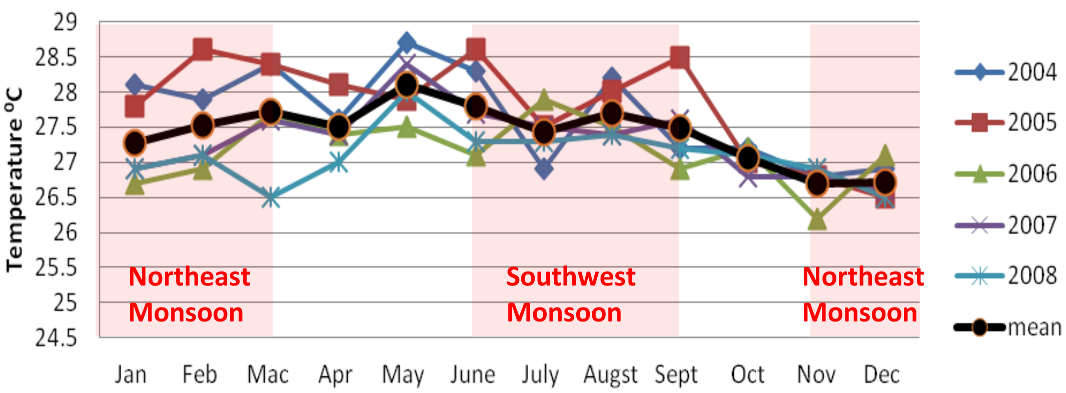


Figure 3.6: Graph of air temperature Kuala Lumpur in 2004-2008
Source: Climatology Department Malaysia

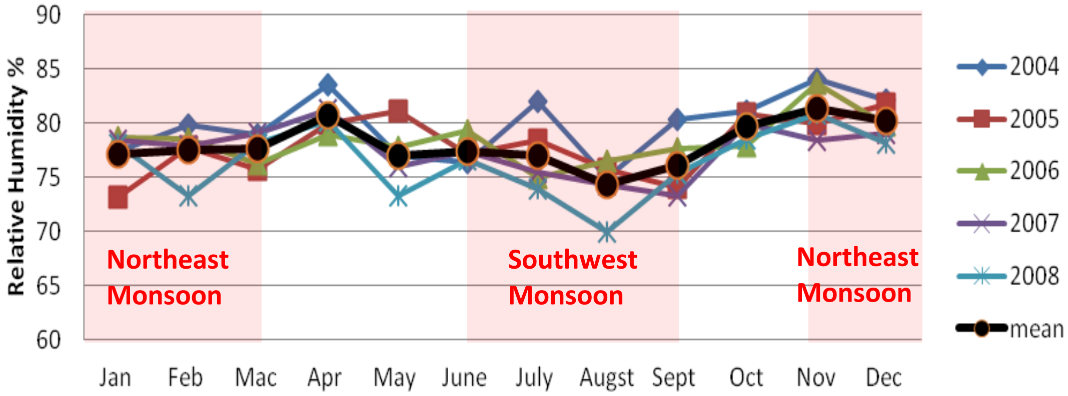


Figure 3.7: Graph of relative humidity Kuala Lumpur in 2004-2008
Source: Climatology Department Malaysia

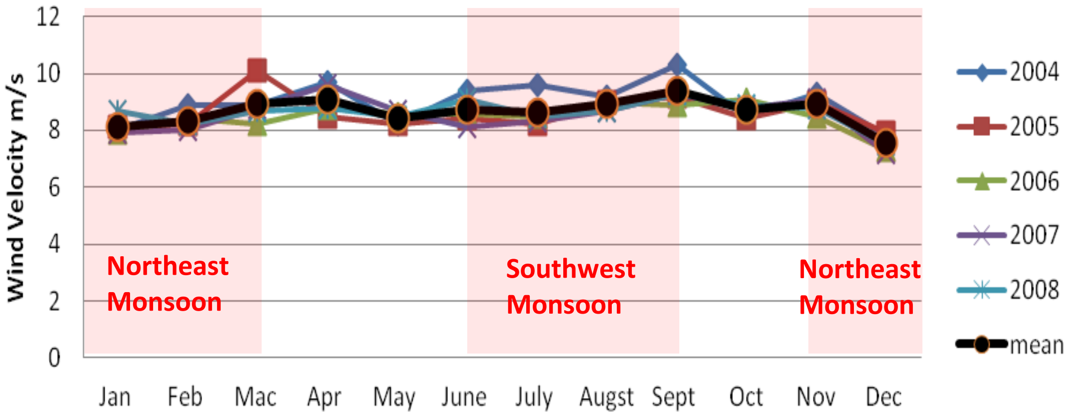


Figure 3.8: Graph of air velocity Kuala Lumpur in 2004-2008
Source: Climatology Department Malaysia

3.4 Window to Wall Ratio Calculation

According to ASHRAE 90.1-2007, *"Window to Wall Ratio is the ratio of vertical fenestration area to gross exterior wall area. The fenestration area is the rough opening, i.e. includes the frame, sash and other non glazed window components. The gross exterior wall is measured horizontally from the exterior surface, it is measured vertically from the top of the floor to the bottom of the roof. The gross exterior wall area includes below grade as well as above grade walls."*

$A_0=A_1+A_2$ (A_0 - gross area of exterior wall, m²; A_1 - opaque wall area, m²; A_2 - fenestration area (glazed), m²)

Window to wall ratio = A_2/ A_0

Window to wall ratio (WWR) can determine the rate of conductive, convective and radiative heat transfer through the window and the wall. Window designs of the selected residences will be analyzed to determine whether the Window to Wall Ratio (WWR) had caused impact on the natural ventilation and daylighting to the internal heat gain and visual comfort. A window chart which include details such as window orientation, type of window, dimension of window, dimension of louver, window area, height of wall, window – height on wall, location of windows, nos of window, area of wall with the windows, level of exposure of the window to wind. was prepared for each of the selected buildings. Floor plans and elevations of each selected residences were studied and calculation of window to wall ratio was done with the window chart. For the calculation of window to wall ratio, windows which had WWR of more than 0.24 allowed sufficient daylight/ventilation to the room. If the WWR for a window was more than 0.24 means this window has let in desirable daylight/ventilation and prevented the unwanted heat that caused overheating from coming in. For windows which had WWR more than 0.30, it means that they had caused overheating to the room.

3.5 Case study-field measurement

In order to ascertain the current situation of the indoor environment in the selected residence, JKR 989 was selected for measurement of indoor thermal comfort parameters such as air temperature, air velocity, relative humidity and daylight in May, June and July 2010 with HOBO data logger. This investigation was not for comparison with others buildings but taken as a case study to verify the hypothesis that windows of Colonial buildings were designed for natural ventilation and daylighting. Only one building was chosen to be investigated as it represented the same scale and size of building proportion with the other four British Colonial residences in Kuala Lumpur. JKR 989 was selected as it has the most critical urban setting which is surrounded by high rise buildings that directly contributed to heat island effects. The measurement was carried out for a period of 7 weeks to give an average picture of the indoor environment's climatic performance. Seven weeks were deemed as adequate to give some indications of the indoor climate. These few weeks reading were based on selection of days which have the most critical temperature and humidity.

3.6 Case study - Computer simulation

AIOLOS software was designed by Santamouris (2001) and it was applied for constructing the computer model of the case study. Consequently, the window analysis part in AIOLOS was used to assess the air flow efficiency of the house in June and July 2010. The testing of the model consisted of evaluating the existing condition, testing for the air changes/air flow rate for different opening sizes in the house. These evaluations revealed that appropriate window design will improve the thermal conditions, especially during afternoon hours when the house has the most penetration of the sun from the windows as well as highest internal temperature.

AIOLOS was developed in 1998 and was designed to assist in the calculation of the airflow rate for natural ventilation configurations based on the principles of network modeling. It was attached with the book ‘Allard, F. (1998). Natural Ventilation in Buildings. The Cromwell Press, UK.’ AIOLOS assisted to calculate the following:

- *Calculation of the global airflow rates in each simulated zone*
- *Calculation of the airflow rates through each of the openings in the building structure.*
- *Sensitivity analysis for the investigation of the impact of specific parameters on natural ventilation.*
- *Optimization process for the derivation of the appropriate opening sizes for achieving optimum airflow rates in the investigated configurations.*
- *A parametrical model for the calculation of the pressure coefficient on exterior surfaces*
- *A thermal model for the assessment of the impact of various natural ventilation strategies on the thermal behavior of the building.*
- *The above calculations can be run for a short (1day) or an extended (up to 1 year) time period. Climatic data can be treated statistically through an inbuilt climatic preprocessor. This feature gives the user the possibility to have a fast assessment of the prevailing climatic characteristics in the region the building is located in. Results are reported in a tabular or graphical form.*

The disadvantages of AIOLOS software are as follows:

- Unable to calculate lighting design
- Many of analysis need to be done to edit to the relevant information and produce a report

- Unable to provide cutting edge 3D spatial model to help users visualize simulation output

AIOLOS is a numerical tool for performing natural ventilation studies in building and shows the users the information that is needed to evaluate window performance in a specific condition. It is this ability of being able to easily relate to window performance data to a broad group of designers, makes AIOLOS software so unique.

This selected British Colonial residence had been divided into 4 zones. Only one zone was chosen for the simulation test. The criteria for determining the zoning was based on the physical conditions of the space and space usage. The space with the same physical condition was categorized under the same zone. For example, in JKR 989, there were two rooms, currently used as gift shop and meeting room with high ceiling and clerestory windows. Thus, they are categorized in one zone. Among the four zones stated above, zone 2 (meeting room) was selected for simulation test. It was selected for following criteria: high ceiling, clerestory louvered windows, different volume within one space and no compartmentalization.

Information recorded were the time opening of selected zone, space usage, area of space, height of space, volume of space, nos. of external opening, nos. of internal openings, internal temperature, internal air speed, window dimension, window orientation, opening system, height of window, window-height on wall, façade shape, shading, wall area, load for lighting and electrical equipment. Petaling Jaya climate data was then inserted into the software to enable the computer to calculate the air temperature, wind velocity and wind direction for the area the window dimensions were inserted into the programme to enable the programme to calculate air changes and air flow rate for the specific zones. Sensitivity analysis of the external opening for each zone will next be calculated by this software. Finally, the optimization analysis results will be proposed for suitable window dimensions for optimum wind flow and air changes for the assigned zone.

3.7 Analysis

The documentation of this research was carried out together with data collection stage. Analysis had been done based on the data collection. These feedbacks had been correlated and analyzed using several sampling strategies, in this case, the result of window to wall ratio calculation and simulation test, the feedback of field measurement.