A Study on Natural Ventilation Performance in Selected Historical Building in Kuala Lumpur

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Abstract

The application of Natural Ventilation System in old and historical buildings at the vicinity of Kuala Lumpur was analysed. The adopted study viewed on the occupants' comfort against the performed activities in the buildings. Investigation carried out to explain the extent of the effects of natural ventilation on occupants and other factors influencing comfort level inside and outside the buildings. Through this mechanism the enhancement of the natural ventilation may be executed in order to have more comfortable ventilation. The main aim of this work is to establish a relationship between comfort level and ventilation system, and at the same time to identify factors that contribute to occupants' comfort level and buildings condition.

The research method involved the distribution of questionnaires and face to face interview with building occupants. Data assessment and analysis are carried out on both quantitative and qualitative. A total of 32 questionnaires were distributed mainly to building proprietors along shop lot at Jalan Tuanku Abdul Rahman, Jalan Brickfields and Jalan Bangsar. The measurement of the buildings' inside and outside temperature and relative humidity were taken by employing Higro-Termometer Digital and Indoor Air Quality Monitors respectively. The two atmospheric parameters were selected to correlate with comfort level and to determine factors which influence the building conditions. All collected atmospheric data were then analysed using Statistical Package for Social Science (SPSS) computer software.

In this work, frequency and average temperature analytical method were used. The results show that there is a significant correlation between ventilation systems used inside buildings with comfort level. Consequently, the results obtained would assist in the improvement of the building occupants' comfort level in the future.

Keywords: Natural Ventilation, Historical Building, Comfort level
Domain: Indoor Environment

1. INTRODUCTION

Historic buildings represent a very sensitive part of built-up. Research that has been into by using the correct methods, long term monitoring and control of microclimate which is the heritage friendly methods that provide necessary criteria for appropriate use historic buildings under today's more complex indoor climate. There are several important issues related to microclimatic and damp control in historic buildings to be solved. The purpose of monitoring conditions in historic buildings is to obtain data about the long term changing of indoor climate and their influence on the material fabrics that are of cultural value. The process of mitigation gives influence to moisture and temperature changing on the material fabrics of monument that should be preserved in good condition. That is especially in the case when indoor surfaces are painted by fresco paintings. The measuring campaigns provide data to be used as valuable source to support the heritage management concerning the future use of monument halls and protection of exhibited objects. They also help in decision-making about the choice of the most suitable heating and ventilation systems in halls opened to public use.

Due to changes in outdoor environment and/or type of usage, historical buildings face the risk of defects and deterioration of their fabric and contents [1]. In historical shop lot with inadequate ventilation system, humidity fication and control, it is possible to mitigate the effects of temperature and humidity extremes on a building and its content by controlling air flow. When used in conjunction with mechanical air conditioning, this method can also save little money. Effective control of air flow requires understanding the existing climatic condition in and around the building, measuring and keeping records of current environmental behaviour and using various techniques to improve air flow within the building. The environmental impact and factors are affecting the building and its surrounding area. The main concern of the building is the ventilation system. People stay in the major part of their time in the indoor environment. Therefore, this study will focus on shop lot building space, the surrounding areas, and ventilation of the space that have been used for shop lots. The study also extended to investigate relationship between ventilation performance with level of comfort.

2. LITERATURE REVIEW ON NATURAL VENTILATION

The indoor environment quality will influence the productivity, the thermal comfort and the health of people. This quality depends on the characteristics of the build, the type of use, the indoor air quality and other variables. In this research three (3) operating rooms were evaluated. In these environments, the indoor air needs major care. In hospital for instance, the indoor air quality is a very important factor to patients' medical requirements and usually it is also part of the treatment. The control of the indoor air in operating rooms it is made through of the controllability of the system. The temperature and the relative humidity need to fulfil requirements in accordance with the types of usage [2].

2.1 Thermal Comfort

Thermal comfort is that condition of mind which expresses satisfaction with the thermal environment. Thermal environment is those characteristic of environment which affects a person heat loss. In terms of bodily sensations, thermal comfort is a sensation of hot, warm, slightly warmer, neutral, cool and cold. From the physiological point of view, thermal comfort occurs when there is thermal equilibrium in the absence of regulatory sweating between the heat exchanges between the human body and the environment [3].

Factors influencing thermal comfort are as below:-

a) Air temperature
b) Humidity
c) Air velocity
d) Radiation temperature

2.1.1 Air Temperature

According to climatology and methodology, air temperature is the ambient temperature indicated by thermometer expose to the air. The temperature indicated by thermometer placed in instrument shelter 1.5 to 2 meter above ground. Air temperature is measure of the heat content of the air. The temperature of atmosphere is controlled by a complex set of interaction between biosphere, lithosphere and atmosphere. Energy is constantly being exchanged between the surface and the air above a place, as well as circulating around the globe [3].

2.1.2 Humidity

Humidity is the amount of water vapour in the air and can be described in different ways. The term that people use most often to describe the humidity is relative humidity. Relative humidity is a measure of the amount of water in the air compared with the amount water the air can hold at the temperature it happens to be when it measures. Relative humidity is expressed as a percentage and can be computed in a variety of way. Humidity can make the warm of the surrounding air feel as if it warmer than the actual temperature would suggest, because the cooling effect of evaporation from the skin is reduced. This is because as environment temperature approach normal skin temperature, cooling of the body becomes difficult. If the atmosphere is warm as or warmer than the skin, blood brought to the body surface cannot lose the heat [3].

2.2 Natural Ventilation

In refurbishment, requirements for natural ventilation need to be fulfilled in order to ensure comfort in a building. Some potential guidelines for natural ventilation in refurbishment works are as follow [3]:

1. Establish the likely heat gains from people, lighting and equipment. $40W/m^2$ is generally seen as limiting value for pure natural ventilation.

2. Determine the noise level at each façade (using simple empirical rules for road traffic noise). A limiting value of 70 dB at the façade should, be careful design, enable a tolerable 50-55 dB to be achieved at perimeter desk position when windows are open.

3. A subjective assessment of outdoor air quality may rule out natural ventilation at this stage, at least at some façade. Proposed definitive values for concentration of various pollutants are given in (The UK national air quality strategy: consultation draft)

4. If natural ventilation still an option, the building itself may then be considered for the viability of, or ease of conversion to, natural ventilation. (Kendrick, et al., (1998)

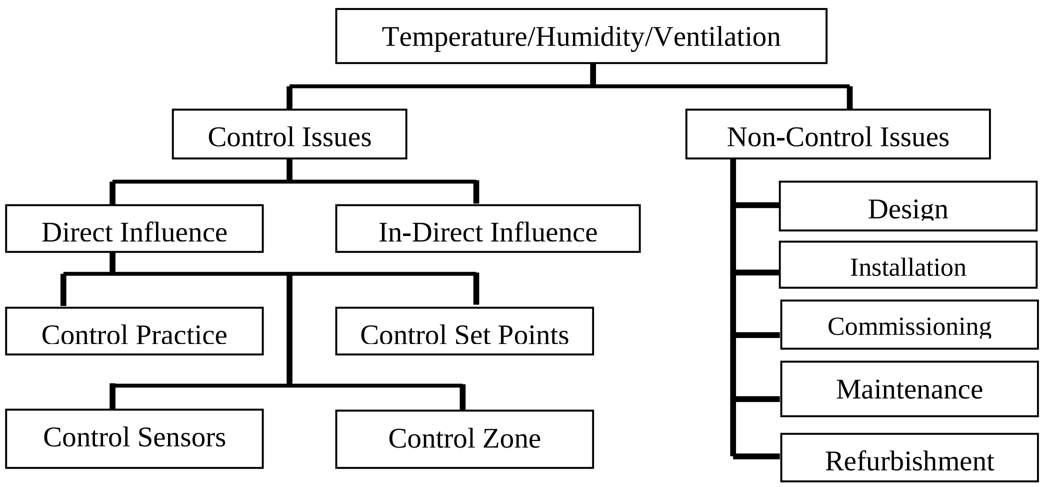
Table 1 shows the different types of building followed by the characteristics and period they were built.

Table 1: Natural ventilation characteristics of different building types

Period/ description	Typical Construction	Advantages for natural ventilation	Disadvantage for natural ventilation
Pre 1990	Masonry	High ceiling Tall window Good natural light High thermal mass	May be listed building structural partition – inflexible space, poor circulation
1900 – pre WWII	Masonry, concrete or steel frame	May have high ceiling Narrow floor plate	May be listed building structural partition – inflexible space, poor circulation
Late 1950s/1960s	Steel frame or reinforced concrete, curtain wall	Narrow floor plate Open plan layout	Low floor-floor height Large glazed area Low floor loading Relatively lightweight
1970s office	Steel frame or reinforced concrete	Larger floor-floor height than 1960s (service) Open layout	Deep plan Lightweight construction

Source: Refurbishment of air-conditioned building for natural ventilation. Technical note, (1998)

Figure 1: Factors that influence Indoor Environment Quality (IEQ)



Source: Refurbishment of air-conditioned building for natural ventilation. (Building Control & IEQ) (Technical note, 1998)

3. RESEARCH METHODOLOGY

The main research method involved the distribution of questionnaires and engaging interview with building occupants. Data assessment and analysis were carried out both quantitative and qualitative. A total of 32 questionnaires were distributed mainly to building proprietors along shop lot at Jalan Tuanku Abdul Rahman, Jalan Brickfields and Jalan Bangsar. The measurement of the buildings' inside and outside temperature and relative humidity were taken employing Higro-

Termometer Digital and Indoor Air Quality Monitors respectively. The two atmospheric parameters were selected to correlate with comfort level and to determine factors which influence the building conditions. All collected atmospheric data were then analysed using Statistical Package for Social Science (SPSS) computer software. The data collection method included interviews from occupants such as building owner and worker, questionnaires, measurement of atmospheric temperature and relative humidity of the building inside and outside areas. These questionnaires are limited to the selected people who are at available site. The advantages of these questionnaires are wide-ranging responses are easily compile and environmental issue may be analysed on ventilation system that effect historical buildings.

3.1 Tool and Equipments

Tools and equipments that were being used during the site survey were as follows:

i. Clipboard and Paper
ii. Measuring Tape (50m and & 7.5m)
iii. Digital Camera
iv. Higro-Termometro Digital Easy Vision. (Model EA20)
v. Indoor Air Quality Monitors (AQ5000 Pro and AQ5001 Pro)

4. RESULTS OF CASE STUDY

4.1 Data Analysis

The analyses were divided in two stages; descriptive and inferential statistics. The analyses on descriptive statistics were presented in form of tables by using percentage and inferential statistics were presented on associative test between factors which related in the survey of historical building at shop lots with the level of comfort for building users.

4.1.1 Descriptive Statistics

Table 2: Category of building occupants

Description/ Scale	Percentage (N=30)
Worker	66.7
Building owner	33.3
Total	100.0

The types of occupant of historical building shop lot in the study are shown in Table 2. Generally, the premises are occupied more by the workers than the proprietors. The workers occupied 66.7 percents of the premises whilst the proprietor occupied only 33.3 percents.

Table 3: Respondent premise occupancy duration in building shop lot

Description/ Scale	Percentage (N=30)
1-2 years	6.7
3-4 years	16.7
5-6 years	46.7
Other (7-20 years)	30.0
Total	100.0

The number of years of premise occupancy is depicted in Table 3. The number of workers-proprietors in the 1 to 2, 3 to 4, 5 to 6, and others (7 to 20) years occupancy periods are 6.7 percents, 16.7 percents, 46.7 percents and 30 percents respectively. The highest recorded occupancy in 5 to 6 years is 46.7 percents comprising of mainly local worker.

Table 4: Rate of work frequency

Description/ Scale	Percentage (N=30)
Daily	50.0
5 day in a week	50.0
Total	100.0

The rate of work frequency is presented in Table 4. In general there are two groups of workers; those who on a day to day basis comprises of 50 percents whilst those employed on a 5 day a week constituted the other 50 percents.

Table 5: Time of operation per day

Description/ Scale	Percentage (N=30)
more than 8 hour	100.0

The time of operation per day is shown in Table 5. One-hundred percents of the occupants work on an 8 hour per day basis from 9.00 am to 7.00 pm with a 1 hour lunch break. Mostly the respondents said that their operations of business were increased when celebration days come.

Table 6: Respondents feedback on level of air quality in building shop lots

Description/ Scale	Percent (N=30)
Poor	3.3
Fair	86.7
Good	10.0
Total	100.0

The level of air quality in the building shop lots is depicted in Table 6. The air quality may be described poor, fair and good. Only 10 percents of respondents agreed that the air quality is good whilst 86.7 percents said that the air quality is fair at very slow 3.3 percents suggested that the air quality is poor due to thermal discomfort and poor air ventilation.

Table 7: Respondent response on ventilation flow in building shop lot

Description/ Scale	Percentage (N=30)
Poor	13.3
Fair	80.0
Good	6.7
Total	100.0

The flow of ventilation system in building shop lots is tabulated in Table 7. The flow of ventilation system could be classified as being poor, fair and good. It might be derived that 13.3 percents of the respondent expressed that the ventilation flow is poor due to restricted opening space. 80 percents of the respondent felt that the ventilation flow is fair whilst a small 6.7 percents of the respondents' said that the ventilation flow is good.

Table 8: Respondent response on building layout

Description/ Scale	Percentage (N=30)
Poor	3.3
Fair	46.7
Good	50.0
Total	100.0

Majority of the occupants are satisfied with the building layout of shop lots as observed in Table 8. A high 46.7 and 50 percents of respondents rated the building layout as fair and good respectively their premises offer a healthy business environment. A very low 3.3 percents of respondent are not satisfied with the building layout and this is probably due to the very small and narrow corridor space which restricted movement.

Table 9: Respondent comment on the overall ventilation system of shop lots

Description/ Scale	Percentage (N=30)
Poor	26.7
Fair	70.0
Good	3.3
Total	100.0

The respondent comment on the overall ventilation system of the building shop lots is shown in Table 9. A relative high 70 percents of the respondent found the overall ventilation system is fairly acceptable in table building shop lots. A relative low 26.7 percents of the respondent otherwise found that the ventilation system is poor due to thermal discomfort and poor building performance.

Table 10: Factors contributing to discomfort in shop lots

Description/ Scale	**Percentage(N=30)**
Building Space	10.0
Area of environment	86.7
Bad lighting condition	3.3
Total	100.0

The major factors causing discomfort in building shop lots is presented in Table 10. There are three types of building discomforts, namely building space, area of environment and bad lighting condition. The area of environmental is the major concern. 88.7 percents of respondent felt that both poor air quality and thermal discomfort are the main cause of the dissatisfaction. Building space is not much a concern as only 10 percents respondent are satisfied with their working area.

Table 11: Respondents comfort levels in building space.

Description/ Scale	**Percentage (N=30)**
Uncomfortable	6.7
Fair	93.3
Total	100.0

From the survey being done on 30 occupants of the shop lot, we know that they encounter level of comfortable in the building. Table 11 shows level of comfortibility in the building space from very uncomfortable to very comfortable. There 93.3 percents of respondent said that the building level of comfortibility is acceptable for them. Being located in famous location of Kuala Lumpur also helps high acceptable level of comfortibility. Next, 6.7 percents of occupants which feel uncomfortable in that situation of shop lot because other causes such as the weather, surrounding environment and other factor that related to the ventilation system.

4.1.2 Inferential Statistics

The statistic data (appendix C) demonstrates that the ventilation system and comfortibility of shop lot building are interrelated. This finding is in good agreement with the reported literature survey of Balocco (2006) quoted from Norhasniza (2009). *"When historic building is refurbished, the indoor climatic condition should be preserved to ensure comfort conditions for people but refurbishment and conservation of buildings with human requirements need different values of indoor parameters"*.

i. Correlation Test

Table 12: The Correlation Ventilation System and Comfortibility

Description	Comfortibility
Level of Air Quality	-.327
Flow of Ventilation	.266
Building Layout	.246
Ventilation System	**.425***
Celsius in	.063
Celsius out	.050
Rh in	.160
Rh out	-.327

* Correlation at 5% significance level

In Table 12, the level of comfortability significantly correlated with ventilation system (Spearman's correlation coefficient 0.425 at 5 percent significant level). The second highest value of comfortibility, which is, 0.266 is with respect to flow of ventilation. The result is in good agreement with ASHRAE Standard (1999), statement who mentioned that the ventilation system effect the comfortable area at the building. Other factors such as building layout, temperature and relative humidity are not significantly correlated with the comfortibility levels. The levels of air quality give a negative comfortibility reading (-0.327). The 5% significance level comfortibility of 0.425 represents the factor of building performance. The ventilation system probably could be improved by

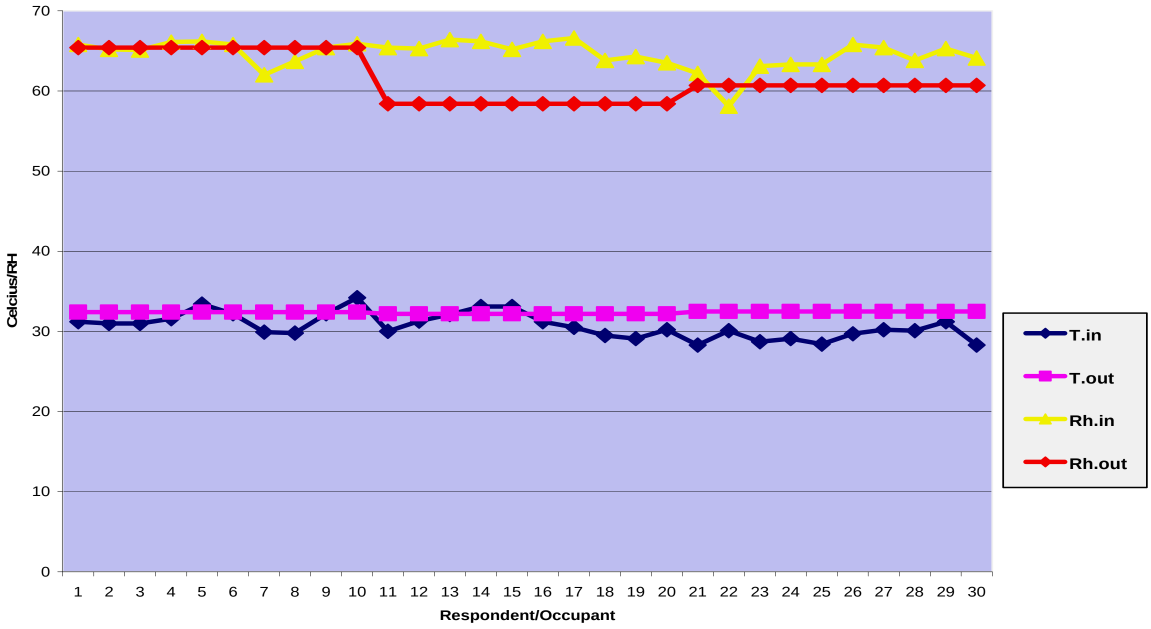
i) Redesigning opening areas of door and windows
ii) Air quality
iii) In and out going air flow and
iv) Introducing mechanical installation such as ceiling fan and air-conditioning.

These improvements enhance longs working hours and thus increase the work productivity. When installed with the additional enhancement in older historical building similar effect of comfortibility may be realized.

ii. Temperature and Relative Humidity

Figure 2 below demonstrates the in and out temperature changes as well as the in and out relative humidity differences. The temperature change is not significant in inside and outside of the building. The average of the in-temperature is 30.7 ^{0}C whilst the average out-temperature is 32.4 ^{0}C, which a difference of only 1.7 ^{0}C. A similar insignificant trod is also observed in the measured relative humidity. The average value of in-humidity is 64.5% whilst the average value of out-humidity is greater then that out-humidity of building (in-humidity > out-humidity).

Figure 2: Temperature and Humidity at Historical Building in Kuala Lumpur



5. CONCLUSION

The following conclusion may be derived from the objectives of the study which were stipulated in in Section introduction are accomplished in the study.

i) To identify indoor and outdoor temperature changes and factor related to theirs changes.

- The average building indoor temperature of Jalan Tuanku Abdul Rahman, Brickfields and Bangsar are 31.7 ^{0}C, 31.0 ^{0}C and 29.4 ^{0}C respectively. The indoor temperature of these building is relatively constant.
- The average building outdoor temperature of Jalan Tuanku Abdul Rahman, Brickfields and Bangsar are 32.4 ^{0}C, 32.2 ^{0}C and 32.5 ^{0}C respectively. The outdoor temperature of these building is very constant.
- The average building indoor relative humidity (RH) of Jalan Tuanku Abdul Rahman, Brickfields and Bangsar are 65.6, 65.3 and 63.4 respectively. The relative humidity of these building is very constant.
- The average building outdoor relative humidity (RH) Jalan TAR 66.4, Brickfield 58.4 and Bangsar 60.7 varies slightly in these areas. This is so because Brickfields and Bangsar are more "greener" than Jalan Tuanku Abdul Rahman (Jln TAR). In Jalan TAR there is more high building, congestion of traffic and over crowdedness.

ii) To analyze environmental issues on ventilation system application and their effect on level of comfort of building users.

- The analyses of ventilation system versus comfortibility exhibit a significant correlation (Spearman rank correlation coefficient at 0.425).

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