Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol 2, No.8, 2012

Evaluation of Indoor Environment Quality (IEQ) of Educational Buildings

Md Azree Othuman Mydin[1*] Norazmawati Md Sani @ Abdul Rahim[2] Mazran Ismail[3]

1. School of Housing, Building and Planning, Universiti Sains Malaysia, 11800, Penang, Malaysia
2. School of Housing, Building and Planning, Universiti Sains Malaysia, 11800, Penang, Malaysia
3. School of Housing, Building and Planning, Universiti Sains Malaysia, 11800, Penang, Malaysia

* E-mail of the corresponding author: azree@usm.my

Abstract

The Green Building Index (GBI) is Malaysia's industry accepted green rating tool for buildings to encourage sustainability in the built environment and hoist consciousness and understanding of these issues along with related stakeholders in the construction industry. The application of GBI has became the benchmark rating system incorporates internationally recognized best practices in environmental design and performance. This paper focuses on the Indoor Environmental Quality of Educational Buildings in Universiti Sains Malaysia (USM). Three libraries in USM were chosen as case studies as the subjected buildings have uniqueness in design and comparison can be made amongst them. The result shows that the level of thermal comfort is not achieved by all of the libraries, as it does not attain the occupants' ideally thermal comfort level. This paper is very useful for future researchers by contributing some important thermal comfort data

Keywords: Green Building Index, Thermal Comfort, Indoor Environment Quality

1. Introduction

Green building becomes a flagship of sustainable development nowadays that carries the responsibility to achieve equilibrium between long term economic, environment, and social health, which relates to the building process that acquires the coordination of several expertise from different disciplines. Green building enhances the concept of energy efficiency in buildings to minimize the impact of human's lifestyle towards mother earth. Green building is a comprehensive process of construction that employs techniques meant to reduce adverse environmental impacts in order to reduce the operational energy consumption of a building (Kibert, 2007).

It is an indispensable element to preserve and conserve the environment. Zane Satterfield (2009) defined green as a practice that is environmentally friendly from building design to landscaping choices. Buildings should meet a certain standard as required in the interpretation of the construction industry. Green buildings have higher standard for the buildings in question by stressing the improvement of overall design (Gowri, 2004). Gowri highlighted the purpose of this category to encourage the reuse of existing and sites, protect land from being overdeveloped, and reduce the adverse environmental impact of new development (Gowri, 2004).

Two different sets of Green Building Indices have been developed for commercial and residential properties. Buildings will be awarded the GBI rating based on six criteria: energy efficiency, indoor environment quality, sustainable site planning and management, material and resources, water efficiency and innovation. 100 points are provided for all criteria. Based on these criteria, commercial buildings are rated on a point-score and can be awarded either GBI Platinum, Gold, Silver or Certified ratings. For the purpose of this study, investigation was carried out at educational building on the erection of libraries in USM's main campus. In this research, experimental tests will be done to prove that the building is applying the concept of GBI

2. Methodology

In order to accomplish building condition survey at this property, a few procedures are followed. First of all, the approvals were obtained from library's authorities to get permission to enter the building to collect data of Indoor Environment Quality. Appropriate instruments have been chosen in the testing for quantitative method. The observation of the relationship between variables and analysis of the data is the prime objective of the quantitative research method. Hence, the researchers can predict, explain and analyze the possible outcome of the research. Microsoft Excel Spreadsheet is the tool used to analyze the data collected.

3. Observation, Results and Data Analysis

Case study was chosen as the method to conduct this research. Testing was performed in Universiti Sains Malaysia's libraries, namely Hamzah Sendut I, II and New. The task of observation such as to determine the temperature, humidity profile, lighting, wind flow and sound of the buildings (to determine how much data obtained complies with the standard requirement of Green Building Index). However, there are limitations due to the assessment of the building space, time and certain geographical location constraints. The testing was carried out using suitable instruments such as; surface thermometer, 3-in-1 humidity, temperature and Airflow Meter (Model 45160); digital sound level meter (Extech 407730) and luxmeter Hanna. A descriptive method will be used to conduct this research project in order to analyze the data collected. Information about the score in a sample can be presented in several ways. The data obtained may be presented in a graph or chart; It is easy to understand what has been found when compare to simply presenting information about the central tendency and dispersion. There are some areas with similar functionality between these 3 selected libraries. Therefore, these libraries are the best example to show the compliance of Indoor Environment Quality (IEQ). Hamzah Sendut I Library was built in year of 1969 with the establishment of Universiti Sains Malaysia that was known as Universiti Pulau Pinang. In the early years of the establishment, it was located at Malayan Teachers' College, Gelugor, Penang. Then, it was moved to a permanent campus in Minden in year of 1971 and situated in a new building in the year of 1979. It was located in the centre of USM main campus and was accessible by all the occupants of the university. On 10th December 2004, the Main Campus Library was officially named as Hamzah Sendut Library after the name of the First Vice-Chancellor of Universiti Sains Malaysia, Tan Sri Hamzah Sendut. Next, Hamzah Sendut II Library has the same history as Hamzah Sendut II Library. However, it started to operate in the year of 1994. It is located near to one of the entrance of USM which is beside Sungai Dua Road. Students and out comers are able to access the building easily with the adequate facilities provided. Finally, Hamzah Sendut New Library is located beside Hamzah Sendut New Library. It was built few years back and is fully utilized now

3.1 Reading Area

Table 1, 2 and 3 demonstrates the data collected which are expressed in the form of tabulation for the 3 buildings.

Table 1. Internal environmental quality of books Reading Area of PHS I

	Reading (Floor Level)			
Element	**1st**	**2nd**	**3rd**	**4th**
Lighting (lux)	222.0	164.0	94.0	160.0
Surface Temperature (°C)	24.5	24.5	24.0	24.3
Temperature (°C)	26.9	26.9	26.9	26.9
Relative Humidity (%)	52.5	51.6	50.9	51.7

Table 2. Internal environmental quality of books Reading Area of PHS II

	Reading (Floor Level)			
Element	**1st**	**2nd**	**3rd**	**4th**
Lighting (lux)	379.0	415.0	463.0	419.0
Surface Temperature (°C)	24.5	25.0	25.0	24.8
Temperature (°C)	30.0	29.7	29.2	29.6
Relative Humidity (%)	50.7	50.6	50.9	50.7

Table 3. Internal environmental quality of books Reading Area of PHS New

	Reading (Floor Level)			
Element	**1st**	**2nd**	**3rd**	**4th**
Lighting (lux)	717.0	855.0	650.0	740.7
Surface Temperature (°C)	24.5	25.5	24.5	24.8
Temperature (°C)	26.6	26.4	26.8	26.6
Relative Humidity (%)	54.8	55.0	54.4	54.7

3.1.1 Lighting

Lighting is one of the controllability systems. The system should provide a high level of lighting control by occupants or groups in a multi-occupant space to enhance the productivity, comfort and well-being of building occupants. Lighting has become an important element. It is not just provided by artificial lighting. To ensure good lighting, glazing is used in the building to give a higher chance to allow the penetration of sunlight into the space. High rise air-conditioned buildings use the single clear glass widely because it is economical.

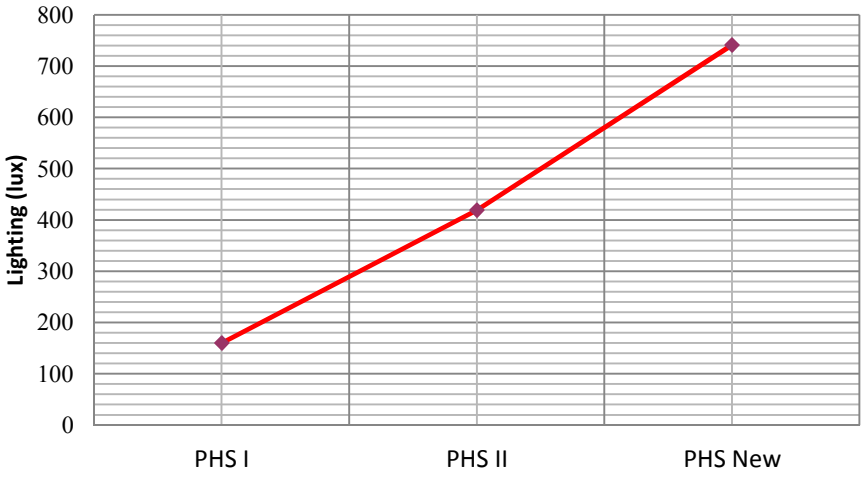

Figure 1. Comparison of the lighting level at reading area between libraries inspected.

Based on Figure 1, it shows that PHS I has the lowest lighting lux in reading area. The moderate lighting is supplied by low penetration of sunlight into the space. The space has been installed with glazing panels on voids to give advance to enhance the lighting in that particular area. However, the reading areas in PHS II and New are both having stronger lighting. According to Lux Light Level Chart [4] as in the Figure 5, area that involves writing and reading is required to have value of lux at 300 or more. The former library has not complied with the requirement. These areas have bigger glazing surface, such as glazing walls. Artificial lighting also installed onto ceiling to provide good illumination for reading and writing.

3.1.2 Thermal Comfort

Conditions for thermal comfort are described in ASHRAE Standard 55-2004 which includes the primary factors of air temperature, radiant temperature, air speed and humidity. Comfort system control for the purposes of this credit is defined as the provision of control over at least one of these primary factors in the occupant's local environment. Control strategies can be developed to expand on the comfort criteria to allow adjustments to suit individual needs and preferences. To achieve thermal comfort in the building, the use of mechanical system is required such as fans and air-conditioning systems, but this will lead to an increase in electrical energy consumption.

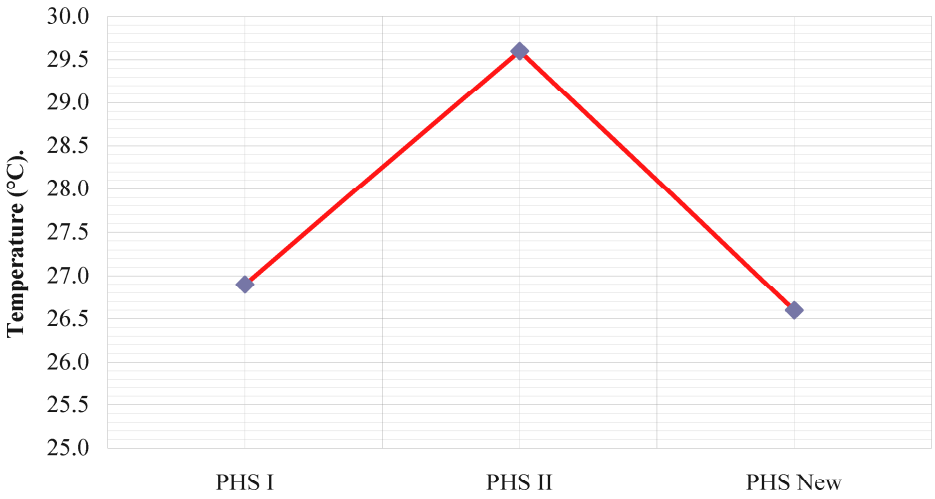

Figure 2. Comparison of the temperature reading at reading area between libraries inspected

Figure 2 above shows the temperature on the first floor. From the chart, it shows that the reading area in PHS II have higher temperature. It is due to the radiation effects from sunlight. Sunlight contains heat that can increase the surface temperature of a building in daytime and release it at night. During the daytime, direct penetration of sunlight into the space has gradually affected the air temperature. Cooling system installed will provide cooling effect after the radiation effect. When thermal equilibrium is reached, the ideal temperature is slightly higher than the original. According to Stefan-Boltzmann Law, it determined the temperature of Sun's surface that the energy flux flow from Sun is 29 times greater than the energy flux density of a warmed metal lamella (1900 °C – 2000 °C estimated by Soret). He deduced 1/3 of the energy flux from the Sun is absorbed by the earth's atmosphere. Hence, Sun's energy flux a value 3/2 times greater, 29 x 3/2 = 43.5. Based on the Radiation Law, it shows that radiation of sunlight influences the temperature of a space.

Heat energy is partially absorbed by the space; the cool atmosphere is needed to produce a change in temperature due to the sun lighting. Net flow of heat energy happened between the occupants, sunlight and cool atmosphere within the space to reach an appropriate thermal comfort. However, reading areas in PHS I and PHS New are having lower temperature. These spaces are installed with air conditioning system.

The cool air circulates the whole space to achieve thermal comfort. It is able to overcome the heat energy transferred from sunlight into the space through radiation as the exposed areas directly to sunlight is smaller than as in PHS II.

Figure 3 shows the comparison of relative humidity among the libraries. All libraries have the approximate reading as in the range of 50% to 55% only. There are three main causes that induce the high relative humidity in a space, namely ventilation issues, air conditioning equipment and building envelope problems (Morse, 2005). These areas are directly exposed to sunlight through the glazing areas. The penetration increases the rate of evaporation of water content in the air by radiation to transfer heat. Ultimately, the water vapor evaporates and the relative humidity decreases.

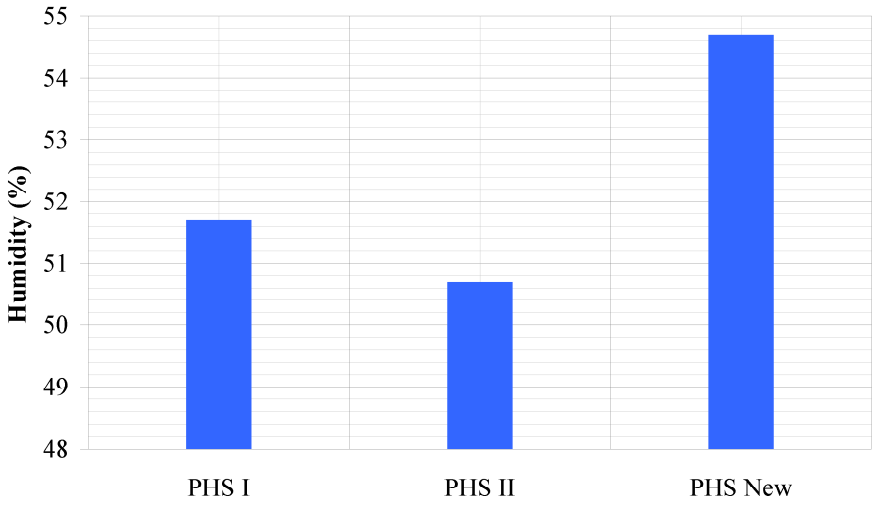

Figure 3. Comparison of the relative humidity at reading area between libraries inspected

3.2. Toilet

Table 4, 5 and 6 shows the data collected which are expressed in the form of tabulation for the 3 buildings.

Table 4: Internal environmental quality of toilet of PHS I

	Reading (Floor Level)			
Element	**1st**	**2nd**	**3rd**	**4th**
Lighting (lux)	101.0	94.0	82.0	92.3
Surface Temperature (°C)	24.0	24.0	24.5	24.2
Temperature (°C)	26.1	26.1	26.1	26.1
Relative Humidity (%)	72.3	72.0	71.6	72.0

Table 5: Internal environmental quality of toilet of PHS II

	Reading (Floor Level)			
Element	**1st**	**2nd**	**3rd**	**4th**
Lighting (lux)	337.0	234.0	315.0	295.3
Surface Temperature (°C)	25.5	25.5	26.0	25.7
Temperature (°C)	28.0	27.9	27.8	27.9
Relative Humidity (%)	58.7	61.2	59.2	59.7

Table 6:Internal environmental quality of toilet of PHS New

Element	Reading (Floor Level)			
	1st	2nd	3rd	4th
Lighting (lux)	233.0	102.0	97.0	144.0
Surface Temperature (°C)	28.0	28.0	28.5	28.2
Temperature (°C)	28.4	28.1	27.7	28.1
Relative Humidity (%)	77.0	72.0	74.0	74.3

3.2.1 Lighting

As can be seen in Figure 4, the toilets of PHS I and PHS New have relatively poor lighting; the artificial lighting is installed onto the suspended ceiling. Compact fluorescent light bulbs were installed along the ceiling panels in PHS I and light bulbs were installed onto the ceiling. The installation is insufficient to improve the lighting system in the toilets. However, the toilet in PHS II is provided with both artificial and natural lighting. The louvered windows are fixed to the window frame. The artificial lighting is achieved by installing a few numbers of fluorescent lights across the space on the ceiling to increase the luminosity of the space.

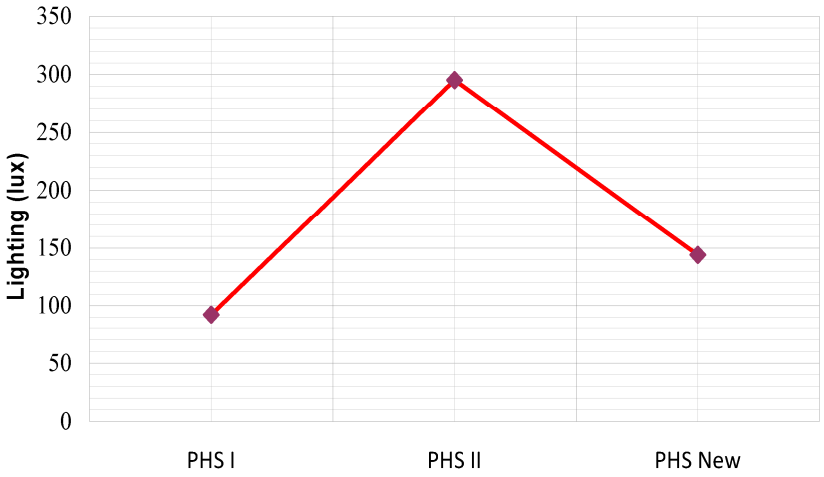

Figure 4. Comparison of the lighting level at toilet area between libraries inspected

3.2.2 Thermal Comfort

The temperature of toilets in PHS II and PHS New are high (Figure 5). The toilet in PHS II has no mechanical ventilating system. It is installed only with few numbers of louvered windows. The louvered windows allow the flow of hot air into the atmosphere outside. However, it is insufficient to reduce the heat trapped in the space. Toilet in PHS New is installed with exhaust fans but they were being turned off during the inspection. Moreover, the penetration of sunlight has increased the temperature of the spaces as it releases heat energy. The heat warms up the air through convection and radiation. Convection happens in the air circulation where the heated air moves up to replace the cool air. The heat transfers to the cool air and the process continues until the air is warmed up. The air circulation shows failure. Hence, the temperature is high. Toilet in PHS I has lower temperature due to high water content which is aided in the cooling system. Furthermore, the cool air from outer spaces is passed into the toilet once the opening is left opened. The air is cooled.

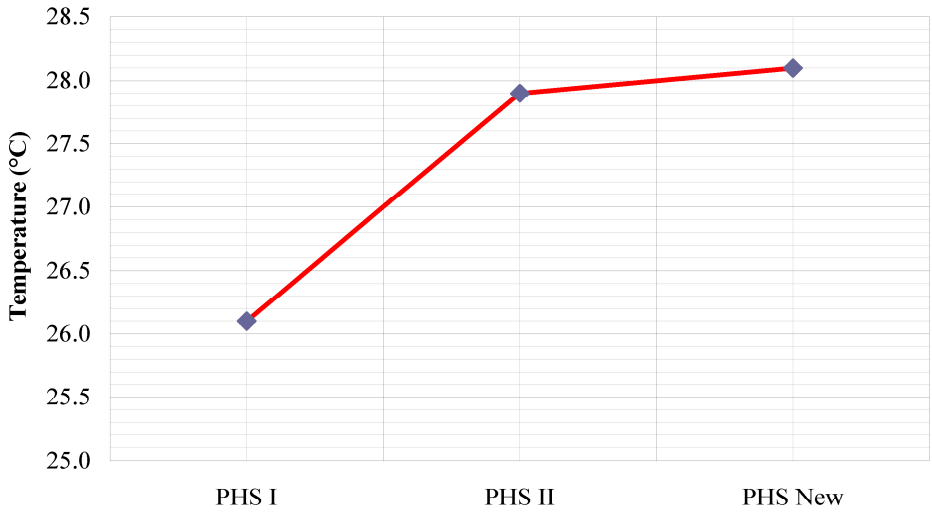

Figure 5. Comparison of the temperature reading at toilet area between libraries inspected

Toilet is an enclosed area but the recorded reading is high due to the water sources in that particular area. The main reason for high humidity of the toilet is due to building envelope (Figure 6). There is no installation of any ventilating equipment such as exhaust fan and the air stays infiltrated within the toilet. The relatively low temperature of the space makes it prone to condensation. According to Bose-Einstein condensate, "Condensation is a state of matter that forms at low temperature…" The cool surface of the space condenses the water content in toilet and increases the humidity level. Plus, the tight enclosed space prevents the escape of moisture from the toilet and reduces the heat loss caused by the poor ventilation. Washing and flushing increase the air moisture and thus increasing the relative humidity.

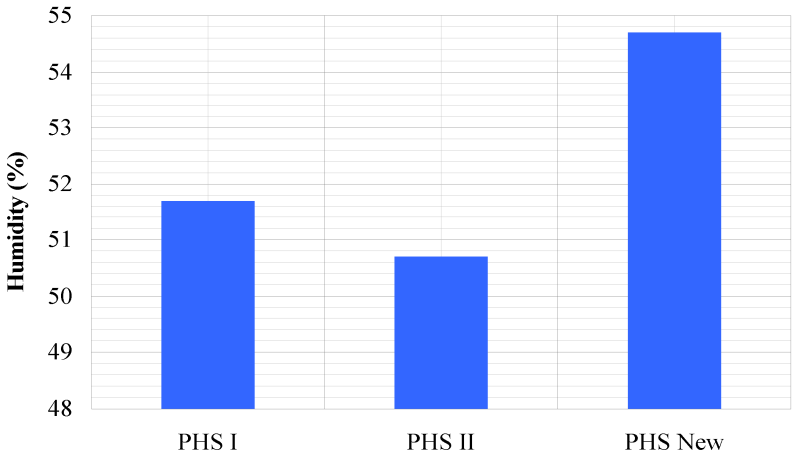

Figure 6. Comparison of the relative humidity at toilet area between libraries inspected

4. Conclusions

This paper has presented the Indoor Environmental Quality (IEQ) of educational buildings, the lighting and thermal comfort that should be achieved by the spaces as in the Green Building Index. From the inspection, it is found that the buildings are not achieving a good level of IEQ especially the PHS I and PHS II. Thermal comfort, lighting and sound decibel are considered as the elements in this research. It is due to the old construction style to concern more on the structure works to support the entire buildings. The concern of green construction was poor at that time. However, all the measurements of temperature, lighting, relative humidity, wind flow and sound decibel had been recorded from PHS I, II and New. Therefore, the IEQ can be considered well in the libraries from the analyses of this paper. The IEQ is generally complied the standard level required by occupancy conformity. The buildings are advisable to be rectified to

achieve a better Indoor Environment Quality for energy saving purpose along the growth of green construction in the world.

Acknowledgement

The authors would like to thank Universiti Sains Malaysia for their financial support.

References

Gowri, K. (2008), "Green building rating systems: An overview, *ASHRAE Journal*, **46**, 56–59

Kibert, C. (2007), "Sustainable Construction: Green Building Design and Delivery" 2nd Edition, New Jersey: John Wiley & Sons, Inc.

IP CCTV (2008), "Specialists use-IP Ltd", Lux Light Level Chart.

Morse, G.G. (2005), "National Institute of Building Sciences, Building Envelope Guide, Indoor Air Quality and Mold Prevention of the Building Envelope in the National Institute of Building Sciences (NIBS)", Whole Building Design Guide.

Satterfield Z. (2009). "Green Building", NESC Engineering Scientist,Winter.