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Comparing Indoor Environmental Quality (IEQ) Factors in UNITEN Offices with the Malaysian Standards

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***Abstract*—** Indoor environmental quality (IEQ) is an important issue which impacts on energy efficiency and also occupant efficiency. Thermal comfort (TC), indoor air quality (IAQ), visual comfort (VC) and aural comfort (AC) are four main physically parameters which are normally used to determine the IEQ. This study compares the IEQ factors in some offices in Universiti Tenaga Nasional (UNITEN) with the Malaysian standards. The results show that except for the air movement, other parameters are approximately in the acceptable ranges of the Malaysian standards.

***Keywords*—** indoor environmental quality; thermal comfort; indoor air quality; visual comfort; aural comfort

I. Introduction

Indoor environmental quality (IEQ) is closely related to the comfort of occupants. Physical parameters of IEQ such as: thermal comfort, acoustic conditions, air quality and also lighting will results in plan decisions and building procedures as well. IEQ effects on occupant productivity [1]. That is why general definitions of green building accentuate employing design and building process strategies aimed at improving IEQ. Civilizing IEQ is essential in all buildings, because the aim of providing a space for healthy and creative occupants should be incorporated in building design. It is mainly significant in green buildings, for the reason that a low-energy building with high resident uneasiness is no more sustainable than a high-energy one. Building occupants are usually worried about their health in indoor environment because in general they spend more time indoors than to outdoors [2].

A major effort has been launched by The United States Green Building Council (USGBC) with the release of the first official structure for ranking green buildings in the United States: Leadership in Energy and Environmental Design (LEED). Water efficiency, materials and resources, energy and atmosphere, sustainable sites, and indoor environmental quality are defined in LEED New Construction (LEED-NC) structure. Measuring of IEQ often looks at four aspects, namely thermal comfort (TC), indoor air quality (IAQ), aural comfort (AC) and visual comfort (VC) [3,4].

A. Thermal comfort

ISO 7730 standard defines thermal comfort as being "that condition of mind which expresses satisfaction with the thermal environment". Also base on ASHRAE Standard 55, success means that a building meets the needs of 80% of the occupants [5]. There are in addition two global standards that are being used apart from ASHRAE standard, i.e. International Organization for Standardization (ISO) 7726, which discusses instruments for measuring physical quantities, and ISO 7730 which uses numerical way to establish comfort level. These values provide detail information about thermal conditions in every building; however they are focusing more on air temperature and humidity. There are six factors which are used in for measuring the thermal comfort:

- Air temperature
- Mean radiant temperature
- Air velocity
- Relative humidity
- Clothing
- Activity levels.

B. Air quality

Indoor air quality (IAQ) is characterized by the focusing on chemicals, particles, and biological particles in the atmosphere and on surfaces immediately nearby the air in a space. It also characterized according to the way which it is professed by occupants, even though these realizations of air quality may not relates directly to the possible health effects resulting from exposure to air**.** Indoor air pollutants directly contact on human physiology. There are a lot of factors which affect IAQ such as: building materials, flooring, wall paint, carpet etc. IAQ is also one of the most important environmental risks for public health according to the report of the United States

Environmental Protection Agency (USEPA) [6]. According to latest researches, it has been suggested that considering and analyzing carbon dioxide (CO_2) can show the acceptability of IAQ and ventilation systems [7-9].

C. Aural comfort

Aural comfort is also recognized as acoustics comfort. Generally, acoustics comfort is related to sound level. Indoor acoustics impose a large impact on the ability of students to concentrate. The ability of students and teachers to communicate with each other will be significantly reduced when background noise becomes excessive and distracting. The level to which background noise affects the ability of a student to learn varies based on age, language proficiency, instances of hearing loss, and individual hearing preferences. Noise can be produced by outdoor an also indoor sources. Outside construction , air planes, traffic, noise of vehicles and so on can be considered as outdoor sources and indoor sources of noise usually come from loud air-condition , ventilation and internal noise from different parts of building.

D. Visual comfort

A good day-lighting will increase productivity. It will be also a factor to reduce energy consumption. In view of lighting accounts for about 20-25% of the full amount energy consumption and even 30-40% in the commercial part, it is simple to realize the enormous potential day-lighting has on the decrease of CO2 and pollutants.

The objective of this research is to compare these four IEQ factors in staff offices in Universiti Tenaga Nasional (UNITEN) with the limits set by the Malaysian standard.

II. Methodology

In this study, objective measurements have been carried out and IEQ factors have been measured and compared with the Malaysia standards [10,11,12]. The field study was conducted in Universiti Tenaga Nasional (UNITEN) Putrajaya Campus, which is located in Jalan Ikram-UNITEN. There are several buildings in this university, and the offices were selected randomly with different size and different sun path for physical measurements. These offices are located in Administration building, College of Engineering (COE), College of Foundation and General studies (CFGS) and library which are shown in Fig 1-5. The field study was carried out for almost two weeks during the month of October 2013 and measurements of each IEQ factors were carried out for 15 minutes. The number of measurements carried out is based on the number of offices in different buildings. Indoor temperature ($^{\circ}C$), relative humidity (%), air velocity (m/s), luminance (LX), sound pressure level (dBA), CO_2 (ppm), particulate (mg/m^3) were measured on the occupants table to analyze the characteristics of IEQ in UNITEN offices. Three devices have been used in this study to measure the IEQ factors. The portable HAZSCANNER™ GB-2000 was used to measure air temperature, air velocity, relative humidity, CO_2 and also particulates. Pro's Kit MT-4008 Sound Level Tester was used for measuring the sound pressure level and the Pro's Kit MT-4007 Light meter was employed to measure the luminance. These equipments are shown in Fig. 6-8.

Fig.1: Universiti Tenaga Nasional (UNITEN)


Fig.2: Administration building

Fig.3: BN Building in COE

Fig.4: library

Fig.5: CFGS

Five offices in different levels of administration building, three offices in different levels of COE, one office in library and one office in CFGS have been considered. The location of the offices and also the number of occupants which are working in each office is demonstrated in Table1. The number of measurement samples is equal to numbers of occupants. The average values of these measurements during 15 minutes period are recorded.

Fig.6: HAZSCANNER™ GB-2000

Fig.7: Pro's Kit MT-4007

III. Results

There are several standards and limits of IEQ factors in the world which show the acceptable range of IEQ. The consequences of IEQ factors measurement in UNITEN offices have been compared with the existing Malaysia standard and limits of indoor environmental quality. Table 2 shows the acceptable range of Malaysia standard and Table 3 shows the average measurement records for each IEQ parameter.

Fig.8: Pro's Kit MT-4008

Table1.
Name and location of offices

Name of office	Building	Level	Number of occupants
OSH	Admin	Ground floor	3
INSPA	Admin	3rd floor	3
HUMAN RESOURCE	Admin	2nd floor	3
FILE RECEIVER ROOM	Admin	2nd floor	1
COGS	Admin	4th floor	3
RESEARCH CENTRE BN-2-043	COE	2nd floor	4
RESEARCH CENTRE BN-2-044	COE	2nd floor	3
LECTURER OFFICE BN-3-	COE	3RD floor	1
LECTURER OFFICE TA-4-221	CFGS	4TH floor	1
REFRENCE AND INFORMATION SERVICE	LIBRARY	Ground floor	2

Fig 9-14 show the results obtained and compared with the Malaysian standards. The graph of temperature in the offices shows that recorded air temperature is in the standard range. The air velocity however, is less than the minimum amount set by the Malaysian standard. The relative humidity is near the limits of Malaysian standards. It can be seen that the amount of carbon dioxide in the reference and information service office of the library and offices in COE buildings are more acceptable than those in the offices of the administration and CFGS buildings. Except for INSPA office in administration building, all offices are placed in accepted range for sound pressure level. INSPA office seems to record a higher measuring due to the noise from the air conditioner. The graph of luminance shows fluctuation in different offices.

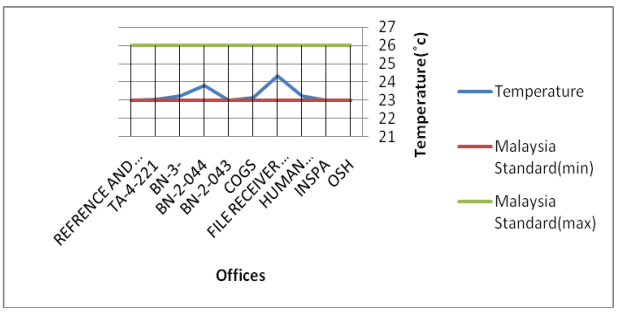

Fig.9: Air temperature in offices

Table2.
Acceptable range for specific physical parameters

Rang of Malaysia standard	Temp (˚c)	Air velocity (m/s)	Humidity (%)	CO_2 (PPM)	Sound pressure level (dBA)	Luminance (LX)
Maximum	26	0.50	70	Below 1000 is acceptable	Below 50 dBA	400
Minimum	23	0.15	40			300

Table3
Average of IEQ factors recorded

Name of office	Temp (˚c)	Air velocity (m/s)	Humidity (%)	CO_2 (PPM)	Sound pressure level (dBA)	Luminance (LX)
OSH	23	0	69	821.5	42.25	235.28
INSPA	23	0.1	71.76	964.2	59.5	341.75
HUMAN RESOURCE	23.25	0.1	68.25	896.9	48.33	199
FILE RECEIVER ROOM	24.35	0	68.8	887.5	34.3	265.85
COGS	23.15	0.1	69.53	766.1	48.5	405.85
RESEARCH CENTRE BN-2-043	23	0.1	75	700	45.55	314
RESEARCH CENTRE BN-2-044	23.8	0.1	65.05	629.7	40.5	509.83
LECTURER OFFICE BN-3-	23.25	0.15	64	830.4	42.5	470.8
LECTURER OFFICE TA-4-221	23.06	0.1	61.18	719.5	40.5	409.25
REFERENCE AND INFORMATION SERVICE	23	0.1	59	501.4	34.5	409.5

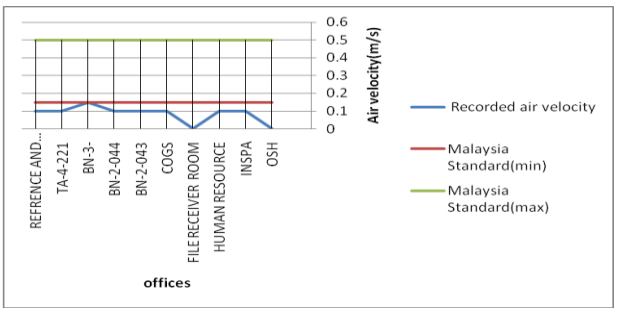

Fig.10: Air velocity in offices

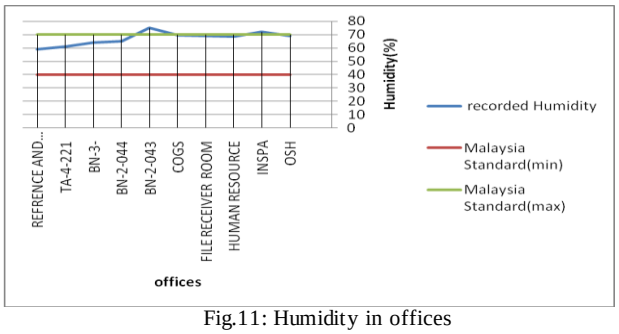

Fig.11: Humidity in offices

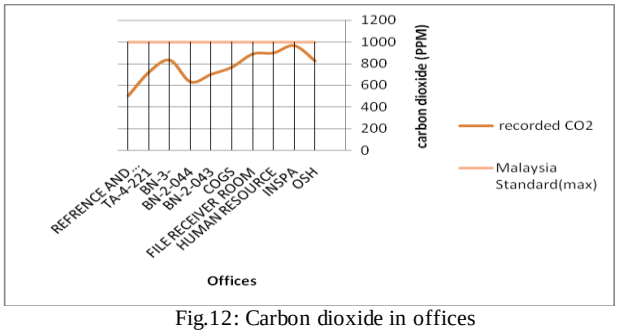

Fig.12: Carbon dioxide in offices

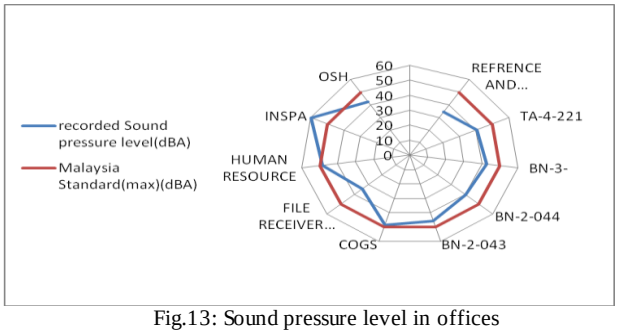

Fig.13: Sound pressure level in offices

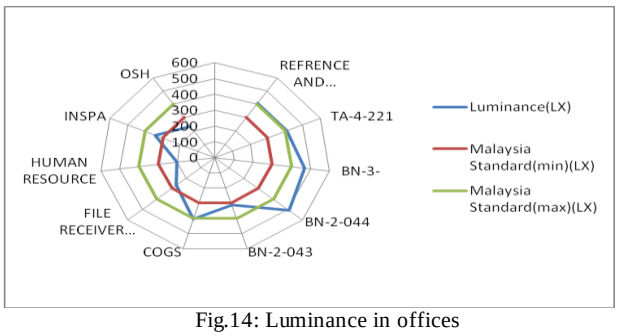

Fig.14: Luminance in offices

IV. Conclusion

In this study, field measurements on indoor environmental quality were conducted for offices in Universiti Tenaga Nasional. The results obtained were compared with the Malaysian standard. Within the scope of this research the conclusions below can be made:

1. Air temperature, humidity and carbon dioxide are in the acceptable range of the Malaysian standards. Luminance and sound pressure are somewhat acceptable and air velocity is lower than the acceptable limitations
2. For CO_2 readings of indoor air quality(IAQ), the amount is more acceptable in the library and COE offices, when compared to the results obtained for administration and CFGS offices.
3. Luminance and sound pressure has to be controlled in some offices which are out of the Malaysian standard limits.

V. Acknowledgment

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