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Evaluation of Indoor Environmental Quality (IEQ) on dense Academic Building: Case Studies Universiti Tun Hussein Onn Malaysia

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Abstract- Indoor environmental quality (IEQ) is a key component in the evaluation for meeting the concept of green building that the aims towards sustainable development. Imbalance of IEQ contributes to sick building syndrome (SBS). The study focused on identifying the framework in the evaluation of IEQ in the context of academic buildings at institutions of higher education. The investigations include two factors; the level of IEQ and the level of users' satisfaction in the academic buildings. Survey and on site scientific measurement approaches have been carried out for data collection. The data then analyze using Statistical Package for Social Science (SPSS). Experimental studies on the academic building focused on a propose IEQ evaluation framework based on four main elements IEQ; thermal (temperature and humidity) and noise comfort, indoor air quality (air movement CO2 concentration) and lighting. Experimental results obtain are compared with Malaysia Standard MS 1525:2007. The results showed that the element of temperature, air movement and the CO2 concentration are at accepted level. Meanwhile the elements of relative humidity, sound and lighting are below prescribed standards. The framework that has been developed as the measurement model can be used in the evaluation of indoor environmental quality (IEQ) at any academic building in Malaysia.

Index Terms- Indoor Environmental Quality, measurement framework, sick building syndrome, academic buildings.

I. INTRODUCTION

Indoor environmental quality (IEQ) is rarely considered as a priority in most development planning and management. IEQ elements account for 21% of green building evaluation criteria for non-residential building such as academic buildings in higher education intuitions [1]. An imbalance of IEQ can also give negative impact to facilities, building and occupants. Many factors contribute to the IEQ. It is not limited for air pollution, thermal conditions, humidity, sound, lighting and odor, but also includes the use of energy, design, and natural ventilation [4].

Imbalance of IEQ contributes to sick building syndrome when, a building unable to function well in terms of ventilation, relative humidity, and so on. This contributes to the health quality of occupant and the case of academic building will affect the teaching and learning process [5]. Thus, the study of IEQ on dense academic building institutions is important to look at how far the levels of the IEQ [2]. It also found that indoor environmental quality not only concern air pollution, but also involve other factors such as comfort, noise, lighting, ergonomic stress and pressure of workers [2].

Thermal comfort is closely related to temperature and humidity, whereas indoor air quality (IAQ) considers volatile organic compound (VOC) and air speed. The presence of VOC such as CO_2, CO or biological impurities is also a main factor that influences IAQ [3]. Therefore, an effective ventilation system and proper maintenance of heating, ventilation and air conditioning equipment are factors that can improve IAQ [6]. Noise Comfort closely related to the ability of buildings to reduce or remove excessive noise from the outside and reduce the noise level within and occupied space or room. Lighting is an effort to maximize the lighting during dark while minimizing glare and heat. The arrangement of space the use of wall color, materials used in furniture and any other equipment is in a space is also part of the factors that may influence the IEQ [8].

Sick Building Syndrome is a broad definition that includes a variety of symptoms considered to be experienced when the occupants spent time in a particular building. A building can be categorized as a sick building when more than 30 % occupants have complained of related symptoms [9]. In this particular study, the IEQ of academic buildings of Universiti Tun Hussein Onn Malaysia (UTHM) is evaluated. The campus is located in a mixed development area which includes a long established industrial area. The study is important as it will reflect the quality and health of building occupants which may directly give impact to teaching and learning,

Objectives of the research are to identify framework for to evaluate the IEQ, secondly is to evaluate the quality of indoor environment (IEQ) based on users perception UTHM academic building and lastly to measure the level of IEQ UTHM campus buildings. Scope for This study only focused on G3 Lecture Complex.

II. RESEARCH METHODOLOGY

This study involved the three research questions. Firstly, what is IEQ measurement framework in the evaluating of IEQ in academic building, secondly, what are the perception of IEQ the main users on G3 complex on IEQ, lastly, what are the level of IEQ of the academic buildings. The main purpose of this research is find out problem issue in this matter.

The study

The main campus of Universiti Tun Hussein Onn Malaysia is located in a mixed development Parit Raja, Johor. Less than 1 km from the main campus is an industrial park, business centre and residential area. The study focuses on the main academic complex of UTHM known as G3lecture complex. This is the largest complex for teaching and learning, and is used by all faculties of the university.

Method of Study

The methodology of the study involves scientific measurement, questionnaire and references. In the scientific measurement process, three levels of the process were used to obtain high quality data to be applied as evidence and support in to strengthen the arguments and views related to this study. Firstly, Preliminary investigation, where initial the observation was done in getting the whole idea of G3 lectures complex design. In this case, the whole environment in a building space was identified for used when making advanced search later. Then, that the relevant building plans such as electrical and mechanical plans, and structure building, that gives some understanding of the technical procedures such as ventilation, lighting and other element that were studied. Scientific measurement was performed using special equipment to test the variables that have been determined. . All data collected were recorded and analyzed.

For questionnaire development, it is involves two types of data, namely primary and secondary data collections. Primary data collection involves survey forms to distribute to the respondents. Questionnaire has been developed based on research objectives to collect research data. Secondary data is data collection from various sources such as reference books, journals, articles, internet, newspaper reports and all sources of publications. Its purpose is to strengthen the validity of the primary data and to achieve the objectives of the study. After all the data were obtained, the data were analyzed using quantitative methods. A program *Statistical Package for Social Science (SPSS)* was used in the analysis of the data.

III. RESULT AND DISCUSSION

a) Measurement Framework

Analytical method for the first objective is to identify the IEQ measurement framework for university academic building though reference from literature. The main references based on Department of Standards Malaysia, Ministry of Science, Technology and Innovation and Code of Practice for Energy Efficiency and Renewable Energy Consumption for non-residential buildings (MS1525: 2007). In the evaluation of IEQ for non-residential buildings, four elements have been chose to become the framework of IEQ evaluation.

i) Thermal comfort

Thermal comfort divides to two main elements. The elements are temperature and relative humidity. For Non-residential building, the indoor temperature must be within a 23 °C-26 °C. Relative humidity level building set between 55% - 70% [7].

ii) Lighting

Lighting intensity level for classroom or teaching and learning process should at level 300-500 lux [7].

iii) Noise Comfort

For buildings used for educational purpose proposed noise level of comfort within 50-70 dB [5].

iv) Indoor Air Quality (IAQ)

Two basic elements of a measurement of indoor air quality (IAQ) are VOC and air speed. For VOC the main elements considers for classroom is concentration of carbon dioxide (CO_2) set at a level below 1.000 ppm. Meanwhile the air movement in a space between 0:15 to 0:50 meters per second (m/s) [7].

b) Evaluation UTHM user perception on the level of indoor environmental quality (IEQ)

The method of achieving this objective was to gauge the perception and opinion of the main users academic building UTHM (students and academic staff). In order to analyze perception of the IEQ element at UTHM, 370 respondents have been selected to answer the questionnaire. 55 % are women while then remaining is male.

Perception of Temperature, 35 respondents (9.5%) indicated that the temperature is very cold, 135 people (36.5%) were cold, 115 (31.1%) said medium, 60 people (16.2%) stated that summer, 18 people (4.9 %) sais very hot and 7 people (1.9 %) said they were not sure.

About Perception of humidity, a total of 5 (1.4 %) of respondents expressed very low, 23 (6.2%) respondents said low, 209 (56.4%) of respondents expressed moderate, 78 respondents o (21.1%) said high, 21(5.7%) of respondents expressed very high and 34 respondents (9.2%) said they were not sure.

Perception of respondents on light intensity11 (3%) respondent said the intensity of light in very dim, 85 (23%) respondent stated that dim, 166 (44.9%) people expressed modest 99 people (26.8%) said brightly, 7 people(1.9%) said very bright and 2 (0.5%) respondent are not sure with the level of light intensity.

Perception of respondents on noise comfort A total of 10 (2.7%) person said it was very noisy, 50 (13.5%) people or stated that noise, 276 people (74.6%) state modest, 29 people (7.8%) said quietly, one people (0.3%) said very quietly and 4 respondent (1.1%) said they were not sure.

Perception respondents on indoor air quality (IAQ) have been found. 6 people (1.6%) mention very good, 63 people (17 %) said good, 153 people (41.4%) said modest state, 115 respondent (31.1%) state poor, 29 people (7.8%) were very poor and 4 people (1.1%) were unsure .

The respondents view on the overall IEQ level of academic buildings UTHM.

Of the 370 total respondents, 9 (2.4%) people said very good, 77 people(20.8%) said good, 166 people (44.9%) state

average, 88 people (23.8%) were good, 30 people (8.1%) state very poor state.

The respondent's opinion on effect IEQ to the teaching and learning process.

For this part, 330 (89%) people from 370 respondents said Yes, 29 (8%) persons indicated no effect and a total of 11 (3%) respondent said they were not sure.

Opinion of respondents on the influence of IEQ to the health impact of the respondents

For this question, 292 (79%) persons indicated yes, 49 (13%) people expressed no and 30 (8%) people express uncertain.

Findings and recommendations

Respondents' views and suggestions for improvement efforts for improved IEQ, 124 persons (33.5%) give their views and proposals relating to maintenance. 48 people (13%) stated that it is related to green technology, 25 people (6.8%) give a control relating to consumer behavior in class, 107 people (28.9%) give depictions of the industrial area located next to UTHM, 31 people (8.4%) give a related layout in the classroom. The remaining 35 persons (9.5%) did not express any opinion.

c) Measurement of indoor Environmental Quality (IEQ) of University.

Measurement has been made in a few selected classrooms, lecture halls and academic multimedia laboratory in G3lecture complex. Measurements were made during the process of learning and teaching to obtain a more accurate reading. Each element of measurement readings was taken five times to get an average reading.

Overall average temperature reading in G3lecture complex was 23ºC. This means that the indoor temperature G3 academic buildings are in good condition as the standards set between 23-27 ºC. The total average relative humidity reading of G3 lecture complex is 73 %, which is higher than the standards set by between 55-70%.While reading the entire G3 lecture complex sound intensity is at 76.4 decibels (dB). This means that sound comfort in bad condition because decibels beyond the prescribed limit of 50-70 decibels (dB). For lighting, the average reading level is 251 lux intensity. This reading indicates a slightly low level of light intensity because, for lighting the standards set are between 300-500 lux. The average reading level of air movement in G3 lecture complex was at a speed of 0.4 meters per second (m/s). Standard set between 0.15 to 0.50 meters per second (m/s). The average reading level of carbon dioxide (CO_2) concentration in the atmosphere is 513ppm *(part per million).* This means that it is in good condition because the concentration of CO_2 in air must be below 1000 ppm reading.

IV. CONCLUSION AND RECOMMENDATION

Based on data obtained from the measurement process in the field study, it can be concluded on overall the quality of indoor environment (IEQ) in the Academic Building UTHM are to be below the prescribed standard. For example, reading for lighting element of 251 lux is below the average standard lighting recommended for learning space 300 lux. Similarly, the sound intensity readings show readings of 76.4 decibels (dB) exceeds the standard set of 50-70 decibels (dB). The other elements measured have shown satisfactory level as compared against the recommended standard.

REFERENCES

[1] GBI organization, *www.greenbuildingindex.com*
[2] http://www.cdc.gov/niosh/topics/indoorenv/
[3] Edwin HW Chan, KS Lam, WS Wong, Evaluation on indoor environment quality of dense urban residential buildings.
[4] Aliffadillah bin Jaffar, The impact of the environmental indoor residential-industrial Neighbourhood industrial estate at Paka Terengganu
[5] UNESCO: 1983, Quality of Life: Problems of Evaluation and Measurement (UNESCO, Paris).
[6] http :/ / www.epa.gov / ebtpages / airindoorairpollusickbuildingsyndrome.html
[7] Malaysia Standard: Code Of Practice On Use Of Energy Efficiency And Renewable Energy For Non-Residental Buildings (First Revision) MS 1525:2007
[8] Mustafa Kamal Bin Mohd. Shariff, 2001 Building environmentally friendly. Article Green Era part 4
[9] Mohammad Zainal Md Yusof, 2011 "Getting to Know Our Buildings Better: Ventilation, Thermal Comfort, Air Freshness, Indoor Air Quality (IAQ), Sick Building Syndrome (SBS).

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Table 1.1: Summary of Standard Elements IEQ measurements

IEQ measurement element	Reading set
Temperature	23-26 ° C
Relative humidity	55-70%
Sound	50-70 dB
Light	300-500 lux
Air movement	0:15 to 0:50 m / s
Concentration of CO_2	Below 1000 ppm

Table 1.2: Perception of respondents on temperature

Perception of temperature	Frequency	Percent
Very cool	35	9.5
Cold	135	36.5
Simple	115	31.1
Hot	60	16.2
Very hot	18	4.9
Not sure	7	1.9
Total	370	100

Table 1.3: Perception of respondents on humidity

Level of humidity	Frequency	Percent
Very Low	5	1.4
Low	23	6.2
Simple	209	56.4
High	78	21.1
Very high	21	5.7
Not sure	34	9.2
Total	370	100

Table 1.4: Perception of Light

level of lighting	Frequency	Percent
Very dim	11	3.0
Dim	85	23.0
Simple	166	44.9
Bright	99	26.8
Very bright	7	1.9
Not sure	2	0.5
A mount	370	100

Table 1.5: Perception of Sound

The sound level	Frequency	Percent
Very noisy	10	2.7
Noise	50	13.5
Simple	276	74.6
Silent	29	7.8
Very quiet	1	0.3
Not sure	4	1.1
Total	370	100

Table 1.6: Perception of ventilation

Level of ventilation	Frequency	Percent
Very good	7	1.9
Good	94	25.4
Simple	177	47.8
Less well	80	21.6
Very bad	9	2.4
Not sure	3	0.8
Total	370	100

Table 1.7: Results of IEQ measurements in G3 lecture complex

room	temperature	Relative humidity	Sound level (DB)	Lighting lux	Air movement	CO2 concentration
E4	24	66	73.3	277	0.3	442
E3	26	68	73.5	289	0.3	489
E2	24	71	75.9	281	0.7	424
E1	24	73	75.1	251	0.4	515
Hall F4	23	80	83.1	202	0.8	804
M.Multi media 1	20	74	75.1	212	0.3	528
M.Multi media 2	22	77	71.0	220	0.4	388
B10	23	67	74.4	257	0.5	517
B6	23	77	86.5	266	0.3	514
AVERAGE	**23**	**73**	**76.4**	**251**	**0.4**	**513**