Sustainability in Energy and Buildings: Research Advances:
Vol 3: Sustainability in Energy and Buildings (SEB-14) Short Papers pp.64-69 : seb14s-025

Effects of Air-Conditioning System on the Building Occupants' Work Performance

Norhidayah Md Ulang, Faizal Baharum and Shahril Nizam Ismail

Building Technology Department, School of Housing, Building and Planning, Universiti Sains Malaysia, Penang, MALAYSIA

Most of the office building offices in Malaysia are equipped with adequate air conditioning system. It is necessary to maintain the right temperature and humidity in the buildings. Malaysian climate which is warm and humid throughout the year would indirectly impact the internal condition of an office thus giving either positive or negative impact on workers' productivity. This research was conducted in the selected offices north of Malaysia which is in Kedah Darul Aman to determine the relation between the building internal temperature and the level of workers' performance at the offices. Hypothetically, the right temperature set in the air conditioning system not only saves cost for electric bills but also increase workers' performance. This paper presents the first part of the data collection. At the end of this stage, it was found that, the better performance of the air conditioning system would positively influence their work performance and there is better chance to save electric usage cost for air conditioners.

1 Introduction

Offices in Malaysia must provide clean, cost effective and comfortable environment along with good indoor air quality (IAQ) to ensure the employees' optimum health condition to carry out tasks in them. This is vital because their health condition inevitably affects their performance at work and it will affect the organization performance [1]. The modern air conditioning system is now as part of our everyday life. Air conditioned working area in an office is much comfier than offices without air conditioner. Room comfort condition is dependent on various factors including air temperature, mean radiant temperature, humidity, clothing, metabolic rate and air movement preference of the occupant. Malaysian Standard 1525 recommends that the indoor design conditions of an air-conditioned space for non-residential, buildings comfort cooling should be between 22 ºC – 27 °C. This research was carried out by three objectives, namely, to analyse air conditioning system in the selected offices, to analyse the occupants' satisfaction of the air conditioning system as well as to recommendation for better air-conditioning system. This paper only presents the findings from initial stage data collection which mainly focuses on the occupants' satisfaction of the air conditioning system in their offices. This study was carried out based on literature review and questionnaire survey. Subsequently, data collection of the questionnaire survey being analyzed using the statistical methods. This includes the selection of sampling methods, data collection and data analysis. The methods of analysis used is

ISSN 2054-3743 : http://nimbusvault.net/publications/koala/sebra

the average index, percentage, and frequency analysis. The results are interpreted in descriptive forms of graphical presentation such as graph, pie charts and histogram.

2 Problem statements

There are many factors that will influence the individual to do something effectively. Comfort problems related to thermal comfort may be the dominant influence on the individual's work performance. In Malaysia, air conditioning systems are installed in offices to create a comfortable thermal environment for the building occupants to have a comfortable working environment thus perform better at work and become more productive. However, in many cases, the installation of air conditioning system not taking into account the possibilities of improper temperature settings would result in uncomfortable working conditions and further reduce the workers' performance. According to Ismail [2], too high temperature in the workplace, especially indoor office, will be uncomfortable for workers, who would easily get drowsy. This condition requires temperature setting to be suitable so as not to interfere the workers' focus and comfort.

3 Results and Analysis

This study was carried out in six offices in one of the states in north of Malaysia which is Kedah Darul Aman. Measurements have been made related to the radiant temperature, dry bulk, wet bulk, humidity and air movement. The measurement data were collected using specific tools such as Extech 3-in-1 Thermohydrometer, Surface Thermometer and Sling Psychometric. The readings were taken during working hours from 8 am to 5 pm, at three different set points at every hour. Table 1 shows the list of the selected offices with the number of air conditioners in the building.

ITEM	BUILDING	TYPES OF AIR CONDITIONING	UNIT
1	HB Construction Sdn Bhd	Ascon Wall Mounted , Model , AWM 15 / ALC 15C, Cooling Capacity : 13000 Btu/h	4 units
2	Bernas Rice Mill (Bukit Raya)	Acson Ceiling mounted series, Model ACM 20D / ALC 20, Cooling Capacity : 20000 Btu/h.	4 units
3	PTPTN building (Alor Star)	Air-Cooled Rooftop Packaged Cooling Capacity: 59,000 Btu/h.	1 unit
4	Pendang Land Office	Topaire Ceiling split air conditioner, Cooling capacity : : 26000 Btu/h	7 units
5	Pendang District Office	Ceiling Mounted D Series Model: ACM 40D / ALC 40C Cooling Capacity: 40000 Btu/h	8 units
6	Kedah Public Works Department	Air Handling Unit	1 unit

Table 1 List of selected offices with the number of air conditioner in each building.

Generally average temperatures of the offices within the range of 23° C - 27 °C. It complies with the minimum qualifications prescribed by the efficiency Malaysia Standard (MS 1525:2007) “Code of Practice on Energy Efficiency and Renewable Energy for Non-Residential Building” which is within the range of 22° C - 27 ° C. During the measurement of the temperature, it was found that HB Construction Sdn Bhd showed temperature above 30° C. This is due to a broken air conditioner as it was not well maintained. On the other hand, the other buildings’ temperatures are between 26-27° C.

ITEM	Frequency					Total	Average index
	1	2	3	4	5		
The level of thermal comfort in the office	0	42	55	47	0	144	3.53
The noise level of the air conditioning system in the office.	0	0	17	73	54	144	4.56
The level fresh air, air movement and comfort ventilation in the office	0	0	28	75	29	144	4.03

Table 2 Respondents' feedback on the level of satisfaction of air conditioning performance in their office

The questionnaire assesed the level of thermal comfort, noise and the freshness of air, air movement and ventilation comfort as shown in table 2. The results showed that 47 respondents were satisfied with the level of

thermal comfort in the office, 55 were less satisfied and 42 were dissatisfied. 73 out of 144 of the respondents were satisfied with the noise level of the air conditioning system in the office. Followed by 17 people less satisfied and there are 54 people who are very satisfied with this aspect. The overall respondents feel satisfied with the sound level in the air conditioning system and the system operates very well without any problems that interfere with work occupant. Air conditioning system works very well and does not interfere occupant in the office building. In regards to the air freshness, air movement and ventilation comfort in the office building, 75 of the respondents were satisfied while the other 29 of respondents was very satisfied ventilation in offices and 28 of respondents are dissatisfied, It explains that the average index of the level of thermal comfort in the office is only 4.03 which shows respondents were satisfied with the condition of the ventilation comfort in their offices. Although some of the offices only have one ventilation fan installed on the wall, but it is sufficient to provide comfort and ventilation to the building occupants, especially in the compacted office spaces and have many workers in that area at the same time.

4 Discussion of Findings

The first part of the questionnair shows that the air conditioning in the building works efficiently and comply with the standard requirements except for one office that has a problem with its air conditioner. The later parts of the questionnaire was looking for the other factors that would affect the building performance in terms of air conditioning system as well as investigating whether the workers in those buildings were able to carry out their tasks while sitting at their desk such as doing calculation, writing, typing, reading and so on. As shown in Figure 1, the respondents were assessed on their satisfaction of the performance of the existing air conditioning system as well as whether the existing air conditioners need improvement.

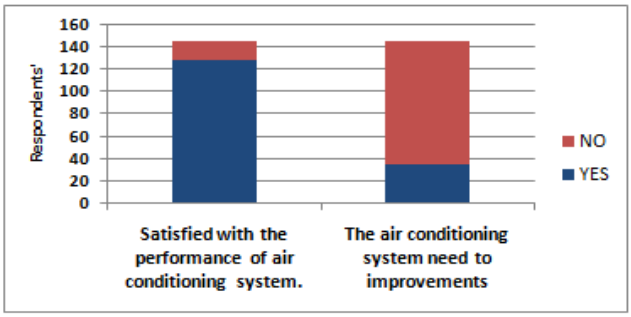

Figure 1Respondents' feedback on the of performance of air conditioning system

When the respondents were asked whether the utilization of air conditioning systems in office buildings helps to ensure ventilation and comfort during working hours, majority of respondents said yes, which about 86.2% of total respondents. The respondents agree that their office environment dramatically improved thus improve their willingness to be more productive. The other 13.8% of the respondents not agree that their office environment improves with the utilization of air conditioning system. For them the air conditioning system does not effect their willingness to be more productive rather the other factors are more crucial such as salaries, bonuses and other monetary incentives. Looking at whether the air conditioning system in the offices need improvement or otherwise, majority of the repsondents are happy with the current air conditioning system thus there is no need for improvement. However, a small number of respondents think that the air conditioning in their offices need improvement in order to be more effective thus provide more comfortable working environment.

The questionnaire given to the workers from the six selected offices were also looking at their level of satisfaction when the carrying out basic office activities such as calculation, writing, typing, reading and so on. Table 3 shows the results of the ability of the workers to carry out the said tasks in the current building condition. On the other hand, Figure 2 shows the comparison of the level of satisfaction among the main groups of basic office activities.

ITEM	Frequency					Total	Average index
	1	2	3	4	5		
Doing the calculation work, writing and typing during working hours	0	9	82	28	18	144	3.65
The simple quick reaction in the execution work during the office hours	0	13	71	41	19	144	3.89
Reading and focus while the office hours.	0	3	67	51	23	144	4.07

Table 3 Results of satisfaction level of current building condition to carry out basic office activities.

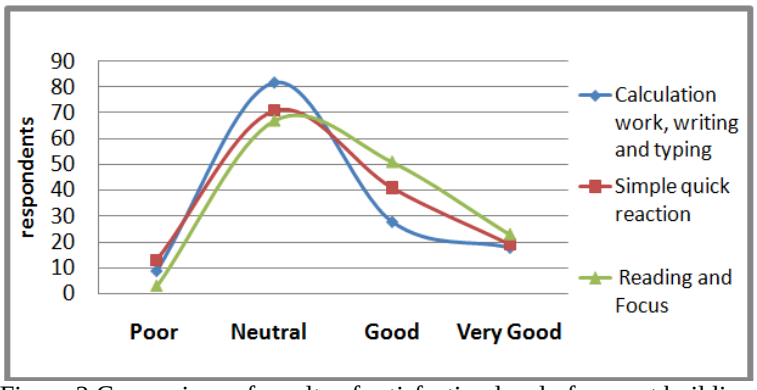

Figure 2 Comparison of results of satisfaction level of current building condition to carry out basic office activities.

Based onTable 3 and Figure 2, it shows that the most of the respondents were responding variously. Major of the respondents felt that they work effectively under the current building condition, as can be seen that the index is 3.65 for doing the calculation, writing and typing. The index of 3.89 for simple quick reaction of execution of work during the office hours shows the neutral satisfaction level as well as for the reading and to focus while doing the work in the office which shows index of 4.07. In general, very few felt that it is impossible to work efficiently with the currect building condition and the others find that the current building condition is optimum for them to carry out basic tasks in the offices due to the comfort produced by the utilization of the current air conditining system.

5 Conclusion

It can be concluded that to achieved the occupants' satisfaction at workplace, there are several aspects that need to be highlighted. It is not only the aspects of air conditioning systems but also other criteria such as comfortable ventilation and a better environment in the office building. Temperature is the most important factor in determining occupant satisfaction in an office building. This study shows that the effects of air conditioning for temperature variables can impact directly on productivity and the level of user satisfaction.

6 Reference

1 Cheong, K. W., & Chong, K. Y. (2001). "Development and application of an indoor air quality audit to an air-conditioned building in Singapore". *Building and Environment.*

2 Ismail, M.F., (2010) "*Benchmark Study of Efficiency for Air-Conditioning System"*. Mechanical Engineering Branch, Public Work Department of Malaysia: Kuala Lumpur.