Thermal Comfort in Enclosed Lift Lobby of a Tropical Educational Institution

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Abstract

The enclosed lift lobby is categorized as unique building transitional space. This paper reports on an evaluation of thermal comfort conditions in a prominent building transitional space – the enclosed lift lobby of an educational institution in Malaysia, using a field survey which included objective measurement and subjective assessment. The temperature set-point of an air conditioner was increased to investigate human thermal perception in the enclosed region. Comparison was made on the percentage of thermal sensation, preference, acceptability, general comfort and effect on work productivity obtained from the field survey. The outcomes clearly indicate that human thermal perception in the enclosed lift lobby is directly proportional to the level of human occupancy, and sudden temperature change may lead to thermal discomfort of occupants. The respondents generally prefer a cooler rather than warmer environment. Also, a comfortable temperature can be obtained even with higher thermostats settings. These findings may serve as a guideline for building operators in the tropics to control the energy consumption of cooling equipment attached to enclosed lift lobbies.

Keywords: Transitional spaces, Enclosed lift lobby, Thermal comfort, Educational institution, Tropics

1. Introduction

Transitional spaces are defined as the architectural area situated between outdoor and indoor environments, acting as buffer spaces. Some examples are lift lobby, foyer, passageway as well as other ancillary spaces not directly occupied by occupants in relation to activity of buildings (Chun et al., 2004, Pitts & Saleh, 2007). They are referred as the parts of buildings where there are close links to the external environment. Conditions in such areas may be perceived differently compared to commonly occupied rooms (Pitts et al., 2008). In hot and humid climates typically found in Malaysia, it is not uncommon to identify the operation of air conditioners in the transitional zones. For facilities including air conditioning and mechanical ventilation systems, operation of these systems contributes notably to the energy consumption of the buildings (Mathews et al, 2001, Wijewardane & Jayasinghe, 2008). In most buildings, the cooling equipment consumes 30 to 60% of the total energy consumption and has the largest energy saving potential (Lam et al., 2003, Feriadi & Wong, 2004). Recently, some thermal comfort researchers directed their attention to the transitional spaces, as current thermal comfort standards such as ASHRAE Standard and ISO 7730 do not distinctly specify the thermal comfort requirements in the transitional spaces (Chun et al., 2004), and have not been applied extensively to such spaces. Due to that reason, it is crucial to investigate the thermal comfort in transitional spaces as these areas are commonly encountered in daily life (Hwang et al., 2008). This paper attempts to evaluate the occupants' perception of thermal comfort at an enclosed lift lobby of an educational institution in Malaysia by applying a field survey which covered objective measurement and subjective assessment with controlled temperature setting. Comparison of thermal perceptions, general comfort and effect on work productivity are made in this study. The objective measurements were confined to air temperature, relative humidity and air flow rate only. As for subjective assessment, questionnaires which consisted of thermal comfort related questions were presented to the test subjects and the outcomes gathered and analyzed concurrently with the objective measurements. The predicted mean vote (PMV) index, predicted percentage dissatisfied (PPD) index and comfortable temperature were calculated and compared to the results from subjective assessment of thermal comfort in the enclosed region.

2. Features of Enclosed Lift Lobby

The enclosed lift lobby distinguishes itself as a unique form of region categorized under building transitional spaces and available in various architectural designs. Most commonly a lift lobby is known as the place where people assemble and wait for the arrival of elevators. In some cases, this region may have several features that are similar to commonly occupied spaces in a building. Activities such as setting up of sales and promotion counters, meeting points, etc., are occasionally performed in the buildings' lift lobby. Figure 1 shows the enclosed lift lobby found in a tropical educational institution. The enclosed-type of lift lobbies in buildings are classified as protected or non-protected forms according to local fire protection specifications (UBBL, 1984). In some building designs, it is not directly linked to the external environment. Figure 2 illustrates an enclosed lift lobby which is built between indoor and external environment, and Figure 3 shows a lift lobby bounded within an interior environment. Both type of lift lobbies share similar requirements in cooling, where the thermal environment in such areas should be controlled by mechanical means. Cooling via natural ventilation is desirable in some transitional spaces (MS 1525: 2007), however it is impractical for enclosed lift lobbies. This is due to the possible effects on functionality of detectors which lead to disturbance of fire fighting systems.

Thermal conditions of this area could have significant impact on the emotions of elevator users since the human body is very sensitive towards changes in surrounding temperature, air flow rate, and humidity. Consequently, the work performance of building occupants may be affected due to thermal discomfort in the lift lobby, as effects from an immediate unpleasant experience may last for some time. For these kinds of lift lobbies, which are not directly linked to the external environment in tropical countries, it is presumed by most building engineers that low operating temperature of air-conditioners is needed to provide a thermally comfortable environment to the occupants. On behalf of that reason, the necessity of investigating the acceptable range of indoor temperature is required, as under most circumstances such a system is the highest consumer of energy. Any possibility in reduction of useful energy is desirable for all types of buildings, including educational institutions, as these kinds of facilities may have limited budgets.

Figure 1 Enclosed Lift lobby of the depart-

ment of mechanical and manufacturing engineering, UPM

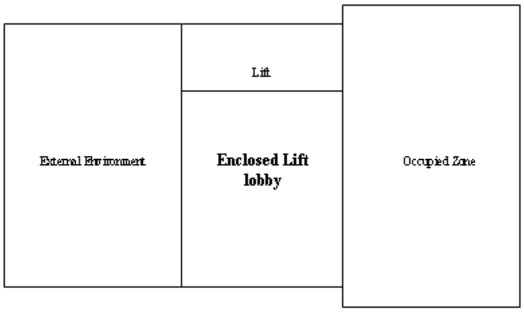

Figure 2 Enclosed lift lobby connecting outdoor and indoor environment

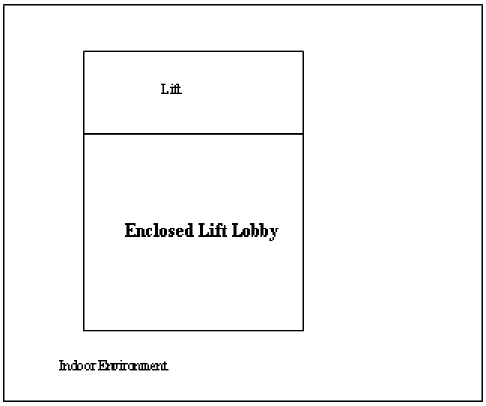

Figure 3 Lift lobby bounded in indoor environment

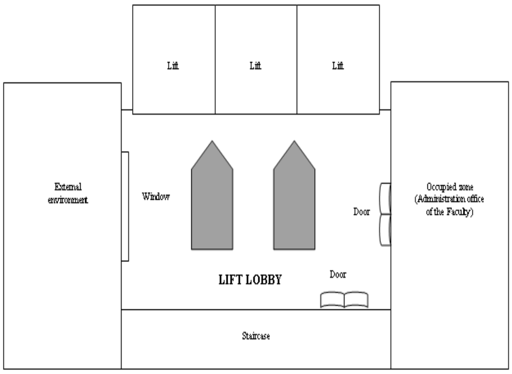

Figure 4 Brief layout plan of investigated lift lobby

3. Climatic Conditions of Malaysia

Malaysia is situated 2° 30 N and 112° 30 E, referring to geographic co-ordinates and has similar climatic characteristics as other hot and humid countries – high temperatures, high humidity and plentiful rainfall throughout the year. Malaysians enjoy diurnal temperatures ranging from minimum 21°C to 25°C and maximum 30°C to 36°C, with a mean relative humidity of 70% to 90%. For peninsular Malaysia, the lowest mean temperature appears in the months of April and May, while the highest mean temperature is obtained in December and January each year (JMM, 2008).

4. Related Works

It is concluded in a field survey that temperature change was a major factor in affecting thermal comfort at the transient zones (Chun & Tamura, 1998). Another work conducted by the same researchers identified that thermal comfort at a point of the transitional space was closely linked to a person's prior thermal experience (Chun and Tamura, 2005). Jitkhajornwanich and Pitts (2002) noted the test subjects' acclimatization to a controlled cooler environment and the expectation of an unpleasantly warm sensation when encountering the outdoor environment. Pitts et al. (2008) suggested that people passing through such spaces are more tolerable of variations in conditions required for com-fort.

Hwang et al. (2008) conducted field measurements and thermal perceptions were compared. The results obtained showed that the upper boundaries for guests and staff were beyond the upper limit specified by ASHRAE standard 55, by about 2 °C.

5. Methodology

Field surveys were performed from August to November 2008 at the lift lobby of the Department of Mechanical and Manufacturing Engineering, University of Putra Malaysia (UPM), which is also a part of the administration building. The lift lobby has dimensions of 7.94 m in length, 3.16 m in width, and 2.7 m in height. Ceiling type centralized air-conditioning split units are installed in the lift lobbies.

Throughout the period of this survey, the thermostat temperature set-point of air conditioners in the lift lobbies was maintained at 26 °C. This is to achieve energy saving purposes (MS 1525: 2007), and to examine the thermal comfort perceptions of occupants.

This paper focuses on the results obtained by questionnaire surveys as well as outcomes of objective measurements for relative humidity, air temperature, and air velocity, where both assessments were conducted concurrently. Before commencement of the field surveys, initial field visits were made to obtain useful information regarding the dimensions and characteristics of the lift lobby. The author noted the average waiting time (AWT) along with maximum waiting time (MWT) of the users waiting for the arrival of elevators, and users' activities and behavior in that particular area were observed. All information obtained from the pilot studies formed the basis for the objectives of this research, such as placement of measuring devices, development of relevant questions for lift lobby conditions and modification of the clothing lists in the questionnaire to make it suitable for Malaysians.

A total number of 113 persons, in which most of them were undergraduate students, took part in this survey. Only subjects who have stayed in the lift lobby for more than 30 seconds are invited to participate in the survey, as the average waiting time for users of elevator in this area is calculated to be 33 seconds during peak hours, with variance of ± 17 s.

5.1 Thermal Environment and Objective Measurement

For thermal environment measurements, methods and specifications of conducting field measurements were based on ASHRAE Standard 55, where parameters relating to human thermal balance were measured at 1.1m above the floor level, 1.0m inward from the center of windows. Upon observation made on users' behavior in the lift lobby, most users occupied the two regions in between lift entrances, which are in front of lift control panels as indicated by block–arrows in Figure 4. Air temperature was measured using an electronic temperature sensor connected to a data logger, which provide an accuracy of ± 1 °C. A precision digital-thermometer was employed to measure the relative humidity. For determining the rate of air flow, a thermo-anemometer with low friction vane probe attached was used, and all the measuring equipment is shown in Figure 5. The indoor environment was continuously measured and recorded from 9:00 am to 5:00 pm daily and all data were transferred a portable computer on a daily basis. The results obtained from objective measurements were tabulated and applied for calculation of PMV and PPD, which are useful to predict the thermal comfort conditions in the enclosed lift lobby.

5.2 Subjective Assessment – Questionnaire Surveys

Questionnaire surveys were performed at the lift lobby. The questionnaire consists of a section of subjective ratings on a variety of thermal scales and questions of human preferences towards thermal comfort. Respondents were requested to note down how they felt at that particular moment on a seven-point ASHRAE Thermal Sensation Scale as shown in Table 1. Next, they were asked to mark their preference on the three-point McIntyre Thermal Preference Scale. In order to understand the general comfortableness perceptions, the participants were also required to state their comfort perception in a four-category comfort vote. Several technical terms were translated to the Malay language to allow better understanding for the respondents about the contents in the questionnaire. Comments of respondents' satisfaction of current thermal environment were obtained and questions concerning possible effects of thermal environment towards their work performance were presented. In later parts of the questionnaire, test subjects were required to note down their respective demographics, which included gender, age, height, weight, clothing, footwear, date and time, when they were being interviewed.

Table 1 Rating scale for the subjective measurements

ASHRAE scale	General Comfort	Acceptability Vote	McIntyre Scale
-3 cold	Very Uncomfortable	Acceptable	Warmer
-2 cool	Slightly uncomfortable	Unacceptable	No Change
-1 slightly cool	Comfortable		Cooler
0 neutral	Very comfortable		
+1 slightly warm			
+2 warm			
+3 hot			

Figure 5 Data logger and electronic sensors

6. Experimental Results and Discussion

6.1 Field Measurements and Individual Parameters

Physical measurements were taken for a period of 4 months and the measured value of thermal comfort parameters are as tabulated in Table 2. Throughout this survey, two recruitment activities for new members from local students' organizations were conducted alongside the field assessment in the enclosed lift lobby. The measured air temperature was within 23 to 32 °C, with mean value of 28.1 °C. The range of relative humidity was between 63 % and 78 %, and with mean value of 72.6 %. The indoor air velocity was measured to be from 0.1 m/s to 0.20 m/s, and mean value of 0.15 m/s. In order to determine the value of mean radiant temperature, an equation derived by ASHRAE fundamental handbook (2001) for calculation of mean radiant temperature was used.

The clothing level of test subjects was identified by the clothing list attached in the questionnaire. The dressing code of Malaysian students and working staffs are different, as compared to people in other tropical countries, as a portion of subjects marked higher clothing level than average, due to distinctive cultural practices. The attire of the test subjects was converted to a numerical clo value with reference to ASHRAE standard 55, and the calculated clo value was 0.62 with a standard deviation of 0.08. As the typical activity for most of the subjects is standing up, waiting for the arrival of elevators, or having a conversation among each other, the metabolic rate as referred to ASHRAE standard 55 is 70 W/m^2 (1.2 met) for standing up, relaxed.

6.2 Thermal Perception of Subjects

ASHRAE scale of thermal sensation was applied with the assumption of people finding their thermal environment acceptable if they place their votes within the three central categories (-1, 0, 1). Most of the test subjects entered the lift lobby from the administration offices and classrooms which are air-conditioned with temperature setting of 16 – 18 °C. An averaged temperature difference of ± 6 °C occurred between the region studied and the indoor environment, and respondents were assumed to experience such changes in surrounding temperature.

From the data obtained from field survey, it is identified that most of the subjects found the thermal environment acceptable for them. As shown in Table 2, the thermal sensation of respondents move towards the warmer side as the number of occupants increased in the lift lobby. This outcome shows that the human occupancy level in the enclosed transitional region is one of the major elements which greatly affects thermal comfort perception of occupants. The work of Colon et al (2004) stated that heat is being generated by human bodies and continuously lost to the surroundings, which in certain extent causes a rise in internal temperature of the lift lobby during the survey being performed. Some underlying factors which possibly contributed to this phenomenon, such as perceptions of humans in crowded places and personal fondness within a building were encountered in this study, and further investigation is required.

Table 2 Thermal comfort parameters and operative temperature

Date (08)	Toperative	Thermal Sensation Vote							Thermal Preference Vote			Thermal Acceptability Vote		General Comfort			
	(°C)	-3	-2	-1	0	1	2	3	Warmer	No change	Colder	Accept-able	Unaccept-able	VU	SU	CM	VC
17-Aug	27.48	0	1	2	5	0	1	0	2	3	4	9	0	0	1	8	0
13-Sep	27.44	0	0	3	2	2	0	1	0	4	4	7	1	1	2	5	0
21-Sep	28.08	2	1	2	5	2	0	0	1	8	3	12	0	0	4	5	3
10-Oct	28.15	0	0	3	4	8	4	3	1	6	15	17	5	2	11	9	0
11-Oct	28.06	0	1	2	5	2	0	1	0	6	5	9	2	2	3	5	1
17-Oct	27.79	0	0	2	7	11	8	3	1	5	25	18	13	2	16	13	0
3-Nov	26.66	0	1	0	3	3	2	0	0	3	6	8	1	0	5	4	0
4-Nov	26.03	1	1	4	1	3	1	0	1	6	4	10	1	1	2	6	2

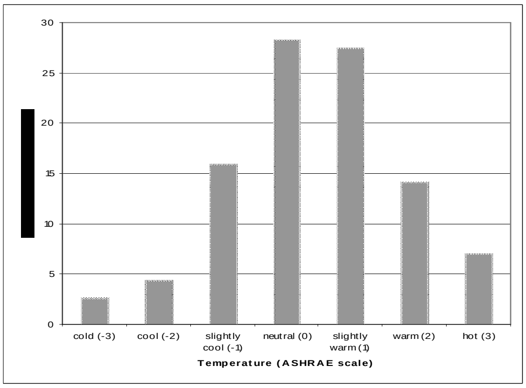

Figure 6 Distribution of subjective thermal sensation vote

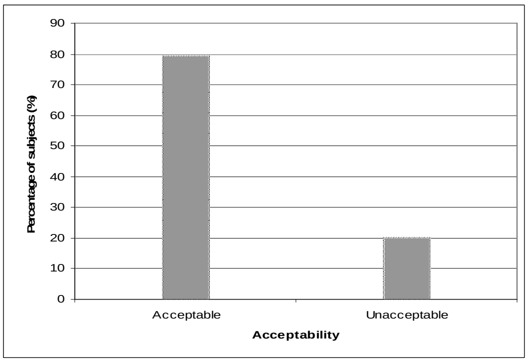

Figure 7 Distribution of subjective thermal acceptability vote

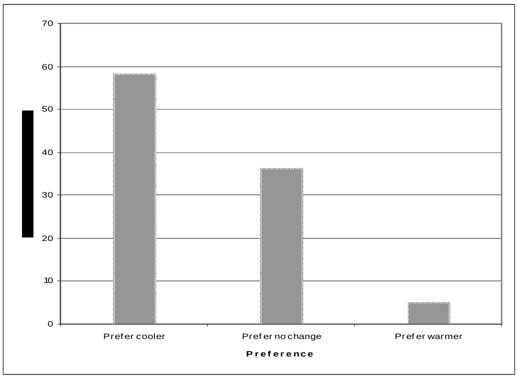

Figure 8 Distribution of subjective thermal preference vote

6.3 Percentage of Thermal Acceptability versus Sensation

In this research, it is clearly shown in Figure 6 that the users of elevators are generally agreeable with the thermal conditions of the lift lobby, as 72% of the votes fall within the three mid-classes (-1, 0, +1) of the scale. The count of respondents who voted “neutral” constituted the highest portion within the comfort zone, followed by “slightly warm”. Figure 7 presents the percentage of thermal acceptability, and distinctly indicates that 80% of the respondents found the thermal environment of the enclosed lift lobby acceptable, which is higher than the percentage of votes in ASHRAE sensation scale. This disagreement is mainly due to a number of respondents who did not feel comfortable with the hasty change in human occupancy once they entered the investigated area. Some expressed that the conditions were unsatisfactory, even though votes were placed within the comfortable categories with expectation of future improvement in the particular environment. Such phenomenon is also noted by Wong & Khoo (2003) in the tropical classrooms. Additional information gained here is the higher percentage of respondents that sensed the environment to be warm or hot, compared with subjects who felt cold. The reason for this peculiarity is that the people in tropical countries may prefer to have cooler surroundings rather than staying warm (Feriady & Wong, 2004). Moreover, the sudden change in temperature experience, when the respondents entered the enclosed space, may have induced some thermal discomfort (Chun & Tamura, 2005), especially those who entered from a cooler environment.

6.4 Percentage of Thermal Preference versus Acceptability

Thermal preference of respondents in the area studies is as shown in Figure 8. It can be observed that most of the test subjects prefer to experience lower temperature in the enclosed lift lobby. Only 36% of the total respondents wish to maintain the existing environment, and a smaller portion of 5% wants to be warmer. It is apparent that a large portion of the respondents preferred to have changes in thermal conditions of the enclosed lift lobby, even though the current environment is acceptable for them. This result is dissimilar to other thermal comfort studies performed in transitional spaces, where the largest part of the subjects wanted no change to their occupied area (Hwang et al, 2008). This finding affirms that people in the enclosed transitional space may have similar cooling requirements as the commonly occupied spaces, and suggests that enclosed transitional spaces are noticeably different from other transient areas in a building, especially to those who may have to stay in the enclosed region for a certain period of time. This is more apparent when people voting "cold" claimed that the environment was acceptable by them. This is due to the fact that people in the tropics generally prefer a cooler environment. A person will be more comfortable if the surrounding is cooler (Nicol, 2004).

6.5 Percentage of Thermal Sensation versus Preference

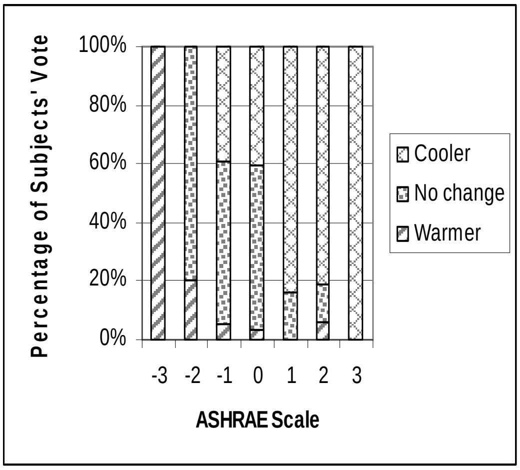

Figure 9 Thermal sensation versus preference

An analysis of subject's thermal sensation and thermal preference was performed as illustrated in Figure 9. It is shown that 56% of the respondents voting "neutral" and wanted no change in their thermal state. This percentage is higher than results obtained by Wong & Khoo (2003), which is 24.1%. The results also showed that a large portion of respondents prefer to be cooler, even in "slightly cool" category. Moreover, most of the respondents who sensed the environment as "slightly cool" prefer to not have changes to the existing conditions. Another fact that clearly marked Malaysians thermal perception towards cooler environment is proven where 57% of the test subjects who voted in the three central categories wanted to feel cooler, and 84% of them who selected "slightly warm", during the survey prefer to be cooler. In extreme categories such as "hot" and "cold", the preferences given by respondents were no doubt towards the opposite meanings. Yet, for respondents who voted "cool", 80% of them prefer no change to the current environment. This is contradictory to the respondents who sensed the environment as "warm", and most of them wanted cooler surroundings. These indicated that the thermal perception of test subjects who felt "cool" and "cold" have very unlike preference towards desirable thermal environment, and clearly supports the fact that Malaysians generally prefer surroundings which are colder, as an absolute majority of the votes falling within the warmer categories wanted to be cooler.

6.6 Thermal Sensation and Work Productivity

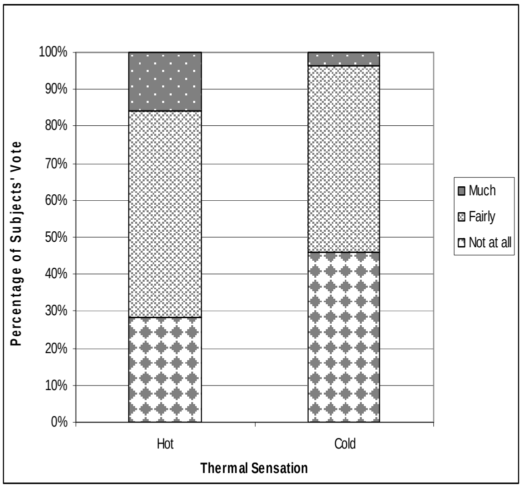

Figure 10 Thermal sensation and work productivity

The effect of thermal sensation towards work productivity of staff and students of an educational institution was investigated in the field survey. The main purpose of performing this portion of study was to figure out the possible influence of extreme thermal conditions in the enclosed lift lobby, towards the work performance of occupants. Referring to Figure 10, a higher number of respondents said that a cold environment would not have any effect on their emotions, as compared to a hot environment. Also, more people considered a hotter environment to cause disturbance in their work efficiency, as 72% of them claimed such. The percentage of respondents who stated a hot atmosphere may cause much discomfort to them is about 12% higher than a similar effect from a colder one. These findings demonstrated that although most people do not stay within the enclosed transitional space for long, the thermal conditions still exert a substantial influence towards work performance for some of the occupants. This is supported by the work of Chun & Tamura (2005) where human adaptations to thermal sensations vary widely. These outcomes pointed out the importance of air conditioners in controlling temperature within the university, where Olsen (2005) has suggested that an improved thermal environment may increase the productivity of workers about 5 to 10 %. This hidden fact that was identified in the outcomes is the root cause of excessive usage of air conditioning systems in educational institutions.

6.7 Comparison of Thermal Sensation and General Comfort

In this paper, the comparison of thermal sensation against general comfort of test subjects in the lift lobby is as presented in Figure 11. It is identified that 58% of the respondents who perceived their thermal environment within the three central categories found themselves to be generally comfortable. Those who are slightly uncomfortable comprised 33% of the total respondents. The highest percentage of general comfort is found in the slightly cool (-1) region, where 83% of the respondents stated themselves as generally comfortable. Comparing the percentage of votes between people who experienced cool and cold (-2, -3) and warmer environment (+2, +3), a larger portion of respondents termed their perception as slightly uncomfortable when they feel warm in the enclosed transitional space. In contrast, most of the test subjects who voted -2 (cool) in the ASHRAE scale selected "comfortable" in the general comfort survey, and some of them indicated that the environment was very comfortable, although they felt cold. This outcome suggested that people in tropical countries are generally biased towards a cooler sensation (Feriady & Wong, 2004), even in transitional spaces, where most people feel more comfortable in a cooler environment. Also, thermal comfort is found to be a prevailing factor in affecting general comfortableness of humans.

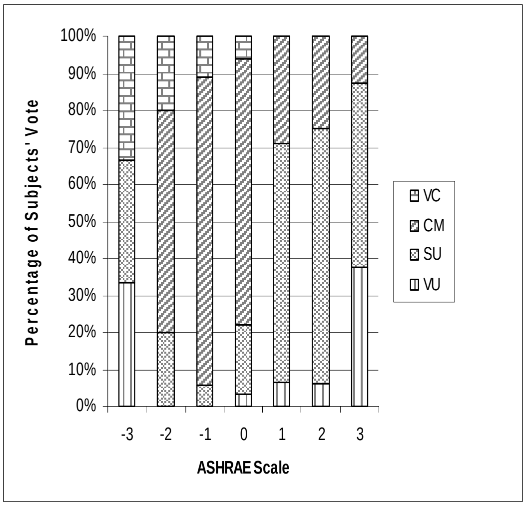

Figure 11 General comfort versus thermal sensation

6.8 Prediction of Thermal Environment

Calculation of thermal comfort indices, which consists of Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD) was made by employing a BASIC computer program provided in ASHRAE Standard 55 (2004) and ISO 7730 (1994). Variables in this calculation were air temperature, mean radiant temperature and relative humidity. The values for clothing level, metabolic rates of test subjects and relative air velocity were set as constant measures. Table 3 shows the results of field measurements together with calculated PMV and PPD values for each day of the survey performed.

The averaged value for PMV index is 1.15, which means that the enclosed loft lobby is observed to be in the range of slightly warm category. As for PPD index, the calculated mean value appeared to be 35%. This outcome specifies that about 35% of the occupants in this survey are expected to be in discomfort with the thermal environment of the enclosed lift lobby. While comparing these results to the values obtained from questionnaire assessment, disagreement happens between the calculated PMV value and the mean thermal sensation mentioned by test subjects, which is 1.15 against 0.44. This is primarily due to the overestimate of the PMV model, which predicts slightly warm when the respondents actually felt neutral at certain temperatures. For PPD index, 28% of the respondents voted outside the three central categories of the ASHRAE scale, and a 7% difference is obtained with the result from the predicted value. The main factor that contributed to this dissimilarity is the overestimation by the PPD indices which predicted warmer temperature than actual thermal sensation (Wong & Khoo, 2003). Students in tropical universities may have a different perception on thermal environment, and each individual may have their own preference towards desirable surroundings.

6.9 Comfort Temperature in the Enclosed Lift Lobby

In this study, the comfort temperature of the enclosed lift lobby is calculated by using the method of Fanger (1970), which utilized a slope a* of 0.33 in his climate chamber experiments. The resulting equation is as follows:

$$T_c = T_{gm} + (4 - C_m)/a^*, \qquad (1)$$

where T_c is the comfort temperature, T_{gm} is the mean internal temperature, C_m is the mean comfort vote and a* is the slope or the regression coefficient which carries the value of 0.33. From the objective measurements performed, the mean air temperature obtained was 28.1 °C. The value of mean thermal sensation vote was established by calculating the total average sensation scale, and identified as 4.44. Thus, the comfort temperature for the enclosed lift lobby is found as 26.8 °C. In other words, this region does not require cooling below the defined comfort temperature to sustain thermal comfort of occupants. The air temperature obtained from the field survey proved to be slightly higher than the comfort temperature. The thermostat temperature set-points of air conditioners can be lowered by 1 to 2°C to provide a more acceptable thermal environment for the occupants during high occupancy periods in a day. However, the energy implication should be carefully considered as every additional 1°C in thermostat settings may increase the energy consumption by 6%/K (Aynsley, 2007).

Table 3 Data of field measurements and thermal comfort indices

Variable	date							
	17-Aug	17-Sep	21-Sep	10-Oct	11-Oct	17-Oct	13-Nov	14-Nov
Clothing (Clo)	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
Metabolic Rate (Met)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
External Work (Met)	0	0	0	0	0	0	0	0
Air Temp. (°C)	28.22	28.02	29.12	29.18	28.93	28.68	27.05	25.95
Mean Radiant Temp. (°C)	26.73	26.86	27.04	27.21	27.2	26.9	26.28	26.1
Relative Air Velocity (m/s)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Relative Humidity (%)	70.78	68.19	76.97	70.02	72.75	73.03	76.3	72.39
PMV	**1.1**	**1.1**	**1.4**	**1.4**	**1.4**	**1.3**	**0.9**	**0.6**
PPD	**33**	**31**	**49**	**47**	**45**	**41**	**22**	**12**

7. Conclusions

The thermal environment of enclosed transitional spaces is equally important as the normally occupied spaces in buildings, as some activities which require human occupation are occasionally performed in these regions. Temperature change is one of the main factors which may affect human thermal comfort, especially for individuals who entered the surveyed region from a colder areas. Although people may not stay in the enclosed lift lobby for long, the thermal environment of such area do impose certain level of influences towards emotions of occupants

The thermal sensation of occupants in the enclosed transitional space is greatly affected by the number of persons gathered within a certain period of time. This is strongly evidenced when more people are feeling warmer during high human occupancy periods. Preference towards a cooler environment is a common phenomenon for residents in the tropical countries, with no exception for Malaysians.

The comfort temperature obtained in this survey is 26.8 °C. Results from the field survey proved that 80% of the participants found the thermal environment acceptable. This shows that air-conditioners in the enclosed lift lobby may be operated in higher temperature settings rather than conventional set-points of 16 – 18 °C. Additional attention should be given to the control of temperature if activities which involve a high concentration of people are to be planned in an enclosed lift lobby. This is to prevent thermal discomfort conditions from occurring.

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