SEUJA,VOL. 1, NO. 1, JUNE. 2021, PP. 39-47

ARC. SEU

Southeast University Journal of Architecture

Journal homepage: www.seu.edu.bd/seuja

Comparative Analysis Between Occupant's Response to Thermal Comfort in A Mixed Mode Office Space and A Mechanically Controlled Office Space in The Tropics

Nafisa Bari [a]*

[a]*Lecturer, Department of Architecture, Southeast University, Dhaka, Bangladesh. nafisa.bari@seu.edu.bd*

ARTICLE INFORMATION

Received: April 25, 2021
Revised: May 10, 2021
Accepted: July 02, 2021
Published online: July 03, 2021

Keywords:
Thermal comfort ,
occupant's satisfaction ,
Post-occupancy evaluation ,
Mixed-mode,
Mechanical Ventilation,
Predicted Mean Vote (PMV) ,
Percentage People Dissatisfied (PPD)

ABSTRACT

Western world has always put a major influence in terms of setting trend in our region. Be it in fashion or building design. In recent times the use of glass in façade treatment of commercial buildings is a very common phenomenon which increases the number of buildings using mechanical ventilation as heat gain is increased due to the use of all-glass façade. Another mode of ventilation in these commercial buildings is mixed-mode. Mixed-mode' refers to a hybrid approach to space conditioning that uses a combination of natural ventilation and some form of mechanical ventilation and/or cooling(Brager).In a mixed-mode space people have the freedom to choose which ventilation system they want to use . Often it's heard from the users of a mechanically ventilated space that they cannot differ between day and night . They stay inside a concrete jungle. They have no connection with the outer world. The aim of this paper is to perform a comparative analysis between two office spaces one having mixed-mode system and the other having mechanical ventilation and find out the occupants satisfaction regarding thermal comfort. The study is based on the hypothesis that the occupants of commercial office buildings in the tropics prefer such environment which they can control that refers to the mixed-mode system. Therefore , two cases are analyzed one having mixed-mode system and one having mechanical ventilation and using the thermal comfort calculator the Predicted Mean Vote (PMV) and Percentage People Dissatisfied (PPD) are determined to understand occupants' response towards thermal comfort.

1. Introduction

In current commercial buildings in the U.S., cooling and mechanical ventilation account for over 30% of total energy use, approximately 20% of electricity use, and approximately 40% of peak demand. However, prior to the 1950s, air conditioning and mechanical ventilation were not yet commercially viable, and so commercial buildings had little choice but to utilize natural ventilation for cooling. Buildings typically had extended perimeter zones so that every office could have access to windows that would open to the outdoors, and provide the primary source of light and fresh air. But the availability in the 1950's of large-scale mechanical ventilation and cooling, along with other technologies such as curtain walls and fluorescent lighting (as well as market pressures to maximize floor areas and flexibility of interior space), led to the more common commercial building forms of today that are typically all-glass, flush-skin buildings with large floor plates and no operable windows. These buildings miss out on the large number of documented benefits of operable windows. – thermal comfort over a wider range of temperatures based on the adaptive comfort zone (Humphreys, M.A) ,(De Dear, R. and G. Brager), reduced energy consumption compared to conventional air-conditioned buildings (Emmerich, S.J. and J. Crum) and fewer Sick Building Syndrome symptoms (Seppänen, O. and W. Fisk)which is extremely rare.

While building services engineers and facility managers have focused on maintaining a steady and tight indoor temperature all year round, the research literature

* *Corresponding author : Nafisa Bari, Lecturer, Department of Architecture, Southeast University, Dhaka, Bangladesh*
This article is published with open access at www.seu.edu.bd/seuja
ISSN No.: 2789-2999 (Print), ISSN No.: 2789-3006 (Online)

on adaptive thermal comfort suggests that an acceptable range of indoor temperatures in naturally ventilated (NV) spaces drifts in sync with the outdoor seasonal cycle (R.J. de Dear, G. Brager, M.A. Humphreys,). According to the adaptive comfort theory, the indoor comfort zone tracks prevailing outdoor weather – shifting up in warm weather and down in cool weather. As long as indoor temperature is maintained within the acceptable range appropriate to the season, it is possible for most building occupants to achieve thermal comfort. Accommodating this natural adaptability of occupants within the building's operation strategy has very positive implications for energy efficiency. Compelling empirical evidence indicates up to 30% HVAC energy saving can be achieved by relaxing the set-point temperature without sacrificing occupant comfort or satisfaction (T. Hoyt, E. Arens, H. Zhang).

The mixed-mode (MM) building operation, which integrates both natural ventilation and air conditioning strategies, is deemed a viable alternative to the fully sealed-facade HVAC approach for both comfort (G. Brager, L. Baker)

(G.S. Brager) and energy efficiency (S.J. Emmerich). Mixed-mode buildings allow internal spaces to be naturally ventilated through vents or operable windows whenever external conditions are favourable, but utilise mechanical systems if natural ventilation is unable to deliver comfort for the occupants. A classification scheme for MM buildings was proposed by Brager (G.S. Brager) , including a) concurrent, in which mechanical cooling and natural ventilation operate simultaneously within the same part of the building, b) changeover, in which the operational mode switches between mechanical cooling and natural ventilation on the basis of externally and internally measured environmental data, and c) zoned, in which mechanical cooling and natural ventilation operate simultaneously in different parts of the building.

The shift between the two modes can be determined either manually by occupants or automatically by a building management system (BMS) supplied with real-time internal and outdoor environmental data. The main aim of MM is to maintain comfort by relying on natural ventilation as much as possible, thereby minimising the energy penalty associated with operation of HVAC system. By employing 4 appropriate design and operation strategies, MM buildings can simultaneously improve comfort and energy performance, especially in mild climates like Sydney Australia which are characterised by subtropical summers and mild winters with no extreme seasonal differences.

Lastly , the thermal comfort issue should be discussed. Different people may have different response regarding comfort in the same space due to certain factors such as temperature, air velocity, relative humidity, metabolic rate (Met) and clothing value (Clo).The reason for creating thermal comfort is first and foremost to satisfy man's desire to feel comfortable, in line with his desire for comfort in other directions[13].Comfort is sensed by body and perceived by brain. That's why the science of indoor climate engineering comes before HVAC (Heating , Ventilation and Air conditioning) engineering. It is well known that poor thermal comfort forced the users to look for high energy alternatives to achieve thermal comfort (P.O. Fanger). By investigating the thermal comfort attributes in the commercial spaces , the indicators of thermal problems can be determined. Here ,to predict thermal comfort conditions the PMV (Predicted Mean Vote) and PPD (Predicted Percentage Dissatisfied) models are used as tools.

PMV (Predicted Mean Vote) is a means of tool by which thermal comfort can be assessed according to human perception. This index helps individuals to determine their impression regarding thermal comfort in indoor climate which holds the amalgamation of the thermal

comfort factors.

The PMV index predicts the mean response of a larger group of people according the ASHRAE thermal sensation scale [9]:

Table 01- Ideal range of PMV values

PMV	-3	-2	-1	0	+1	+2	+3
Thermal Sensation	cold	cool	Slightly cool	neutral	Slightly warm	warm	hot

Table 02- Criteria for PMV, PPD for typical spaces.

Category	**General comfort**	
	PPD [%]	Predicted Mean Vote [-]
A	<6	-0.2<PMV<+0.2
B	<10	-0.5<PMV<+0.5
C	<15	-0.7<PMV<+0.7

Developed by (P.O.Fanger) ,the predicted percent dissatisfied (PPD) is an index that predicts the percentage of thermally dissatisfied people who feel too cool or too warm, and is calculated from the predicted mean vote (PMV). The PMV and PPD form are therefore closely related, and both indices take the form of a U-shaped relationship, where percentage dissatisfied increases for PMV values above and below zero (thermally neutral). At the neutral temperature as defined by the PMV index, PPD indicates that 5 % of occupants will still be

dissatisfied with the thermal environment. The standard BS EN ISO 7730:2005 (British Standards Institution 2006) uses both the PPD and PMV .

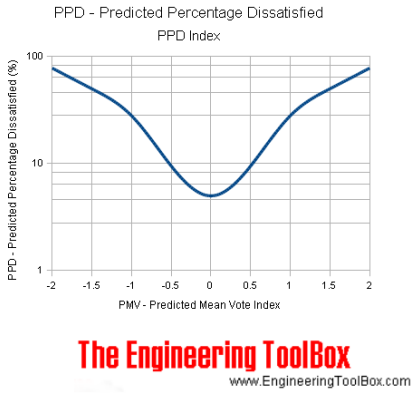


Figure:1- PMV-PPD Index

Table 3- Validity intervals for PMV input parameters, taken and adapted from ISO-7730 and(M.Humphreys and Nicol) .

Parameter	ISO 7730	Humphreys and Nicol	
		PMV free from bias if:	Comment
Clothing insulation [I_{cl}]	0-2 clo (0- 0.310 m^2 KW^{-1})	0.3<I_{cl}	Overestimation of warmth of people in lighter and heavier clothing, serious bias when clothing is heavy. Little information exists for conditions when I_{cl}<0.2 clo
Activity level [M]	0.8-4 met (46-232 Wm^{-2})	M<1.4 met	Bias larger with increased activity. At 1.8 met overestimation sensation of warmth by 1 scale unit
Air temperature [ta]	10-30 °C		
Mean radiant temperature [t_r]	10°-40°C		
Air velocity [v_a]	0-1 ms^{-1}	va<0.2 ms^{-1}	

2. Methodology

a)Literature Survey

b)Field survey

Field survey includes reconnaissance survey of the office space to understand the architectural features , the location of air-condition with respect to work station , assessing the type of openings.

c)Questionnaire survey

Questionnaires are distributed among the occupants to find out their response towards thermal comfort in their work place.

d)Measurements are conducted in the study area with the help of thermometer and thermo-anemometer to measure the temperature , air velocity and relative humidity. Putting these values along with Clo(clothing insulation) and Met(Metabolic rate) in a comfort calculator (ISO-7730-1993) the PMV-PPD values are predicted.

Figure:2- Survey Instruments

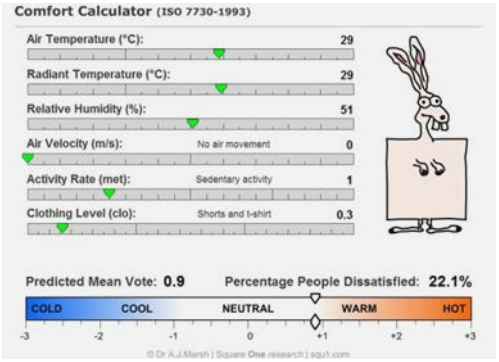


Figure 3- Comfort Calculator

3. Case Study

Case 1:

City Bank Card Division , Gulshan-1

Floor area:5235 sft

Study area:2230sft

HVAC System: VRV system (Mechanical Ventilation)

No of operable windows: N/A
Sliding :N/A
Swing:N/A
Fixed glass: On four sides
No of AC: 6
Capacity of AC: 1.5 ton (per AC)
No of Fans: N/A
No of occupants: 10

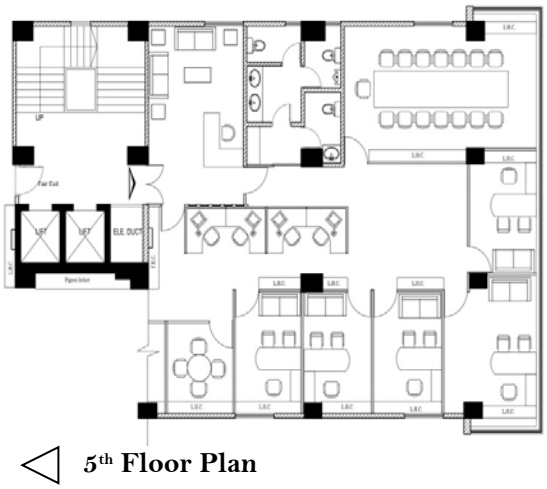


Figure 4- City Bank Card Division

Case 2:
MW3 Design + Partners Office
Floor area:1500 sft
Study area:1500sft
HVAC system: Mixed-Mode
No of operable windows: 7 (sliding windows including 4 high windows for toilet)
Sliding : 7
Swing: N/A
Verandah :03 with sliding doors
No of AC: 04
Capacity of AC: 1.5 tons (per AC)
No of Fans:6
No of occupants:11

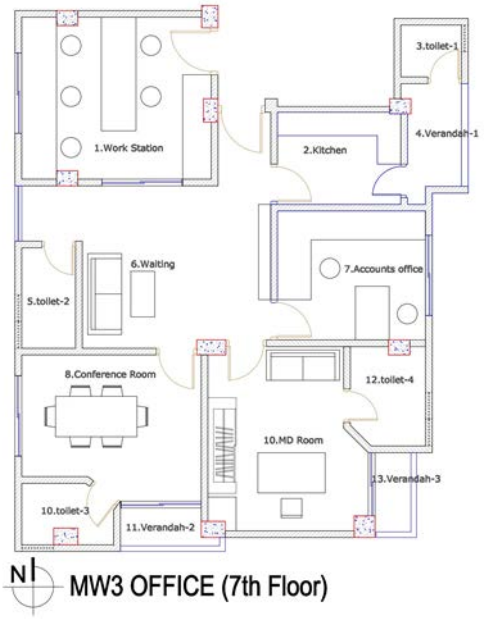


Figure 5- MW3 Design + Partners floor plan

4. Weather Data

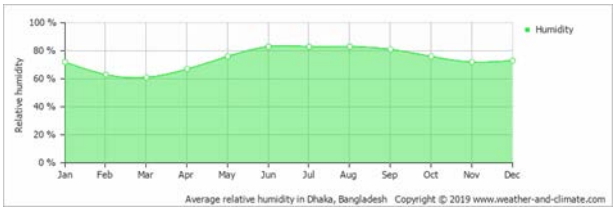
Here the principal data are collected in August 2019, which is considered to be the most humid month in Bangladesh (bmd.gov.bd/p/Monthly-Humidity-Normal-Data).

Average humidity in Dhaka
- On average, August is the most humid.
- On average, March is the least humid month.
- The average annual percentage of humidity is: 74.0%

It is essential to conduct the study during the most humid period where the users find the weather condition to be thermally most uncomfortable as the research focuses on occupant's satisfaction in office space.

The mean monthly relative humidity over the year in Dhaka, Bangladesh.

As a warm-humid tropical country, the annual average temperature in Bangladesh ranges from , with an average relative humidity of throughout the year (Ref meterology dept)
- The average annual maximum temperature is: 30.0° Celsius (86° Fahrenheit)
- The average annual minimum temperature is: 21.0° Celsius (69.8° Fahrenheit)



Monthly Normal Humidity (%)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dhaka	71	64	62	71	76	82	83	82	83	78	73	73
Tangail	80	74	69	74	79	84	85	85	85	83	80	81
Mymensingh	77	72	71	77	81	86	87	86	86	83	79	79
Faridpur	77	72	67	72	79	85	87	85	85	82	78	78
Madaripur	77	72	70	74	79	84	86	85	85	82	78	78
Srimangal	80	73	70	75	80	84	85	85	85	85	82	81
Sylhet	75	68	68	76	81	87	87	86	86	83	77	75
Bogra	77	70	66	72	78	84	86	85	86	82	77	77
Dinajpur	79	70	63	68	76	82	84	84	85	82	78	78
Ishurdi	76	70	63	66	75	83	86	85	85	82	77	77
Rajshahi	78	71	63	65	75	83	87	86	86	83	78	78
Rangpur	82	75	68	74	81	85	86	85	87	84	80	81
Sayedpur	78	70	63	70	77	82	83	83	83	80	75	76
Chuadanga	78	72	65	68	74	83	86	86	86	83	78	78
Jessore	77	72	69	72	77	84	87	86	86	83	79	78
Khulna	78	74	73	76	79	85	87	86	87	84	80	79
Mongla	75	73	73	77	80	86	88	88	88	85	80	77
Satkhira	74	71	69	72	75	82	85	85	86	82	77	75
Barisal	81	78	76	80	83	88	90	89	89	87	84	83
Bhola	81	77	77	81	84	88	90	89	89	86	83	82
Khepupara	76	75	76	79	81	86	88	87	87	85	81	78
Patuakhali	78	76	76	81	83	88	90	89	89	86	82	80
Chandpur	78	73	73	77	80	85	86	85	85	82	78	78
Ambagan(Ctg)	73	66	70	77	80	86	87	86	85	84	79	77
Chittagong	73	70	74	77	79	83	85	85	83	81	78	75
Comilla	77	75	77	81	82	86	87	86	86	84	80	79
Cox's Bazar	72	71	75	78	80	87	89	88	86	82	77	74
Feni	76	73	74	79	81	85	87	86	86	84	80	78
Hatiya	76	74	76	79	82	87	89	88	86	84	80	79
Kutubdia	75	75	80	81	81	86	88	87	85	83	79	76
Maijdi Court	79	76	76	78	81	86	88	87	86	83	80	80
Rangamati	77	69	67	72	78	84	85	85	85	84	82	81
Sandwip	79	77	79	82	84	88	90	89	88	85	82	81
Sitakunda	75	72	74	78	81	85	87	86	85	83	80	78
Teknaf	69	68	73	77	81	88	90	89	87	83	77	71
Country	76	72	71	75	79	85	86	86	85	83	79	77

Bangladesh Meteorological Department

Figure 6- Average Humidity data

The monthly mean minimum and maximum temperatures over the year in Dhaka, Bangladesh.

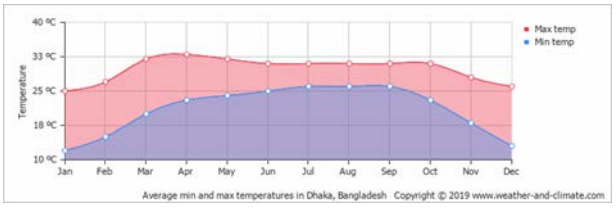


Figure 7- Average temperature

5. Data Collection & Analysis

The two parts of the study are:

1.Field measurement and a
2.Questionnaire survey

Data collection for both parts were conducted in August 2019.It should be mentioned that for case-2 thermal readings are taken on two separate days using the thermometer and thermo-anemometer as the office has mixed-mode system . On the first day readings are taken keeping the air-condition on to get the AC temperature. On the second day the windows were kept open for natural ventilation and the fan was also on . Based on these the readings were taken on the second day.

1. Field Measurement

The field measurement focuses on measuring thermal comfort parameters such as air temperature, relative humidity etc which are recorded using thermo-anemometer and hygrometer.

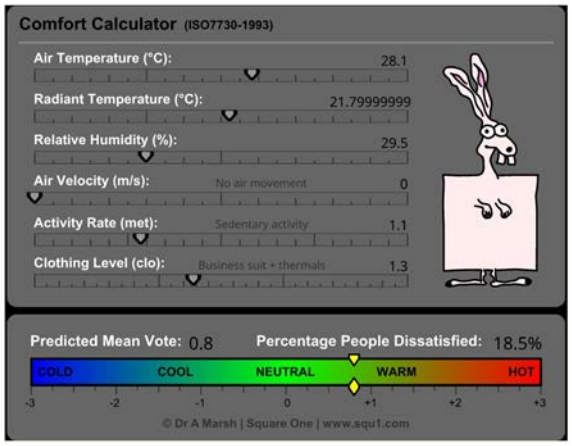
The office building operates between 9 am to 6 pm. As the buildings face maximum heat gain due to low sun angle between 3 pm to 6 pm therefore readings were taken at that time on August 18 , 2019 for case-1 and for case-2 the s days for taking measurements were August 19 and 20 ,2019. The readings of each zone were taken every 5 minutes interval.

Case 1:

Table 4- Field measurements of thermal comfort parameters at Case 1

Zone	Temperature		Humidity	Time
	AC temp	Actual temp		
1.Open work station	20 °C	27°C	25%	3:00 pm
2.Conference room	Off	29°C	30%	3:05 pm
3.Closed room	22°C	28°C	27%	3:10 pm
4.Head of dept	23°C	26°C	27%	3:15 pm
5.Small meeting room	Off	28°C	31%	3:20 pm
6.Reception+ Waiting	22°C	27°C	26%	3:25 pm
7.Lift Lobby	N/A	28°C	32%	3:30 pm
8.Toilet	N/A	30°C	35%	3:35 pm
Average	21.75 °C	28°C	29%	

There is a difference between AC temperature and actual temperature due to heat dissipation from human body , office equipments , emission from building materials and difference in levels of exposure to sun. From table 4 we can see that the average AC temperature is 21.75°C, actual temperature is 28°C and average humidity is 29%.Putting the average values in comfort calculator we can get the PMV and PPD values.



	Met (Activity rate)	Clothing Level (Clo)	PMV	PPD
Case 1	1	1	0.8	18.5%

From the analysis it is seen that the PMV value falls between ideal range i.e [-3 to +3] and PPD value is 18.5%.According to P.O Fanger if 85% of the occupants are satisfied (or 15% dissatisfied) with their thermal environments, then the Building/HVAC system is generally considered acceptable. Here PPD is 18.5%. Therefore , the users of the office space are slightly uncomfortable in their work place in terms of thermal environment. As a result it can be said that the mechanical ventilation or controlled environment is responsible for their discomfort.

Case 2:

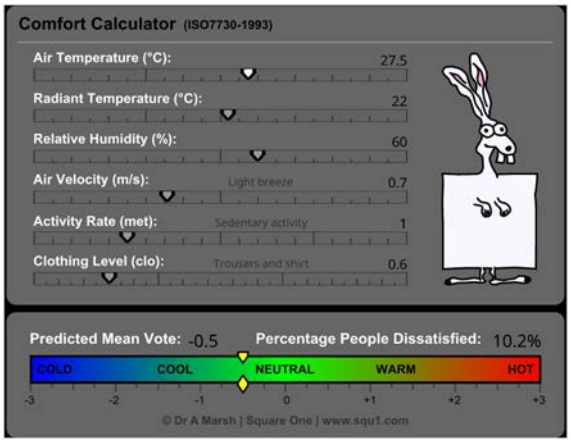


Table:05- Field measurements of thermal comfort parameters at Case 2.

Zone	Temperature		Humidity	Time
	AC temp	Actual temp (Fan on)		
1.Work Station	22◦C	25◦C (window open)	26%	3:00 pm
2.Kitchen	N/A	27.5◦C	30%	3:05 pm
6.Waiting	N/A	27.8◦C (No opening)	35%	3:10 pm
7.Accounts Office	22◦C	27◦C (window open)	28%	3:15 pm
8.Conference Room	21◦C	26◦C (window open)	27%	3:20 pm
9.Md room	23◦C	25.5◦C (window open)	26%	3:25 pm
Average	22◦C	26◦C	29%	

Putting the average values in comfort calculator we can get the PMV and PPD values.

	Met (Activity rate)	Clothing Level (Clo)	PMV	PPD
Case 2	1	0.6	-0.5	10.2%

From the analysis it is seen that the PMV value falls between ideal range i.e [-3 to +3] and PPD value is 10.2% which is in the acceptable range.

Therefore from the analysis it is seen that in case of case-2 PPD falls in acceptable range as it has two ways of ventilation that means it offers the occupants more options. It has a passive cooling system and when the environment is favorable the occupants don't need to put the AC on. Rather they open the windows and the fan is kept on in this way the hot air is pushed outwards. It is not recommended for the office occupants to be in a controlled environment for a very long time. Therefore having the scope to operate the windows gives them more options to feel comfortable.

6. Questionnaire Survey

Questionnaire Survey actually helps to understand users' behavior in indoor thermal environment.For both case 1 and case 2 study was conducted on the fifth floor and both of the building faces south on the part were study is conducted. From the questionnaire it is known that for case 1 the air-conditioning unit is the only means of controlling the environment as there is no provision for

opening the windows or no fan. For case 2 the controlling equipments are windows , blinds, ceiling fan , ac etc.

Case 1 has mechanically controlled system and case 2 mixed-mode.

For case 1 , preferences in a mechanically controlled office are as follows

- 50% said Ac unit should be always on and another 50% said it should be adjusted according to the weather conditions.
- Preferable Ac temperature is in between 21◦C to 25◦C
- 60% said as the only controlling unit is Ac they need to keep warm clothes with them in order to adjust with others' choice of temperature and another 40% don't care about clothing as far as they are exposed to Ac unit.
- 100% people said they are engaged in sedentary activity
- In summer most of the occupants are dissatisfied with the uneven indoor temperature i.e some parts always hot while others are cold.

The recommendations for improving office environment are

- Re-thinking placement of Ac unit
- Treatment at south façade
- Ac can be updated calculating indoor thermal load , humidity and oxygen supply.
- Increase cross-ventilation
- Proper servicing of the Ac unit
- Provision of operable opening at some points. Preferably south.

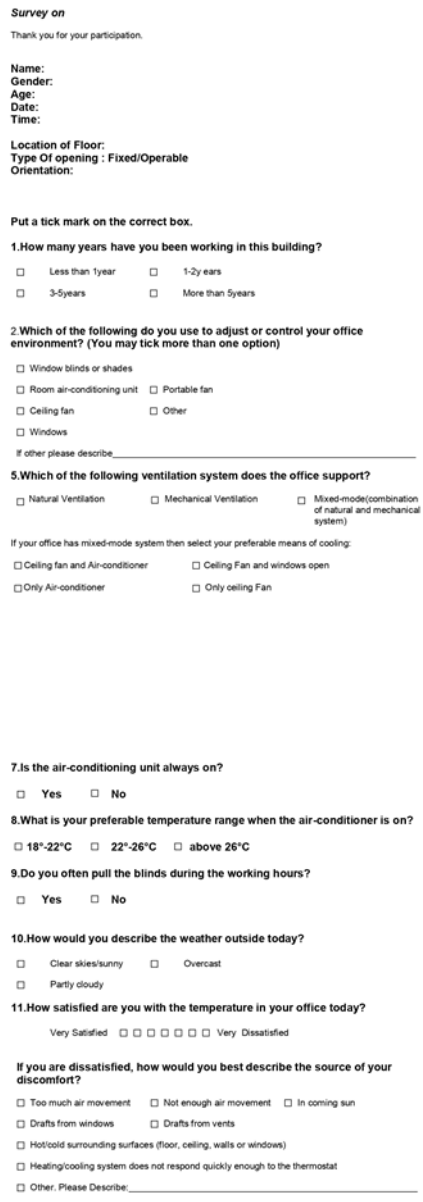
For case 2 , mixed-mode type preferences are as follows

- 70% of the occupants prefer to keep the window open and ceiling fan on.
- 20% prefer only Ac
- 50% said Ac unit should be always on and another 50% said it should be adjusted according to the weather conditions.
- Preferable Ac temperature is in between 22◦C to 26◦C.
- 80% said clothing doesn't affect their working mode.
- 100% people said they are engaged in sedentary activity
- In summer most of the occupants are dissatisfied with the uneven indoor temperature i.e some parts always hot while others are cold.

The recommendations for improving office environment are

- Allow moderate air flow by keeping window open and ceiling fan on.
- South façade could have more opening
- Ac can be updated calculating indoor thermal load , humidity and oxygen supply.
- Increase cross-ventilation

7. Sample Questionnaire



Survey on

Thank you for your participation.

Name:
Gender:
Age:
Date:
Time:

Location of Floor:
Type Of opening : Fixed/Operable
Orientation:

Put a tick mark on the correct box.

1.How many years have you been working in this building?

☐ Less than 1year ☐ 1-2y ears
☐ 3-5years ☐ More than 5years

2.Which of the following do you use to adjust or control your office environment? (You may tick more than one option)

☐ Window blinds or shades
☐ Room air-conditioning unit ☐ Portable fan
☐ Ceiling fan ☐ Other
☐ Windows
If other please describe_____

5.Which of the following ventilation system does the office support?

☐ Natural Ventilation ☐ Mechanical Ventilation ☐ Mixed-mode(combination of natural and mechanical system)

If your office has mixed-mode system then select your preferable means of cooling:

☐ Ceiling fan and Air-conditioner ☐ Ceiling Fan and windows open
☐ Only Air-conditioner ☐ Only ceiling Fan

7.Is the air-conditioning unit always on?

☐ **Yes** ☐ **No**

8.What is your preferable temperature range when the air-conditioner is on?

☐ **18°-22°C** ☐ **22°-26°C** ☐ **above 26°C**

9.Do you often pull the blinds during the working hours?

☐ **Yes** ☐ **No**

10.How would you describe the weather outside today?

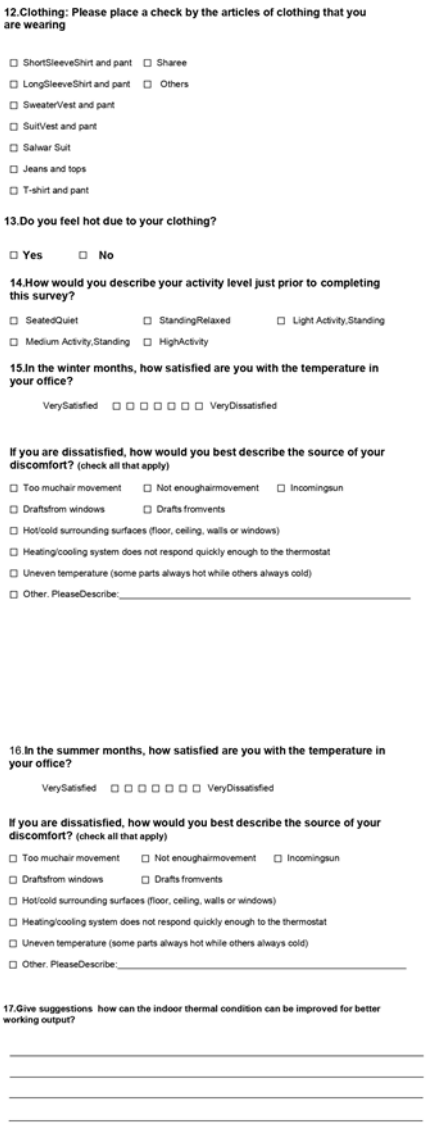
☐ Clear skies/sunny ☐ Overcast
☐ Partly cloudy

11.How satisfied are you with the temperature in your office today?

Very Satisfied ☐☐☐☐☐☐☐ Very Dissatisfied

If you are dissatisfied, how would you best describe the source of your discomfort?

☐ Too much air movement ☐ Not enough air movement ☐ In coming sun
☐ Drafts from windows ☐ Drafts from vents
☐ Hot/cold surrounding surfaces (floor, ceiling, walls or windows)
☐ Heating/cooling system does not respond quickly enough to the thermostat
☐ Other. Please Describe:_____



12.Clothing: Please place a check by the articles of clothing that you are wearing

☐ ShortSleeveShirt and pant ☐ Sharee
☐ LongSleeveShirt and pant ☐ Others
☐ SweaterVest and pant
☐ SuitVest and pant
☐ Salwar Suit
☐ Jeans and tops
☐ T-shirt and pant

13.Do you feel hot due to your clothing?

☐ Yes ☐ No

14.How would you describe your activity level just prior to completing this survey?

☐ SeatedQuiet ☐ StandingRelaxed ☐ Light Activity,Standing
☐ Medium Activity,Standing ☐ HighActivity

15.In the winter months, how satisfied are you with the temperature in your office?

VerySatisfied ☐ ☐ ☐ ☐ ☐ ☐ ☐ VeryDissatisfied

If you are dissatisfied, how would you best describe the source of your discomfort? (check all that apply)

☐ Too muchair movement ☐ Not enoughairmovement ☐ Incomingsun
☐ Draftsfrom windows ☐ Drafts fromvents
☐ Hot/cold surrounding surfaces (floor, ceiling, walls or windows)
☐ Heating/cooling system does not respond quickly enough to the thermostat
☐ Uneven temperature (some parts always hot while others always cold)
☐ Other. PleaseDescribe:_____

16.In the summer months, how satisfied are you with the temperature in your office?

VerySatisfied ☐ ☐ ☐ ☐ ☐ ☐ ☐ VeryDissatisfied

If you are dissatisfied, how would you best describe the source of your discomfort? (check all that apply)

☐ Too muchair movement ☐ Not enoughairmovement ☐ Incomingsun
☐ Draftsfrom windows ☐ Drafts fromvents
☐ Hot/cold surrounding surfaces (floor, ceiling, walls or windows)
☐ Heating/cooling system does not respond quickly enough to the thermostat
☐ Uneven temperature (some parts always hot while others always cold)
☐ Other. PleaseDescribe:_____

17.Give suggestions how can the indoor thermal condition can be improved for better working output?

_____
_____
_____
_____

Figure 08- Sample questionnaire to the occupants

8. Result and Discussion

After analyzing the results from field measurement it is seen that the hypothesis is accepted. The predicted percentage dissatisfied in a controlled space is higher than that of a mixed-mode space.

From the questionnaire survey it is seen that in mixed-mode system people prefer the usage of ceiling fan and keeping the windows open which reduces the humidity. Due to humidity in tropical climate the thermal condition is considered critical. And in a mechanically controlled office due to having less control people feel a certain level of discomfort.

Therefore the results from field measurement and questionnaire survey more or less indicates towards the same result.

9. Conclusion

In conclusion it can be said that the more options there are for the users in terms of ventilation the more is the chance of acceptibility. Whatever the ventilation system is , the users' response towards thermal comfort varies according to the thermal comfort factors associated with them and with proper provision of operable windows , passive cooling system and air-conditioning unit indoor thermal comfort can be achieved and also the space can be energy efficient.

References:

Humphreys, M.A , "Field studies of thermal comfort compared and applied." U.K.,Department of Environmental Building Research Establishment Current Paper. (76/75) , 1975

De Dear, R. and G. Brager, "Developing an Adaptive Model of Thermal Comfort, 1998

Emmerich, S.J. and J. Crum, Simulated Performance of Natural and Hybrid Ventilation Systems in an Office Building. Final Report, Air-Conditioning and Refrigeration Technology Institute, ARTI-21CR/611-40076-01, 2005

Seppänen, O. and W. Fisk , "Association of ventilation system type with sick building
symptoms in office workers", Proceedings: Indoor Air, pp. 98-112, 2001

R.J. de Dear, G. Brager, Developing an adaptive model of thermal comfort and preference, ASHRAE Trans. 104 (1998) 145–167.

M.A. Humphreys, Outdoor temperatures and comfort indoors, Build. Res. Pract. 6 (1978) 92–105.

T. Hoyt, E. Arens, H. Zhang, Extending air temperature setpoints: Simulated energy savings and design considerations for new and retrofit buildings, Build. Environ. 88 (2015)89–96. doi:https://doi.org/10.1016/j.buildenv.2014.09.010.

G. Brager, L. Baker, Occupant satisfaction in mixed-mode buildings, Build. Res. Inf. 37 (2009)369–380. http://www.scopus.com/inward/record.url?eid=2s2.0676512051 85&partnerID=40&md5=147d59dd8a568fa3548f6301338e48e9 .

G.S. Brager, Mixed-mode cooling, ASHRAE J.48(2006)30–37.
http://www.scopus.com/inward/record.url?eid=2s2.0337480928 63&partnerID=40&md5=eb8af7f689ce380aaebb45917ef5dbc4.

S.J. Emmerich, Simulated performance of natural and hybrid ventilation systems in an office building, HVAC.RRes.12(2006)975–1004.http://www.scopus.com/inward/record.url?eid=2s2.0337503056 73&partnerID=40&md5=3e95182949270ea9909d5211a48b9e74.

P.O. Fanger. Thermal Comfort: Analysis and Applications in Environmental Engineering. Newyork: McGraw-Hill Book Company, 1970.

M. Indraganti. "Thermal comfort in naturally ventilated apartments in summer: findings from a field study in Hyderabad,India." Applied Energy 87(3) (2010): 866-83.

P.O. Fanger. "Calculations of thermal comfort: introduction of a basic comfort equation." ASHRAE Trans 73 (1967): 1–4. Thermal comfort, analysis and applications in environmental engineering. New York: McGraw-Hill, 1972.

ISO, ISO 7730, Ergonomics of the thermal environment-- Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria. Geneva: International Organization for Standardization (2005)

M. A. Humphreys and J. F. Nicol: The validity of ISOPMV for predicting comfort votes in every-day thermal environments. Energ Buildings 34(6), 667-684 (2002)