EXPERIMENTAL ANALYSIS AND THERMAL COMFORT INDEX OF AIR CONDITIONED MEETING HALL

Daniel Lawrence I[1], Jayabal S[2], Rajmohan .B[3], Thiruneelakandan G[4]

[1]Faculty, Department of Mechanical Engineering, Anna University Regional Office Madurai, Madurai, Tamilnadu
[2]Faculty, Department of Mechanical Engineering, Alagappa chettiar college of engineering and Technology, Karaikudi, Tamilnadu
[3]Faculty, Department of Mechanical Engineering, Anna University Regional Office Madurai, Madurai, Tamilnadu
[4]Faculty, Department of Mechanical Engineering, Anna University Regional Office Madurai, Madurai, Tamilnadu

Abstract

India's building energy consumption is increasing continuously. The subcontinent does not have custom made thermal comfort standards. We conducted thermal comfort field study in meeting hall, Madurai, tamilnadu, india. Experimental study of thermal comfort was conducted in three levels of load conditions and three levels of air flow in meeting hall during summer 2014. The above three level of load condition and air flow measurements values observed by using direct reading instruments. Thermal comfort indices were also calculated and compare to the natural ventilated meeting hall and outdoor environment. This study aims to evaluate the indoor comfort quality of the meeting hall. This paper is focused on improving the indoor air quality by controlling the vital parameters like carbon dioxide, carbon monoxide, oxygen, room temperature, relative velocity and relative humidity which were used as indicators for indoor air quality and comfort levels. The investigated meeting hall building is located in India, tamilnadu, Madurai and the volume of the building is about 10.60m (length) × 9.14m (width) × 3m (height). This paper provides the detailed specifications to improve the thermal comfort in the air conditioned living atmosphere and ensure safety and healthy living environment. This paper contained Experimental analysis and Calculation of thermal comfort index.

***Keywords**: Meeting hall, Indoor Air Quality, various loads, various air flow rates, thermal comfort index.*

--***--

1. INTRODUCTION

The national building code of India and ASHARE standard -55 specifies two narrow range of indoor comfort temperatures (21°C -26°C) irrespective of building type or location of environment. Indian heating ventilation and air conditioning designers predominantly make use of fanger predicted mean vote (PMV) model to design the indoor environments.

T.T.Chowa at el. Conducted result analysis shows that, like in many other Asian cities, the thermal sensation of the Hong Kong people is sensitive to air temperature and speed, but not much to humidity. With bodily air speed at 0.1 - 0.2 m/s, clothing level 0.55clo and metabolicrate1met, the neutral temperature was found around 25.4°C for sedentary working environment [1]. The outdoor level of carbon-dioxide is usually 350-450 parts per million (ppm). The carbon-dioxide level is usually greater inside a building than outside. If the indoor carbon-dioxide level is more than 1000 ppm, when there is inadequate ventilation, there may be health implications and the occurrence of physical conditions such as headache, fatigue, and irritation of the eyes and the throat [2]. Carbon-monoxide is colorless and odourless, and is a normal constituent of exhaust gases from incomplete combustion. CO is dangerous (more so than CO_2) because it inhibits the blood's ability to carry oxygen to vital organs such as the heart and brain. For office areas, levels of carbon-monoxide are normally between 0 and 5 ppm. Concentrations greater than 5 ppm indicates the possible presence of exhaust gases in the indoor environment and should be investigated. According to the ASHRAE standard, levels of carbon-monoxide inside buildings should not exceed 9 ppm. If the CO level inside a building is detected above 100 ppm, the building should be evacuated until the source is identified and the situation is corrected [2]. The ASHRAE guideline is that indoor temperatures in the winter are maintained between 20°C to 24°C. Temperature in the summer should be maintained between 22.8°C to 26.1°C [2]. Mohammad Taleghani at el. Discussed the main result of the field studies, three internationally well known thermal comfort standards: ASHRAE55-2010, EN15251:2007 and ATG were comprehensively presented. In each standard, database, basic equations, upper and lower boundaries and reference temperatures were discussed comprehensively [3]. M. Kavgic at el. Analyzed the level of indoor air quality and thermal comfort in a typical medium-sized mechanically ventilated theatre, and to identify where improvements could typically be made, a comprehensive post-occupancy evaluation study was carried out on a theatre in Belgrade [5].

K. Luck. Explain the main emphasis in this case is on the well-being of humans, promoting their performance and hence their efficiency, and on achieving high exergetic efficiency [6].

Frauke Oldewurtel at el. Presented this paper an MPC controller, which controls the building based on a standard fixed occupancy schedule, is used as a benchmark. The energy use of this benchmark is compared with three other control strategies [8]. Pawel Wargocki at el. Presented this paper is an overall summary of research by the authors on how classroom conditions affect the performance of schoolwork by children, motivated by the fact that the thermal and air quality conditions in school classrooms are now almost universally worse than the relevant standards and building codes stipulate that they should be[10]. Above papers, a meeting hall with air conditioning facility was selected and experiments were conducted to study the characteristics of IAQ likely carbon dioxide, carbon monoxide, oxygen, room temperature, air velocity and relative humidity which were used as indicators for IAQ and comfort levels in this present investigation.

2. METHODOLOGY

Investigate the air conditioning systems in modern buildings like meeting hall. The Variable parameters of air conditioning Systems are Air Exchange rate, Air velocity, Thermal properties of indoor Equipments and human. The Measurable parameters of air conditioning systems are Air flow, Relative humidity, Temperature and Concentration of Gaseous pollutants and Oxygen. These parameters are to be continuously monitored by an instrument and simulation by using various ventilation systems and have to be calibrated before Experimental measurement.

2.1 Field Study

The experiment was carried out in meeting hall in office building. Measurement data in variable volume rate the room should be in various climatic environments. The measurable parameters are air flow, temperature flow, gas flow and relative humidity was measured every 30 mints in natural ventilation and air conditioning (4 individual duct) was running 8 hours each case . Also outdoor climate condition was measured every half hour once. Indoor conditions the measurement was taken Middle of the room. Were found regarding the current indoor environment of indoor particulate are mentioned below table in field studies.

Table 2.1 Material Used In Indoor Environment

S No	Load	volume
1	Tube light	8 (40w)
5	Roofing	concrete
6	Flooring	Marble (Thickness 10cm)
7	Concrete Wall	4 side (Thickness 15cm)
9	Load	45 person
10	Fresh air supply	10%

2.2 Outdoor Environment

The outdoor measurements were performed in this experiment. Morning to evening reported there thermal comfort. The six parameters are observed in this experiment was completed in eight days for each case two times. The parameters describe the quality of outdoor environment.

2.3 Description of the Problem

- To evaluate indoor air quality (IAQ) factors in three level of air flow volume, three level of load and three level of time period.
- Predict the thermal comfort in meeting hall

2.4 Objective

- To provide better indoor air quality (IAQ) performance to the Occupant.
- To satisfy the all level of expectation on thermal comfort in meeting hall.
- Also eliminate the negative influence upon the human health issue and Adaptive for variable climatic environments.

2.5 Experimental Approach

Investigate the air conditioning systems in modern building like meeting hall.

The Variable parameters of air conditioning Systems are Air flow rate, about Human load with respect to time period.

The Measurable parameters of air conditioning systems are Relative velocity, Relative humidity, indoor Temperature, Carbon dioxide, Carbon monoxide and Oxygen.

These parameters are continuously monitored by direct reading instrument has to be calibrated before Experimental measurement.

Table 2.6 ASHRAE standard parameters for indoor environment [2]

S. No	Parameter	ASHRAE standard
1	Carbon-dioxide	0 to1000ppm
2	Carbon-monoxide	0 to9ppm
3	Temperature	20°C to 26.1°C

2.7. Instruments used for Measurements

- Digital Thermo Hygrometer (Range: Temp -50°C to +70°C, RH 10% to 99%, Accuracy: Temp ±1°C,RH ±5%)
- Anemometer (Range: 0.4-45 m/sec, Accuracy: ±2%+0.1m/s)
- CO Meter (Range: 0 to1000ppm, Accuracy : ±5%+2ppm)
- CO_2 Meter (Range: 0 to 4000ppm, Accuracy : ±40ppm)
- O_2 Meter (Range: 0 to 30%, Accuracy: ±1%+0.2%)

2.8. Measurement observation

Experimental Measurements are noted at three level of air flow volume with sixty human load with furniture's on the one full working hours. The measurable parameters are temperature, relative humidity, relative velocity, carbon dioxide, carbon monoxide and oxygen are continuously measured eight hours time period with 30 mints interval air conditioned environment in meeting hall. Because of urban environment the outdoor environment measurable parameters of the above are measured every half hour once. All the measurable parameters are measured in indoor was taken Middle of the room.

Experimental measurements are presented in table's representation of Air flow volume 1400cfm with human load.

3. RESULT & DISCUSSION

3.1 Experimental Readings for Meeting Hall:

The experimental indoor air quality results are presented in table. Experimental measurements are presented in table's representation of Air flow volume 1400cfm with human load.

Table 3.1 Airflow volume 1400 with without loading

Time	Indoor / Outdoor	Temp (°C)	RH (%)	CO (ppm)	CO_2 (ppm)	O_2 (%)	RV (m/s)
9.00	ID	29.6	56.	0.0	433	19.	0.40
	OD	33.2	50.	1.0	392	19.	1.50
9.30	ID	25.9	49.	0.0	436	18.	0.40
	OD	35.5	47.	1.0	383	19.	1.70
10.00	ID	24.4	46.	0.0	427	19.	0.40
	OD	37.0	45.	1.0	361	19.	1.20
10.30	ID	24.2	48.	0.0	439	19.	0.40
	OD	37.5	45.	2.00	364	19.	1.20
11.00	ID	23.1	49.	0.00	452	18.	0.40
	OD	38.0	46.	0.00	382	19.	0.70
11.30	ID	22.0	50.	0.00	443	18.	0.40
	OD	39.0	44.	0.00	372	19.	1.70
12.00	ID	22.9	49.	0.00	429	18.	0.40
	OD	39.5	36.	0.00	345	20.	0.70
12.30	ID	23.0	47.	0.00	440	18.	0.40
	OD	39.5	37.	0.00	371	19.	0.90
1.00	ID	23.7	45.	0.00	403	19.	0.40
	OD	40.0	35.	0.00	325	20.	1.70
1.30	ID	24.5	43.	0.00	429	18.	0.40
	OD	39.5	35.	0.00	355	19.	0.80
2.00	ID	24.5	45.	0.00	429	19.	0.40
	OD	39.0	36.	0.00	395	19.	0.40
2.30	ID	24.4	47.	0.00	419	18.	0.40
	OD	38.0	36.	0.00	363	19.	0.70
3.00	ID	23.7	42.	0.00	443	18.	0.40
	OD	38.0	34.	0.00	355	19.	0.80
3.30	ID	22.6	43.	0.00	447	19.	0.40
	OD	36.5	37.	0.00	351	19.	0.60
4.00	ID	22.7	45.	0.00	437	18.	0.40
	OD	35.5	38.	0.00	342	19.	0.40
4.30	ID	21.9	47.	0.00	447	18.	0.40
	OD	35.0	38.	0.00	357	19.	0.90
5.00	ID	21.3	48.	0.00	467	18.	0.40
	OD	34.50	40.0	0.00	340	19.6	0.60

Table 3.2 Airflow volume 2100 with without loading

Time	Indoor /	Temp	RH (%	CO (ppm)	CO_2 (ppm)	O_2 (%	RV (m/
9.00	ID	29.1	57	0	483	19	0.4
	OD	30.2	55	1	384	20	1.6
9.30	ID	27	48	0	479	19	0.4
	OD	32.1	54	1	370	20	1.2
10.00	ID	25.5	47	0	488	19	0.4
	OD	34.2	50	1	391	20	1.4
10.30	ID	21.6	45	0	503	19	0.4
	OD	35.6	50	1	371	20	1.1
11.00	ID	20.8	48	0	504	19	0.4
	OD	37.1	44	1	357	20	1.3
11.30	ID	19.6	45	0	507	19	0.4
	OD	37.4	43	0	364	20	1
12.00	ID	20.5	47	0	528	19	0.4
	OD	38	40	0	358	19	1.2
12.30	ID	20.1	48	0	501	19	0.4
	OD	38.2	39	0	351	20	0.9
1.00	ID	20.9	45	0	511	19	0.4
	OD	39.4	37	0	371	20	1.6
1.30	ID	19.9	45	0	514	19	0.4
	OD	39	37	0	335	20	1
2.00	ID	19.5	45	0	538	19	0.4
	OD	38.7	38	0	315	20	1.3
2.30	ID	18.8	46	0	549	19	0.4
	OD	37.5	40	0	352	20	1.4
3.00	ID	18.7	46	0	569	19	0.4
	OD	36.5	40	0	376	20	1.2
3.30	ID	18.8	49	0	561	19	0.4
	OD	36.1	40	0	371	20	1.6
4.00	ID	18.6	47	0	559	19	0.4
	OD	35.5	40	0	368	20	1.5
4.30	ID	18.5	47	0	566	19	0.4
	OD	34.2	40	0	359	20	1.1
5.00	ID	18.5	48	0	568	19	0.4
	OD	33.4	42	0	348	20	0.8

Table 3.3 Airflow volume 2700 with without loading

Time	Indoor / Outdoor	Temp (°C)	RH (%)	CO (ppm)	CO_2 (ppm)	O_2 (%)	RV (m/s)
9.00	ID	29.8	56	0	430	20	0.4
	OD	30.5	55	1	381	20	1.6
9.30	ID	26.6	49	0	426	19	0.4
	OD	32.3	54	1	367	20	1.9
10.00	ID	25.2	48	0	429	19	0.4
	OD	34.2	50	1	397	20	1.3
10.30	ID	21.4	45	0	457	19	0.4
	OD	35.2	49	1	371	20	1.3
11.00	ID	20.3	48	0	449	19	0.4
	OD	36.5	45	0	357	20	1.1
11.30	ID	19.8	51	0	455	19	0.4
	OD	37	43	0	364	20	0.7
12.00	ID	19.8	50	0	455	19	0.4
	OD	37.5	41	0	367	21	1.4
12.30	ID	20.2	49	0	465	19	0.4
	OD	37.1	40	0	353	20	0.6
1.00	ID	20.8	49	0	447	19	0.4
	OD	37.9	37	0	377	20	0.8
1.30	ID	21.1	48	0	473	19	0.4
	OD	38.5	40	0	389	20	1.7
2.00	ID	21.5	47	0	477	19	0.4
	OD	39.3	40	0	371	20	0.9
2.30	ID	21.1	47	0	498	19	0.4
	OD	38.2	42	0	383	20	0.8
3.00	ID	19.8	48	0	511	19	0.4
	OD	37.3	40	0	371	20	1.2
3.30	ID	19.2	49	0	487	19	0.4
	OD	36	43	0	383	20	1.1
4.00	ID	18.8	49	0	521	19	0.4
	OD	35	44	0	405	20	1.6
4.30	ID	19.4	50	0	558	19	0.4
	OD	34.3	44	0	402	21	2.1
5.00	ID	18.5	52	0	553	19	0.4
	OD	33.8	46	0	393	20	1.9

The measured variables of without load in meeting hall are tabulated. Readings are identified better comfort zone with efficient energy consumption. From the above tables without load the meeting hall obtained thermal comfort below 1400cfm as per ASHARE standard. Without human load the meeting hall no need to too cool.

Table 3.4 Airflow volume 1400 with partial load

Time	Indoor / Outdoor	Temp (°C)	RH (%)	CO (ppm)	CO_2 (ppm)	O_2 (%)	RV (m/s)
9.00	ID	30	56	0	429	20	0.4
	OD	31.5	54	2	387	20	1.7
9.30	ID	27.2	52	0	419	19	0.4
	OD	33	53	2	371	20	1.1
10.00	ID	26	51	0	431	19	0.4
	OD	35	50	2	393	20	1.3
10.30	ID	24	50	0	413	19	0.4
	OD	35.5	50	1	374	20	1
11.00	ID	24	50	0	422	19	0.4
	OD	37	44	1	351	21	1.2
11.30	ID	23.3	52	0	411	19	0.4
	OD	37.2	43	0	361	20	0.9
12.00	ID	23.2	46	0	431	19	0.4
	OD	38	41	0	362	20	1.2
12.30	ID	22.7	47	0	439	19	0.4
	OD	37.8	39	0	359	20	1.5
1.00	ID	23.6	46	0	441	19	0.4
	OD	38	37	0	373	20	2.2
1.30	ID	22.8	44	0	407	19	0.4
	OD	37.4	40	0	315	20	0.9
2.00	ID	22.1	44	0	392	19	0.4
	OD	37	44	0	265	19	1.1
2.30	ID	22.4	45	0	439	19	0.4
	OD	37.1	44	0	347	20	1.4
3.00	ID	21.8	47	0	437	19	0.4
	OD	37	40	0	372	20	1.1
3.30	ID	22.6	45	0	443	19	0.4
	OD	36.2	42	40	371	20	1.7
4.00	ID	21.9	48	0	529	19	0.4
	OD	35.5	44	0	365	19	1.5
4.30	ID	22.2	49	0	563	19	0.4
	OD	35.1	41	0	353	20	1.1
5.00	ID	21.6	51	0	597	19	0.4
	OD	34.5	40	0	345	19	0.6

Table 3.5 Airflow volume 2100 with partial load

Time	Indoor / Outdoor	Temp (°C)	RH (%)	CO (ppm)	CO_2 (ppm)	O_2 (%)	RV (m/s)
9.00	ID	29	56	0	489	19	0.4
	OD	29.8	56	0	417	20	0.9
9.30	ID	27.3	47	0	513	19	0.4

	OD	30.5	52	0	409	19	0.5
10.00	ID	24.5	47	0	525	19	0.4
	OD	31	50	0	421	20	0.7
10.30	ID	23.3	47	0	537	19	0.4
	OD	31.1	47	0	416	20	0.8
11.00	ID	22.6	45	0	538	19	0.4
	OD	31.3	45	0	399	19	0.5
11.30	ID	22.8	45	0	549	19	0.4
	OD	32.7	40	0	371	20	0.8
12.00	ID	23.7	45	0	559	19	0.4
	OD	34	38	0	359	20	0.7
12.30	ID	25.1	41	0	549	19	0.4
	OD	36.1	38	0	372	20	1
1.00	ID	23.3	42	0	554	19	0.4
	OD	38.4	36	0	362	20	0.9
1.30	ID	22.2	45	0	569	19	0.4
	OD	38.5	35	0	361	20	1.1
2.00	ID	22.1	45	0	581	19	0.4
	OD	39.1	32	0	355	20	0.6
2.30	ID	21.4	45	0	582	19	0.4
	OD	39	32	0	347	20	0.5
3.00	ID	21	44	0	588	19	0.4
	OD	37.3	38	0	367	20	0.7
3.30	ID	20.7	44	0	591	19	0.4
	OD	36.1	39	0	369	20	0.8
4.00	ID	19.2	44	0	609	19	0.4
	OD	35	41	0	371	20	1
4.30	ID	18.5	46	0	605	19	0.4
	OD	33.9	44	0	391	19	1
5.00	ID	18.5	46	0	632	19	0.4
	OD	31.2	46	0	402	19	0.6

Table 3.6 Airflow volume 2700 with partial load

Time	Indoor / Outdoor	Temp (°C)	RH (%)	CO (ppm)	CO_2 (ppm)	O_2 (%)	RV (m/s)
9.00	ID	29	57	0	442	19	0.4
	OD	29.5	56	0	382	20	2.4
9.30	ID	26.9	47	0	459	19	0.4
	OD	30	54	0	372	20	2.7
10.00	ID	25.5	47	0	464	19	0.4
	OD	30.4	54	0	379	19	2.5
10.30	ID	23.8	47	0	459	19	0.4
	OD	29.2	56	0	384	20	2.4
11.00	ID	22.4	48	0	445	19	0.4
	OD	28.9	57	0	376	20	3.1
11.30	ID	22.8	47	0	459	19	0.4
	OD	30.5	50	0	351	20	2.7
12.00	ID	22.1	48	0	493	19	0.4
	OD	31	50	0	347	20	2.4
12.30	ID	20.8	49	0	523	19	0.4
	OD	31.1	50	0	325	20	2.5
1.00	ID	19.3	49	0	534	19	0.4
	OD	32	50	0	302	20	2.7
1.30	ID	18.9	48	0	517	19	0.4
	OD	31.7	50	0	351	20	2.3
2.00	ID	18.4	46	0	533	19	0.4
	OD	32	49	0	342	20	2.8
2.30	ID	18.8	52	0	554	19	0.4
	OD	32.6	47	0	367	19	2.9
3.00	ID	18.7	45	0	606	19	0.4
	OD	33.5	45	0	380	19	2.7
3.30	ID	18.5	45	0	613	19	0.4
	OD	33.1	44	0	373	20	2.8
4.00	ID	18.7	45	0	577	19	0.4
	OD	33	42	0	366	20	3.2
4.30	ID	18.4	47	0	617	19	0.4
	OD	32.1	40	0	361	20	3.1
5.00	ID	18.3	47	0	621	19	0.4
	OD	31.5	40	0	355	20	3.3

The measured variables of with partial load in meeting hall are tabulated. Here the partial load means only consider furniture and indoor equipments. Readings are identified better comfort zone with efficient energy consumption. From the above tables without load the meeting hall obtained thermal comfort below 1400cfm as per ASHARE standard temperature level. Without human load the meeting hall no need to too cool.

Table 3.7 CFM: 1400 –FULL LOAD

Time	Indoor / Outdoor	Temp (°C)	RH (%)	CO (ppm)	CO_2 (ppm)	O_2 (%)	RV (m/s)
9.00	ID	29.2	56	0	417	20	0.4
	OD	30.1	55	1	357	20	2.2
9.30	ID	29	52	0	1249	19	0.4
	OD	31.5	54	1	379	20	2.4
10.00	ID	28.2	49	0	1725	19	0.4
	OD	33	52	1	384	20	2.8
10.30	ID	28	49	0	2497	19	0.4
	OD	34.5	49	1	375	20	3
11.00	ID	27.6	48	0	3011	19	0.4
	OD	36.1	48	0	391	20	2.4
11.30	ID	27.3	47	0	3469	19	0.4
	OD	37.3	45	0	361	20	2.2
12.00	ID	26.8	47	0	3664	19	0.4
	OD	37.9	42	0	374	20	2.3
12.30	ID	27.1	46	0	3754	19	0.4
	OD	38.4	40	0	359	20	2.7

1.00	ID	26.8	46	0	3939	19	0.4
	OD	39.8	36	0	354	20	3.1
1.30	ID	26.5	46	0	4097	19	0.4
	OD	40.4	34	0	341	20	1.9
2.00	ID	26.5	46	0	4157	19	0.4
	OD	41	31	0	347	20	2.6
2.30	ID	26.4	47	0	4167	19	0.4
	OD	40.1	33	0	371	20	2.8
3.00	ID	26.5	47	0	4159	19	0.4
	OD	39	36	0	364	20	2.1
3.30	ID	26.2	48	0	4198	19	0.4
	OD	37.4	37	0	383	20	2.3
4.00	ID	26.1	48	0	4191	19	0.4
	OD	36.2	39	0	379	20	2
4.30	ID	26.2	49	0	4207	19	0.4
	OD	34.3	43	0	392	20	1.8
5.00	ID	26	49	0	4209	19	0.4
	OD	32.1	47	0	384	20	2

Table 3.8 CFM: 2100-FULL LOAD

Time	Indoor / Outdoor	Temp (°C)	RH (%)	CO (ppm)	CO_2 (ppm)	O_2 (%)	RV (m/s)
9.00	ID	28.3	53	0	443	19	0.4
	OD	29.5	56	1	371	20	1.8
9.30	ID	27.4	52	0	1339	19	0.4
	OD	31.1	54	1	367	20	2.3
10.00	ID	26.5	50	0	1795	19	0.4
	OD	33.4	52	1	384	20	2.5
10.30	ID	25.7	49	0	2361	19	0.4
	OD	34.8	49	0	393	20	2.6
11.00	ID	25.5	49	0	2815	19	0.4
	OD	35.7	46	0	368	20	1.9
11.30	ID	24.9	48	0	3505	19	0.4
	OD	37	43	0	371	20	2.2
12.00	ID	25.5	48	0	3689	19	0.4
	OD	37.7	42	0	353	20	2.1
12.30	ID	25.4	47	0	3869	19	0.4
	OD	38.1	40	0	348	20	2.1
1.00	ID	25.2	45	0	4092	19	0.4
	OD	38.5	36	0	361	20	1.9
1.30	ID	25.2	46	0	4227	19	0.4
	OD	39.2	35	0	338	20	2.5
2.00	ID	25.2	46	0	4294	19	0.4
	OD	39.5	35	0	345	20	2.4
2.30	ID	25	47	0	4318	19	0.4
	OD	40	33	0	357	20	2.7
3.00	ID	24.9	47	0	4318	19	0.4
	OD	39.1	35	0	367	20	2.3
3.30	ID	24.8	47	0	4339	19	0.4
	OD	38.4	37	0	371	20	2.7
4.00	ID	24.7	47	0	4343	19	0.4
	OD	37.1	38	0	383	20	2.4
4.30	ID	24.7	48	0	4339	19	0.4
	OD	35.2	44	0	357	20	3
5.00	ID	24.5	49	0	4347	19	0.4
	OD	33.1	48	0	394	20	2.8

Table 3.9 CFM: 2700-FULL LOAD

Time	Indoor / Outdoor	Temp (°C)	RH (%)	CO (ppm)	CO_2 (ppm)	O_2 (%)	RV (m/s)
9.00	ID	28.5	54	0	464	19	0.4
	OD	30.2	55	1	392	20	1.8
9.30	ID	26.8	50	0	1287	19	0.4
	OD	32.3	53	1	378	20	1.2
10.00	ID	25.9	49	0	1769	19	0.4
	OD	34.7	50	1	398	20	1.6
10.30	ID	24.9	49	0	2472	19	0.4
	OD	35.8	50	1	377	20	1.1
11.00	ID	24.4	50	0	2943	19	0.4
	OD	37.1	44	1	362	20	1.4
11.30	ID	25	48	0	3682	19	0.4
	OD	37.5	43	0	357	20	1.1
12.00	ID	24.5	47	0	3861	19	0.4
	OD	38	41	0	367	20	1.4
12.30	ID	24.6	47	0	4109	19	0.4
	OD	38.4	39	0	352	20	1.9
1.00	ID	25.1	47	0	4287	19	0.4
	OD	39.5	37	0	381	20	2
1.30	ID	24.4	46	0	4410	19	0.4
	OD	40.2	34	0	357	20	1.2
2.00	ID	24.4	46	0	4472	19	0.4
	OD	40	36	0	332	20	1.3
2.30	ID	24.1	46	0	4491	19	0.4
	OD	39.1	38	0	364	19	1.1
3.00	ID	24.1	46	0	4519	19	0.4
	OD	38	40	0	365	20	1.7
3.30	ID	24.1	46	0	4532	19	0.4
	OD	37.2	41	0	374	20	1.1
4.00	ID	24.1	47	0	4537	19	0.4
	OD	35.4	43	0	359	20	1.5
4.30	ID	23.9	47	0	4547	19	0.4
	OD	34.1	46	0	384	19	1.6
5.00	ID	23.9	47	0	4559	19	0.4
	OD	32.9	48	0	394	20	1.2

The measured variables of with Full load in meeting hall are tabulated. Here the full load means only consider furniture, indoor equipments and human load. Readings are identified better comfort zone with efficient energy consumption. From the above tables without load the meeting hall obtained thermal comfort below 2100 cfm as per ASHARE standard temperature level.

Table.3.6,3.7,3.8.Corbon dioxide is constantly increased in the room and it is minimum at morning 9.30am and maximum at evening 5.00 pm. Recommended ASHRAE standard Co_2 value for buildings in indoor is 1000 ppm. The Experimental result CO_2 is crossing maximum value as per ASHARE in meeting hall with occupants of 45 peoples in 1400 cfm, 2100 cfm, and 2700 cfm. Empty and Partial load is taken because of reference purposes.

Table.3.6,3.7,3.8.When the air conditioner is switch on at 9.00 am and inner temperature of the room is decreased slowly. In afternoon time period the 12.30 pm to 2.30 pm the inner room temperature is slightly increase because of outdoor temperature was increased and after 3.00 pm the indoor air temperature is decreased. Recommended ASHRAE standard summer temperature value for buildings in indoor is 22.8-26.1°C [2] in India. The experimental result obtained as per standard in the flow of 2100cfm and 2700cfm.

Table.3.6,3.7,3.8.When the air conditioner is switch on at 9.00 am and inner Relative humidity of the room is constantly maintain 45±5 .Recommended ASHRAE standard Relative humidity value for buildings in indoor is 45 to 55% [2] in India. . The experimental result obtained as per standard in the flow of 1400cfm, 2100cfm and 2700cfm.

Carbon monoxide is not exceeding ASHRAE standard level in indoor environment (0 to 9 ppm) (parts /million) it is 0 in indoor all the time it should be same. Outdoor it should be 1ppm in morning peak hours in (9.00 am to 11.00 am) and remaining time 0ppm.

O_2 level in the room maintained 19±0.2.Air velocity is 0.4 m/s in middle position of the room in all the time it should be same one.

Thermal comfort is obtained from three modes of air flow in meeting hall for empty and partial load. But the human load increase to 45 occupants its obtained thermal comfort in 2100cfm, and 2700cfm. But human comfort not yet obtained in the three mode of air flow because of the obtained value of carbon dioxide. Without fresh air supply or ventilation the human comfort not yet obtained. From the experimental results the 2100cfm it's having comfort compare with 1400Cfm, 2700Cfm.

3.2 Thermal Comfort Index

According to ASHRAE-55, thermal comfort has been defined as the condition of mind which illustrates satisfaction with the thermal environment, and thermal sensation is related to heat balance between the human body and its ambient thermal condition. Depending on the heat transfer, via heat gain or loss, the Thermoregulation system in a human brain regulates skin temperature to maintain a constant core body temperature of 36.5° C. meanwhile indoor temperature 22°C to 26°C, Relative humidity 42% to 48%, Carbon monoxide 0 to 9ppm, carbon dioxide 0 to 1000ppm and Oxygen 19.0±0.2% As per ASHARE. Thermal comfort index of the model are calculated using the fanger model. The volume of data obtained from the experimental value helps to find the comfort condition in high level accuracy.

The fanger model of thermal comfort is calculated by predicted mean vote and predicted percentage dissatisfied. The PMV and PPD model is based on the combined influence of relative humidity, air temperature, mean radian t temperature, air movement to that of clothing and activity level.

$$\mathbf{PMV=3.155(0.303e^{-0.114M}+0.028)\ L}$$
$$\mathbf{PPD = 100 - 95\ exp\ [-(0.03353\ PMV\ 4 + 0.2179\ PMV2)]}$$

The experimental values are calculated to find the PPD and the results are been plotted below, to find the comfort condition. As per fanger model the thermal comfort index calculated. Normally the low bound that PMV>0 was recommended in summer and the up bound that PMV<0 was recommended in winter.

2.5 PMV-PPD model of cabin

S.NO	AIR FLOW RATE	LOAD	FRESH AIR SUPPLY	PMV (-3 to+3)	PPD(%)
1	1400	EMPTY	10	- 0.46	9.5
2	2100	EMPTY	10	-1.15	33.1
3	2700	EMPTY	10	-1.15	32.6
4	1400	P.LOAD	10	-0.38	8
5	2100	P.LOAD	10	-1.17	33.9
6	2700	P.LOAD	10	-1.18	34.5
7	1400	F.LOAD	10	0.73	16.2
8	2100	F.LOAD	10	0.15	5.5
9	2700	F.LOAD	10	0.07	5.1

4. CONCLUSION

Providing comfort environment inside the meeting hall is very complex because of subjective nature. This investigation presented the suitable comfort environment for human load. The results are presented in tabulation. The presented tabulation are expressed the temperature, relative humidity, carbon monoxide, carbon dioxide oxygen and relative velocity about variable loads, air flow rate, and fresh air supply. In general the value of CO_2 in more compare from indoor to outdoor because of increasing human load. To summarize, from our experimental results 1400cfm for without human load, 1400cfm for partial load and 2100cfm for full load are the thermal comfort environment in meeting hall. The result shows that parameters are clearly. The carbon monoxide and oxygen and relative velocity are may be same because of observed values are same in maximum observation. But carbon dioxide temperature and relative humidity are changed in each and every frequency of variable climatic conditions.

As per fanger model the thermal comfort index calculated. Normally the low bound that PMV>0 was recommended in summer and the up bound that PMV<0 was recommended in winter. Recommended ranges of indoor air design parameters were determined for meeting hall was 1400cfm air flow with 10% fresh air supplies for without load obtained PMV value -0.46 and PPD 9.1%, 1400cfm air flow with 10% fresh air supply for Partial loads obtained PMV value -0.38 and PPD 8% and 2100cfm air flow with 10% fresh air supply for full loads obtained PMV value 0.15 and PPD 5.5% are also the comfort environment as per thermal comfort index.

Concluding from these experimental results the quality of indoor air parameters are observed about variable climatic condition in normal standard fresh air supply. The experimental results and thermal comfort index are point out the comfort environment in cabin were both of the results are same, so on the predicted results are provide the human and thermal comfort with healthy environment. The results showed the PMV and PPD values are surprisingly closed to zero and the human and thermal comfort parameters are also the limit of ASHARE standard in the meeting hall.

REFERENCES

[1]. T.T.Chowa, K.F.Fong, B.Givoni, ZhangLin, A.L.S.Chan. Thermal sensation of Hong Kong people with increased air speed, temperature and humidity in air-conditioned environment. Elsevier - Building and Environment (2010) Vol. 45 PP 2177 - 2183

[2]. Shubhajyoti Saha, Abhijit Guha, Subhransu Roy. Experimental and computational investigation of indoor air quality inside several community kitchens in a large campus. Elsevier-Building and Environment (2012) Vol.52 PP 177-190.

[3]. Mohammad Taleghani, MartinTenpierik, StanleyKurvers, Andyvanden Dobbelsteen. A review into thermal comfort in buildings Elsevier – Renewable and Sustainable Energy Reviews (2013) Vol. 26 PP 201–215

[4]. Fabrizio Ascione, Laura Bellia, Alfonso Capozzoli. A coupled numerical approach on museum air conditioning: Energy and fluid-dynamic analysis. Elsevier - Applied Energy (2013) Vol 103 PP 416–427

[5]. M. Kavgic, Mumovic, Z. Stevanovic, A. Young .Analysis of thermal comfort and indoor air quality in a mechanically ventilated theatre. Elsevier -Energy and Buildings (2008) Vol.40 PP 1334–1343

[6]. K. Luck. Energy efficient building services for tempering performance-oriented interior spaces - A literature review. Elsevier - Journal of Cleaner Production (2012) Vol.22 PP 1- 10

[7]. Li Lan, Li Pan, Zhiwei Lian, Hongyuan Huang, Yanbing Lin. Experimental study on thermal comfort of sleeping people at different air temperatures. Elsevier - Building and Environment (2014) Vol.73 PP 24 -31

[8]. Frauke Oldewurtel, David Sturzenegger, Manfred Morari. Importance of occupancy information for building climate control. Elsevier-Applied Energy (2013) Vol.101 PP 521–53

[9]. Cuimin Li, Jianing Zhao. Experimental Study on Indoor Air Temperature Distribution of Gravity Air-Conditioning for Cooling. Elsevier - Energy Procedia (2012) Vol.17 PP 961 – 967

[10]. Pawel Wargocki, David P. Wyon. Providing better thermal and air quality conditions in school classrooms would be cost-effective. Elsevier - Building and Environment (2013) Vol.59 PP 581- 589