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Study and Analysis of Indoor Air Quality Characteristics on Air Conditioned Application in Hospital Room

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Abstract - **Hospital is one of the most critical buildings in indoor air quality (IAQ) and thermal comfort demand, since the proper indoor environment may effects on health and well-being of both staff and patient. This study aims to evaluate the indoor air quality and thermal comfort of the patient room in one of hospital, Madurai,Tamilnadu, india. A new study in indoor air quality monitoring method using continuous CO_2, CO, O_2, temperature, relative velocity and relative humidity sensors was developed and validated through field studies. Field tests were conducted in hospital room eight weekdays using Gas sensors coupled with data loggers. Indoor temperature, relative humidity (RH), Relative velocity, Oxygen, CO and CO_2 concentrations were continuously monitored while outdoor parameters combined with on-site climate conditions were recorded. Statistical results indicated that good indoor performance was achieved. This paper is focused on improving the indoor air quality by controlling the vital parameters like carbon dioxide, carbon monoxide, oxygen, room temperature, air velocity and relative humidity which were used as indicators for IAQ and comfort levels. The above stated parameters have to be studied under various rates of ventilations, fresh air supply and load. The investigated volume of the building is about 4.70m (length) × 4.00m (width) × 2.7m (height). This paper provides the detailed technical specifications to improve the human and thermal comfort in the air conditioned living atmosphere and ensure safety and healthy living environment.**

Key words - Hospital room, Indoor Air Quality, various air flow volume, sick building syndrome, cooling load, climatic environment.

1.INTRODUCTION

One of the more unfortunate aspects of modern global development has been the introduction and wide spread acceptance of the use of mechanical means for providing desired comfortable indoor air quality (IAQ) for building users. This phenomenon has led to huge energy consumption in the building stock, and nowadays, around one third of fossil fuel is consumed in buildings. In this regard, IAQ boundaries are limitations which help building physicists to estimate to what extent buildings should be heated or cooled. Indoor air quality (IAQ) is a term which refers to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants. Thermal comfort is defined as that condition of mind which expresses satisfaction with the thermal environment. Air conditioning systems has been used in many parts of the world. The purpose of most systems is to provide human and thermal comfort and an acceptable indoor air quality (IAQ) for occupants. With the improvement of standard of living, occupants require more and more comfortable and healthful indoor environment. People spend 80-90% of their time indoors, and indoor environment has important effects on human health and work efficiency. The factors affecting indoor environment mainly include temperature, humidity, air exchange rate, air movement, ventilation, particle pollutants, biological pollutants, and gaseous pollutants. By analyzing recent studies, there was an increase in prevalence of sick building syndrome (SBS) in the buildings with air-conditioning systems when compared with natural ventilation systems [1]. All of these events are a warning for indoor environment problems related to AC systems. 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. Carbon-monoxide is colorless and odorless, 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. 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]. However it is exciting that some comfortable and healthy air-conditioning systems were proposed in the past few years. In order to control the concentration level of indoor pollutants and to improve IAQ, many researchers have investigated the control methods of IAQ. In this paper, will be study on air-conditioning systems indoor air quality control in Indian residencies.

II. METHODOLOGY

Investigate the air conditioning systems in modern buildings like Rooms, Apartments, and Auditorium. The Variable parameters of air conditioning Systems are Air Exchange rate, Air velocity, Compressor Speed, Refrigerant mass flow rate, Thermal properties of indoor Equipments and furniture's, cooling capacity.

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. Reference for ASHRAE standard parameters for indoor Environment [3].

2.1. Field study

The experiment was carried out in patient room of hospital building in India. 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 (1central 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 hospital room field studies. The study in India shows that people were exposed to too low or high air temperature and CO_2 concentration etc.

S No	Load	volume
1	Tube light	2 (40w)
2	Patient cot	1
3	Chair	2
4	Trolley table	1
5	Roofing	concrete
6	Flooring	Marble(Thickness 10cm)
7	Concrete Wall	4 side (Thickness 15cm)
8	Air conditioner	1 central duct (1.5 ton)
9	Load	3 person
10	Fresh air supply	10%

Table 2.1 Material Used In Indoor Environment

2.2 Outdoor Environment

The outdoor measurements were performed in this experiment. Morning to evening reported there air quality. 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.

Time	Temp (°C)	RH (%)	CO2 (ppm)	CO2 (ppm)	O2 (%)	Rv (m/s)
9.00	29.8	55	1	422	19.8	1.8
9.30	30.3	55	1	432	19.4	2
10.00	32.4	52	1	411	19.5	2.1
10.30	34.2	48	1	381	19.3	1.4
11.00	35.8	45	0	374	19.8	1.4
11.30	37.1	43	0	389	19.6	1.1
12.00	38.1	37	0	392	19.1	1.1
12.30	39.4	35	0	381	18.9	1.8
13.00	39.1	35	0	385	19.2	2.2
13.30	38.1	36	0	391	19.1	2
14.00	37.4	38	0	373	19.4	1.6
14.30	36.8	38	0	367	18.9	1.2
15.00	36.5	37	0	367	20.3	1
15.30	35.2	38	0	371	20	1.9
16.00	34.1	40	0	378	20	2.1
16.30	33	44	0	381	19.3	1.1
17.00	31.4	47	0	409	19.2	1.4

Table 2.2 Outdoor Air Quality Parameters

III.RESULT AND DISCUSSION

Shows the physical parameters describing the indoor environment in the patient room. The stated six parameters are observed in patient room in mentioned standard load conditions. The relative velocity did not deviate from the intended levels. No significant thermal comfort was found in natural ventilation and 200 cfm air flow rate.

Time	Temp (°C)	RH (%)	CO2 (ppm)	CO2 (ppm)	O2 (%)	Rv (m/s)
9	29.6	51	0	411	19.2	0.4
9.3	29.2	50	0	401	19.2	0.4
10	30.9	46	0	407	18.9	0.4
10.3	30.4	46	0	410	19.1	0.4
11	30.9	46	0	434	19.1	0.4
11.3	29.8	47	0	476	19.1	0.4
12	29.4	48	0	480	19.8	0.4
12.3	32	44	0	494	19.5	0.4
13	31	45	0	515	18.9	0.4
13.3	30.8	45	0	543	19.1	0.4
14	30.5	44	0	592	19	0.4
14.3	31	41	0	563	19.1	0.4

15	31.4	41	0	574	19.1	0.4
15.3	31.2	42	0	581	19.2	0.4
16	30	44	0	585	19.2	0.4
16.3	29.6	46	0	591	19	0.4
17	29.1	48	0	595	19.5	0.4

3.1 Condition: Natural Ventilation

From our result the maximum and minimum temperature and relative humidity are obtained 32°C, 29.1°C and 55 %, 41%.In the morning and evening time the temperature is nearer to minimum and Relative humidity Maximum. In after noon time period the temperature maximum and Relative humidity minimum. In our result conclude about Human and Thermal comfort is good on morning and evening time period compare to afternoon in natural ventilation condition. In afternoon 11.00am to 3.00 pm there has increasing of temperature and decrease of relative humidity. Between this times is inconvenient to patients.Carbon monoxide is not exceeding ASHRAE standard level in indoor environment (0 to 9 ppm). Its 1ppm in morning peak hours in (9.00 am to 11.00 am) and remaining time 0ppm.Corbon dioxide is constantly increase in the room and it is minimum at morning 9.30am 401 ppm and maximum at 5 .00 pm 595 ppm. It can be below the ASHRAE standard indoor value is 1000 ppm.O_2 level in the room maximum 19.8 % and minimum 19.1%.Air velocity is 0.4 m/s in middle position of the room in all the time it same. Poor thermal comfort impairs cognitive performance in patients, and more significantly, impacts in difficult to take rest in patient room.

Time	Temp (°C)	RH (%)	CO2 (ppm)	CO2 (ppm)	O2 (%)	Rv (m/s)
9.00	29.5	51	0	418	19	0
9.30	28.6	45	0	488	19	0
10.00	28.8	44	0	589	19	0
10.30	27.9	47	0	656	19	0
11.00	27.1	43	0	613	19	0
11.30	27	43	0	677	19	0
12.00	27	44	0	667	19	0
12.30	27	44	0	691	19	0
13.00	27.4	44	0	748	20	0
13.30	27.4	44	0	716	20	0
14.00	27.1	44	0	755	20	0
14.30	27.1	44	0	784	20	0
15.00	26.6	45	0	810	19	0
15.30	26.4	45	0	821	19	0
16.00	26.4	45	0	843	19	0
16.30	26.2	45	0	861	19	0
17.00	26.2	45	0	884	19	0

3.2 Condition: Air Flow Rate 200cfm

Single central duct Air conditioner is running in the room (200cfm). From our result the maximum and minimum temperature and relative humidity are obtained 28.6°C, 26.2°C and 47 %, 43%.When the air conditioner is switch on at 9.00 am and inner temperature of the room is decreased slowly. In after noon time period the 12.30 pm to 1.30 pm the inner room temperature is slightly increase because of outdoor temperature was increased and after 2.00 pm the indoor air temperature is decreased.Carbon monoxide is not exceeding ASHRAE standard level in indoor environment. It should be 1ppm in morning peak hours in (9.00 am to 10.00 am) and remaining time 0ppm.Corbon dioxide is constantly increase in the room and it is minimum at morning 9.30am 488 ppm and maximum at 5 .00 pm 884 ppm. O_2 level in the room maximum 20.1% and minimum 18.1%. Air velocity is 0.4 m/s in middle position of the room in all the time it should be same one.

Time	Temp (°C)	RH (%)	CO2 (ppm)	CO2 (ppm)	O2 (%)	Rv (m/s)
9.00	29.2	57	0	406	19	0.4
9.30	26.3	51	0	574	19	0.4
10.00	24.1	51	0	691	19	0.4
10.30	23.4	52	0	754	19	0.4
11.00	23.4	52	0	787	19	0.4
11.30	23.4	52	0	793	19	0.4
12.00	22.5	52	0	804	19	0.4
12.30	22.5	52	0	816	19	0.4
13.00	22.8	52	0	828	19	0.4
13.30	22.9	52	0	831	19	0.4
14.00	22.9	52	0	864	19	0.4
14.30	22.9	52	0	827	19	0.4
15.00	22.3	54	0	885	19	0.4
15.30	22.2	54	0	894	19	0.4
16.00	22.2	56	0	916	19	0.4
16.30	22.2	56	0	972	19	0.4
17.00	22.2	56	0	942	19	0.4

3.3 Condition: Air Flow Rate 400cfm

Single central duct Air conditioner is running in the room (400cfm). From the result the maximum and minimum temperature and relative humidity are obtained 26.3°C, 23.2°C and 56%, 51%.When the air conditioner is switch on at 9.00 am and inner temperature of the room is decreased slowly. In after noon time period the 2.00 pm to 2.30 pm the inner room temperature is slightly increase because of outdoor temperature was increased and after 2.00 pm the indoor air temperature is decreased. Carbon monoxide is not exceeding ASHRAE standard level in indoor environment (0 to 9 ppm)(parts /million). Its 1ppm in morning peak hours in (9.00 am to 10.00 am) and remaining time 0ppm.Corbon dioxide is constantly increase in the room and it is minimum at morning 9.30am 574 ppm and maximum at 5 .00 pm 972 ppm. The value is above the ASHRAE standard indoor value is 1000 ppm.O_2 level in the room maximum19.4 % and minimum 18.8%.Air velocity is 0.4 m/s in middle position of the room in all the time it should be same one.

Time	Temp (°C)	RH (%)	CO2 (ppm)	CO2 (ppm)	O2 (%)	Rv (m/s)
9	29.6	56	0	459	19	0
9.3	25.5	53	0	546	19	0
10	23.2	55	0	687	19	0
10.3	23.7	56	0	781	19	0
11	23.5	59	0	869	19	0
11.3	23.4	59	0	897	19	0
12	23.4	59	0	938	19	0
12.3	23.4	59	0	987	19	0
13	23.2	58	0	1059	19	0
13.3	22	58	0	1171	19	0
14	22	58	0	1085	19	0
14.3	21.5	59	0	1085	19	0
15	21.5	59	0	1094	19	0
15.3	21.3	60	0	1097	19	0
16	21.7	60	0	1115	19	0
16.3	21.3	60	0	1138	19	0
17	21.3	60	0	1147	19	0

3.4 Condition: Air Flow Rate 600cfm

Single central duct air conditioner is running in the room (600 cfm). From our result the maximum and minimum temperature and relative humidity are obtained 25.5°C, 22.3°C and 60 %, 53%.When the air conditioner is switch on at 9.00 am and inner temperature of the room is decreased slowly. In after noon time period the 12.30 pm to 1.30 pm the inner room temperature is slightly increase because of outdoor temperature was increased and after 2.00 pm the indoor air temperature is decreased. Carbon monoxide is not exceeding ASHRAE standard level in indoor environment (0 to 9 ppm)(parts /million). It should be 1ppm in morning peak hours in (9.00 am to 10.00 am) and remaining time 0ppm.Corbon dioxide is constantly increase in the room and it is minimum at morning 9.30am 546 ppm and maximum at 5 .00 pm1147 ppm. The value is above the ASHRAE standard indoor value is 1000 ppm. O_2 level in the room maximum 19.5% and minimum 18.6%. Air velocity is 0.4 m/s in middle position of the room in all the time it should be same one.

IV. CONCLUSION

This Study has offered new Quantitative information about the IAQ conditions inside the patient room, together involved in providing good IAQ in a environment. Recommended air flow volume are summarized for three adults in patient room, hospital Building, Madurai, south tamilnadu, india, which is available for air contaminant exposure and health risk assessment studies for people in those areas. Moreover co, co2, o2, Temperature, Relative humidity and relative velocity in indoor air are influenced by Physical condition, Outdoor environment and so on. From the results, it was found that temperature comfort were obvious in two air flow rates. Thermal environment in two different air flow rate from three are acceptable. The temperature and relative humidity is high in the natural ventilation, compare with air conditioned ventilation. When the air conditioning is running, the level of co_2 is high and the oxygen level is low compare to natural ventilation. In the air conditioner running condition with 200cfm air flow volume, the room will be slightly cool. In the air conditioner running condition with 400 cfm air flow volume, the room will be normally cool. In the air conditioner running condition with 600cfm air flow volume, the room will be cool. From the above experimental study, 400 cfm air flow volume got better human as well as thermal comfort from the three various airflow rates in the occupied zone cooling load. The occupied zone cooling load may be overestimated or under estimated there is reversed flow at the upper boundary of the occupied zone. This paper is very useful to provide the comfort level of the human and thermal in the hospital patient room with sufficient energy consumption.

REFERENCE

[1]. Nyuk Hien Wong, Bernard Huang. Comparative study of the indoor air quality of naturally ventilated and air-conditioned bedrooms of residential buildings in Singapore. Elsevier-Building and Environment (2004) Vol.39 PP 1115 – 1123.

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

[4] .K.W. Cheong, K.Y. Chong. Development and application of an indoor air quality audit to an air-conditioned building in Singapore. Pergamon-Building and Environment (2001) Vol.36 PP 181-188.

[5]. Qiong Li , Hiroshi Yoshino, Akashi Mochida , Bo Lei , Qinglin Meng, Lihua Zhao , Yufat Lun. CFD study of the thermal environment in an air-conditioned train station building. Elsevier-Building and Environment (2009) Vol.44 PP 1452–1465.

[6]. Yan Ding, Qiang Fu, Zhe Tian*, Meixia Li, Neng Zhu. Influence of indoor design air parameters on energy consumption of heating and air conditioning. Elsevier-Energy and Buildings (2013) Vol.56PP78–84.

[7] .S.Atthajariyakul, T.Leephakpreeda. Real-time determination of optimal indoor-air condition for thermal comfort, air quality and efficient energy usage. Elsevier-Energy and Buildings (2004) Vol.36 PP 720–733

[8]. V. Vakiloroaya, Q.P. Ha, B. Samali. Energy-efficient HVAC systems: Simulation–empirical modelling and gradient optimization. Elsevier-Automation in Construction (2013) Vol.31 PP 176–185.

[9]. D.G. Leo Samuel, S.M. Shiva Nagendra, M.P.Maiya. Passive alternatives to mechanical air conditioning of building: A review. Elsevier-Building and Environment (2013) Vol.66 PP 54-64

[10].Pedro Nunes, Maria M. Lerer, Guilherme Carrilho da Graca. Energy certification of existing office buildings: Analysis of two case studies and qualitative reflection. Elsevier- Sustainable Cities and Society(2013)Vol.9PP81–95.

[11]. 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.

[12] .R. Karunakaran S. Iniyan, Ranko Goic. Energy efficient fuzzy based combined variable refrigerant volume and variable air volume air conditioning system for buildings. Elsevier- Applied Energy (2010) Vol.87 PP 1158–1175.

[13] .Tuan Anh Nguyen, Marco Aiello. Energy intelligent buildings based on user activity: A survey. Elsevier-Energy and Buildings (2013) Vol.56 PP 244–257.

[14]. Asit Kumar Mishra, Maddali Ramgopal. Field studies on human thermal comfort - An overview. Elsevier-Building and Environment (2013) Vol.64 PP 94-106.
(2013) Vol.53 PP 93 – 98

[15] Pawel Wargochi, 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 – 5893.

[16] A. Norhidayah, Lee Chia-Kuang, Azhar, S. Nurulwahida. Indoor Air Quality and Silk Building Syndrome in Three Selected Building, Elsevier -Procedia Engineering.

[17]. B.F. Yu, Z.B. Hu, M. Liu, H.L. Yang, Q.X. Kong, Y.H. Liu. Review of research on air-conditioning systems and indoor air quality control for human health. Elsevier-International journal of refrigeration (2009) Vol.32 PP 3 – 20

[18] .Piotr Batog, Marek Badura. Dynamic of Changes in Carbon Dioxide Concentration in Bedrooms. Elsevier-Procedia Engineering (2013) Vol.57 PP 175 – 182.