

COOLING LOAD ESTIMATION OF A ROOM

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Abstract: Human comfort is the most important parameter in present context with enhancement in quality of lifestyle and rising atmospheric temperature. Electrical air conditioning equipment's are not preferred for large buildings as they consume bulk amount of power and have less life. Central air conditioning provides more reliability in addition to lower maintenance cost. Large buildings such as commercial complex, auditorium, office buildings are equipped with central air conditioning system. Educational and research institutions also requires human comfort with the increment in the population of student community, year after year. The effective design of central air conditioning system provides lower power consumption, lower capital cost and helps in improving aesthetics of a building. This paper gives the results of cooling load evaluated in different climatic conditions by using CLTD method^[1]. Calculation of cooling load from items such as people heat gain, lighting heat gain, infiltration and ventilation heat gain can easily be represented on the MS-Excel programme. The programme can be used to calculate cooling load from walls and roofs.

The calculated results were compared with standard data given by ASHRAE and CARRIER Fundamental Hand Books, and the results are satisfactory.

Key Words: CLTD, Cooling Load, Air conditioning, Human comfort, HVAC.

1.INTRODUCTION

In present time there is a problem of ecological imbalance which is due to energy consumption by industries and buildings. 72% of world energy is consumed by infrastructure, industry, commercial buildings, residential houses, and markets. In a large building or complex, which is air-conditioned, about 60% of the total energy requirement in the building is allocated for the air-conditioning plant installed to use the cooling purpose.

In order to minimize energy consumption we must provide exact amount of cooling and heating load, proper sizing of heat ventilation air conditioning (HVAC) and optimal control of HVAC system^[3]. The prime factors which affects the cooling load are external climatic conditions such as outdoor temperature, solar radiations and humidity. Local climatic conditions are also an important parameters for the energy efficiency of buildings because the energy

consumption in buildings depends upon the climatic conditions and the performance of heating ventilating and air conditioning (HVAC) systems changes with respect to them, better design in building HVAC applications that take account of the right climatic conditions^[4]. It will result in better comfort and more energy efficient buildings.

Calculation of thermal load helps us to install accurate air conditioning equipment and air handling unit. It also provides better human comfort and good air flow in AC zone. This project Cooling load estimation for a room is presented by using CLTD method^[1].

2.EFFECTIVE TEMPERATURE

The degree of hotness and coldness felt by humans mainly depends upon the following factors:-

1. Dry bulb temperature, 2. Relative humidity, 3. Air velocity^[1].

The combined effects of the three factors is called effective temperature, which is defined as the index which co-relates the combined effects of air temperature, relative humidity and air velocity on the human body.

The practical application of the concept of effective temperature is presented in Fig 1.1 and is known as 'Human comfort chart' [1]. This chart is the analysis of research made by involving different kinds of people subjected to wide range of environmental temperature, relative humidity and air movement by the ASHRAE.

All men and women above 40 years of age prefer 0.5°C higher effective temperature than the person below 40 years of the age^[1].

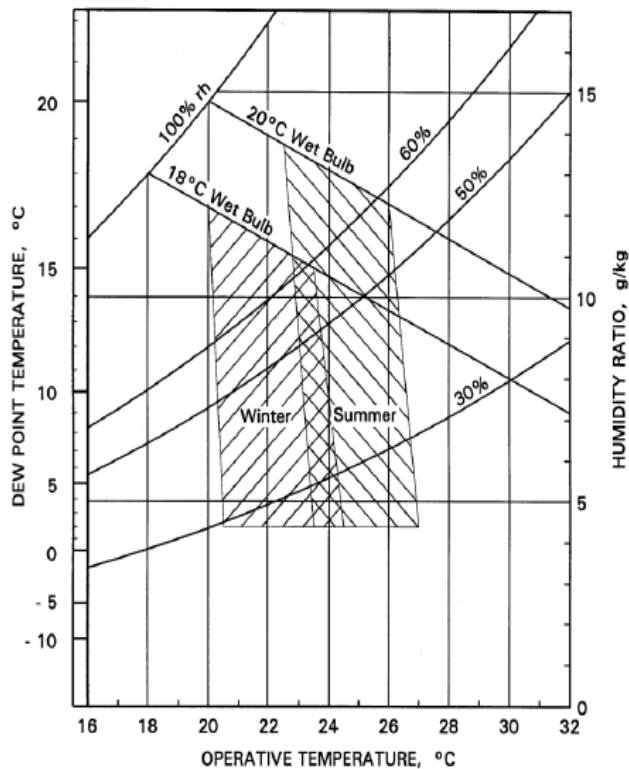


Figure-1: Human Comfort Zone.

3.HEAT TRANSFER ANALYSIS

In any building or space, heat is transmitted through various mediums such as external walls, top roof, floor of the ground, windows and doors. Heat transfer takes place by three modes namely conduction, convection and radiation. The cooling load of a building depends upon several factors such as local climate, thermal characteristics of material and building type. There are also various software for cooling load calculations such as DOE 2.1E, BLAST, Elite or HAP 4.3 are available. They make the use of transfer function method and heat balance method. These methods require a complex and lengthy data input, hence most of the designers do not use these methods. They prefer a more compact and easy method over these software. A more basic version for calculating a cooling load using the transfer function method is to use the one step procedure, which was given in the ASHRAE Handbook of Fundamentals of the year 2005. This method is cooling load temperature differences (CLTD) method and employs the use of hand calculations for calculating cooling load.

Hand calculations were done for a small portion of the building (tutorial room) using the all equations mentioned in Chapter 3^[6], calculation procedures and information. All equations mentioned are required for heat transfer through the building and for the inside's load in order to calculate

thermal load. Then, all the equations were inserted in a particular program MS Excel in order to get the results.

The general step by step procedures for calculating the total heat load are as follows

1. Select inside design condition (Temperature, relative humidity).
2. Select outside design condition (Temperature, relative humidity).
3. Determine the overall heat transfer coefficient U_o for wall, ceiling, floor, door, windows, below grade.
4. Calculate area of wall, ceiling, floor, door, windows.
5. Calculate heat gain from transmission.
6. Calculate solar heat gain.
7. Calculate sensible and latent heat gain from ventilation, infiltration and occupants.
8. Calculate lighting heat gain.
9. Calculate total heat gain and
10. Calculate TR.

4.DESIGN CONDITIONS

The amount of cooling required to keep buildings comfortable in summer and winter depends on the desired indoor conditions and on the outdoor conditions on a given day.

These conditions are known as “indoor design conditions” and the “outdoor design conditions” respectively.

The recommended indoor temperature and relative humidity for human comfort conditions are as follows

DBT – 22.78 °C to 26.11 °C, and RH – 50% for summer^[2].

The cooling load of the tutorial room is based on 23 °C dry bulb temperature and 50% relative humidity Indoor design condition^[2].

The outdoor design conditions are determined from published data for the specific location, based on weather bureau or airport records. The outdoor design conditions of Ghaziabad City are 40.6 °C DBT and Relative Humidity 46% for summer (month of April).

5.COOLING LOAD ESIMATION PRESENTED ON THE WORKSHEET

The calculations of the cooling load of Tutorial room is represented on a MS EXCEL worksheet^[5].

We have displayed heat gain from various sources.

Worksheet: Cooling load sheet for 30 seated Tutorial room^[5].

			Area	IMS ENGINEERING COLLEGE			
			City	Ghaziabad /UP			
Project	TUTORIAL ROOM COOLING LOAD		Month	April for Summer			
Space	30 SEAT LECTURE ROOM 1		Time				
Length (m)	=	8.7	Summer				
Width (m)	=	4	CONDITION				
Height (m)	=	3.04	Outside	DBT	WBT	%RH	kg/kg
Area (m ²)	=	34.8	Inside	40.6	31	46	0.0231
Volume (m ³)	=	34.8	Difference	23	16	50	0.00866
BPF	=	0.12	No of Air Changes / Hr.	= 1.00			
SUMMER							
SOLAR HEAT GAIN FOR GLASS							
Item	Area (sq. m)	Factor	W/m ²	W			
Glass (N)		0.48	43.24	0			
Glass (N-E)	2.4	0.13	96.14	30.74			
Glass (E)		0.11	144.58	0			
Glass (S-E)		0.14	131.5	0			
Glass (S)		0.22	79.38	0			
Glass (S-W)		0.52	131.57	0			
Glass (W)		0.52	144.58	0			
Glass (N-W)		0.47	96.14	0			
SOLAR & TRANSMISSION HEAT GAIN FOR WALLS & ROOF							
Item	Area (sq. m)	Factor(W/m ² .°C)	Temp Diff (°C)	W			
Wall (N)		1.07	17.7	-			
Wall (N-E)	8.8	1.07	22.7	214.47			
Wall (E)		1.07	24.7	-			
Wall (S-E)		1.07	24.7	-			
Wall (S)		1.07	19.7	-			
Wall (S-W)		1.07	24.7	-			
Wall (W)		1.07	24.7	-			
Wall (W-N)		1.07	22.7	-			
TRANSMISSION HEAT GAIN EXCEPT FOR WALLS & ROOF							
Item	Area (sq. m)	Factor(W/m ² .°C)	Temp Diff (°C)	W			
All Glass	2.507	5.63	22.7	320.39			
Ceiling	34.8	2.47	19.7	1693.33			
Floor	34.8	2.84	2.5	247.08			
HEAT GAIN DUE TO INFILTRATION							
Infiltrated Air	Bypass	Factor	Temp Diff (°C)	W			
2.6	1	20.44	17.6	935.33			
INTERNAL GAIN							
Item		Factor	Temp Diff (°C)	W			
People	30	70		2100			
Lights(W/m ²)	14	15		210			
Motor (KW)				0			
Equipment (KW)				0			
ROOM SENSIBLE HEAT SUBTOTAL :			5751.34				
S. A. heat gain, leak loss & Safety Factor (6%) :			345.08				
ROOM SENSIBLE HEAT (R.S.H.) :			6096.42				
ROOM LATENT HEAT CALCULATIONS :							
Infiltrated Air	Bypass	Factor	Diff kg/kg	W			
2.6	1	50000	0.0144	1877.2			
ITEM		Factor	Diff kg/kg	W			
No. Of People	30	45		1350			
Steam				0			
Appliances				0			
Vapour Trans				0			
S. A. heat gain, leak loss & Safety Factor (5%) :			161.36				
ROOM LATENT HEAT (R.L.H.) :			3388.56				
ROOM TOTAL HEAT (R.T.H.) :			9484.98				

OUTSIDE AIR HEAT:						
OUTSIDE AIR SENSIBLE HEAT (OASH)						
Outside Air	1 - BPF	Factor	Temp Diff (°C)	W		
2.5	0.88	20.44	17.6	791.43		
OUTSIDE AIR LATENT HEAT (OALH)						
Outside Air	1 - BPF	Factor	Diff kg/kg	W		
2.5	0.88	50000	0.0144	1584		
SUBTOTAL :				11860.418		
R.A.heat, leak gain& Safety factor (5%)				593.02		
GRAND TOTAL :				12453.438		
TONS = {(W)/3500} :				3.558		

6.RESULTS

The load estimation of tutorial room is done and following results appeared-

- Load through glass = 320.39 W
- Load through ceiling = 1693.3 W
- Load through floor = 247.08 W
- V infiltration = 2.6 m³/min
- Room sensible heat gain = 6096.42 W
- Room latent heat = 3388.56 W
- ROOM TOTAL HEAT = 9484.98 W
- Outside air sensible heat gain= 791.438 W
- Outside air latent heat gain= 1584 W
- OUTSIDE AIR TOTAL HEAT= 2375.438 W
- GRAND TOTAL HEAT GAIN= 12453.4389 W
- TONS OF REFRIGIRATION =3.558 TR

6.CONCLUSION

In this study, a tutorial room which is an integrated part of a research institution located in Ghaziabad City was considered for calculating cooling loads. Cooling load temperature difference (CLTD) method was used to find the cooling load for summer (month of April). Cooling load items such as, people, light, infiltration and ventilation can easily be mentioned in the MS-Excel program. The program






can also be used to calculate cooling load due to walls and roofs.

The results show that the total cooling load for the AC required rooms is **3.558** tons for summer (month of April).

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BIOGRAPHIES

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