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Cooling Load Estimation Using CLTD/CLF Method for an Educational Building of Institute of Engineering & Technology Devi Ahilya Vishwavidyalaya Indore

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Abstract: ***Cooling load calculation may be used to accomplish to many objectives such as provide information about the heat gain into the conditioned space through the building envelope, varies in magnitude from minimum cooling required to a maximum value, size of the A/C system. In this paper calculated the manually cooling load estimated for summer season applied the method to the Indore, these methods are very widely used by air conditioning engineers as they yield reasonably accurate results and estimations can be carried out manually in a relatively short time, that method accounts for the combined effect of inside and outside temperature difference, daily temperature range ,solar radiation and storage in the construction building mass. It is affected by latitude orientation, tilt, month, day, hour, etc. In this paper cooling load calculation is done for the two storey education building through the calculation it is obtained that total heat gain in the ground floor is about (72483W approximate 20.71 TR) and first floor is about (145362W approximate 41.53 TR) .The maximum heat gain from the roofs about 24.44% of the total heat.***

Keywords: Cooling load, CLTD/CLF, A/C System

1. Introduction

The building sector represents about 33% of electrical consumption in India. Bureau of energy efficiency ECBC compliant buildings can use up to 40 to 60% less energy than conventional building about 60% of the total energy requirement in the building is allocated for the air-conditioning plant installed to use the cooling purpose[1]. The method of heat Gain determination is using cooling load temperature differential (CLTD) and cooling load factors (CLF) based on ASHRAE 1997 fundamental handbook and then verified by data provided by contractor of building.[2] Calculation of thermal load helps us to install accurate air conditioning equipment and air handling unit[3].. Design outside conditions is selected from a long-term database. The conditions will not take any actual year, but are representative of the location of the building[4] the load on the building due to solar radiation is estimated for clear sky conditions, full load capacity, the building orientation, weather condition, building size, buildings materials etc. Cooling load calculation for class rooms, CAD lab faculty room and practical labs Indore is a city in the state of Madhya Pradesh college building located at IET DAVV at latitude: 22.72n long: 75.80e at an elevation of about 567meters above sea level Building

2. Literature Survey

Anurag Kumar Singh at el (1) Cooling load estimation for Library is done for the library. Through the calculation it is obtained that total heat gain in the library and gives the suggestion for the size of air conditioning system.

Deepak Kumar Yadav at el (2) Cooling load estimation of a room cooling load calculated through ms-excel program for month of April and determined the size of air conditioning system .

F.A. Ansari at el (3) A Simple Approach for Building Cooling Load Estimation to compared the result in computer software and thumb rule in this paper use some building parameters and its orientation before starting the construction and describe the technique .

Deepak V K, at el (4) The cooling load calculation is done for two floors of a show room in a mall using CLTD/CLF method according to the load analysis, suitable air-conditioning systems were selected for the building and Duct sizing is calculated by velocity reduction method.

The current paper discusses about cooling Load Calculation using CLTD/CLF method for educational building.

3. Data Collection and Methodology

3.1 Basic information

Before estimating cooling load of any building there are some basic information’s are necessary to design an exact HVAC systems, like building orientation, weather condition, building spacing, buildings materials etc.

3.1.1 Orientation of building –

Building orientation (N, S, E, W, NE, SE, SW, NW, etc)

3.1.2 Building Location-

College building located at IET DAVV at Latitude Lat: 22.72N Long: 75.80E at an elevation of about 567meters above sea level

3.1.3. Climate conditions of space for June-

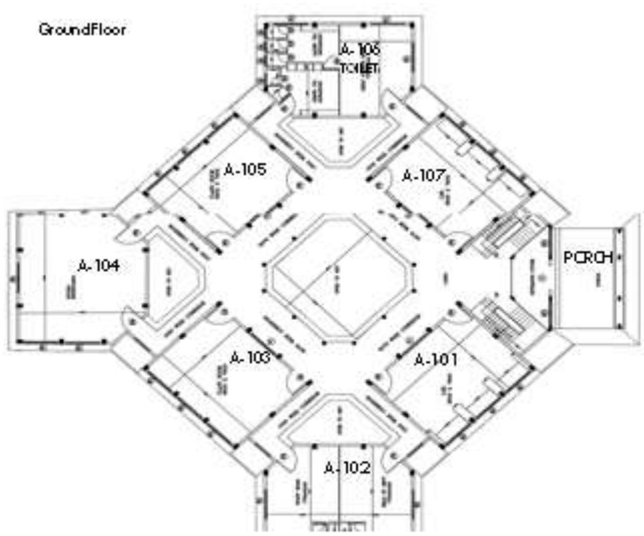
Indore has a composite climate zone ,maximum temperature in summer 32^{o} C to 42^{o} relative humidity in wet months 60% to 95% and minimum in dry month 30% to 40%

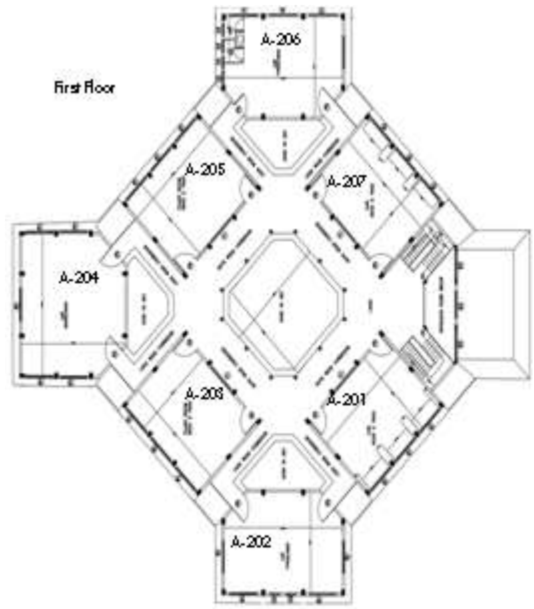
Table 1: Inside and outside design temperature

Item	T db in °C	Twb in °C	Relative Humidity %	Specific humidity (Kg/kg of d .a.)
Inside	24	17	50	0.0095
Outside	40.5	25	28	0.0135
Difference	16.5			0.004
Average temp	29.45 °C	Daily range		11.21°C

Average temperature & Daily range from ISHRAE Handbook 2014 (table 1-T-4)
Outside temperature are calculated for 21 June 4pm according to carrier handbook shown in below table-

3.1.4 Architectural Plan





3.1.5 Building specification

Table 2: Specification of building

Description	Item	specification
Walls	outer walls and cement plaster	20mm
	Inner wall sand cement plaster	12mm
	Clay Bricks	200x100x100mm
Foundation	RCC (M-20)	
Roof and structure	RCC slab(M-20)	150mm
	Ceiling sand cement plaster	4mm
	Outer sand cement plaster	6mm
Flooring	Kota stone(stair case)	20mm
	concrete	25mm
Window	frame (wooden)	145x235x30mm
	shutter (wooden)	60x115mm
Glass	Single clear	6mm thick
Doors	Frame and shutter	1100x2300mm

3.1.6 Dimensions of Building

Ground Floor-

Ground floor of building having five rooms, such as computer labs, faculty room practical labs and classroom etc.

First floor-

First floor of building having seven rooms which is classrooms labs etc**.**

Table 3: Dimension of building

Room No.	Length(m)	Width(m)	Area(m^2)
A-101CAD Lab	9.5	7.6	72.2
A-102 Faculty Room	10.8	7.75	83.7
A-103som Lab	9.5	7.6	72.2
A-104 RAC Lab	9.55	10.93	83.07
A-105 TOM Lab	9.5	7.6	72.2
A-107 DOM Lab	9.5	7.6	72.2
Height 3.3 meter			
A-201 Class Room	9.5	7.6	72.2
A-202 Vib. lab	10.9	7.75	84.47
A-203 Class Room	9.5	7.6	72.2

A-204 Class Room	10.93	9.55	104.4
A-205 Class Room	9.5	7.6	72.2
A-206 App. Chem. Lab	10.9	7.75	84.47
A-207 Class Room	9.5	7.6	72.2
Height of each room 4.2 and 2.65 meter			

Table 4: Thermodynamics properties of building material and calculate the value of U

S.N.	Material	Thick.	Thermal Conductivity W/m. C	U $w/m^2\ ^oc$
1	**Wall**			
	Outer Plaster Cement	20mm	8.65	2.36
	Inner Plaster Cement	12mm		
	Bricks	200mm	0.77	
2	**Roof**			
	Outer Plaster	6mm		3.82
	Inner Plaster	4mm		
	Concrete	150mm	1.73	
3	**Flooring**			**3.65**
	Granite	25mm	1.73	
	Concrete	20mm		
4	**Doors** Wooden	25mm	0.1	2.43
5	**Window** Glass	6mm	0.78	4.2

3.2 Components of cooling load

The total building cooling load consists of heat transferred through the building envelope (walls, roof, floor, windows, doors etc.) and heat generated by occupants, equipment, and lights.

3.2.1 Solar heat gain through glass

The space of glass window cooling load Q is calculated as

$Q = A_{unshaded} \cdot SHGF \cdot CLF \cdot SC$

Where $A_{unshaded}$ = Area of the glass windows in m^2

SHGF = solar heat gain w/m^2 (ASHRAE 1985 fundamental handbook chapter-26 table 11)

CLF= Cooling load factor, (CLF For Glass ASHRAE 1985 fundamental Handbook chapter 26 table 14)

SC=Shading Coefficient, (SC=0.6 ,IIT Khadagpur notes unit 33 tabe-33.2)

3.2.2 Transmission heat gain

Q =U A (CLTD)

CLTD=8 for glass taken from-ASHRAE 1985 Fundamentals Handbook chapter 26 table 10)

Where U= Overall heat transfer coefficient $w/m^2\ ^OC$

3.3 Heat transfer through opaque surfaces

This is a sensible heat transfer process. The heat transfer rate through opaque surfaces such as walls, roof, floor, doors etc. is given by

Q_{opaque} =A .U. CLTD

3.3.1 Solar Transmission Gain From Wall

Solar transmission gain from wall depend upon the mass of the wall and orientation

Mass of wall per unit area .02(1885) +0.2(1600) + 0.012(1885) =380kg/m2

Adjustments to Values:

$CLTD_{corre}$ = [(CLTD+LM) . K + (25.5- Ti) + (T_{av} – 29.4)] (CLTD from ASHRAE 1985 Fundamental handbook chapter 26 table 7)

LM = latitude –month correction from CLTD correction for latitude and month applied In Walls And Roofs, North Latitude (Ref-AHRAE 1989 Fundamental handbook chapter 26 table-9

K = color adjustment factor, k= 1 for dark colored

3.3.2 Solar transmission gain from roofs-

Q_{roof}=A .U. CLTD (CLTD from ASHRAE fundamental handbook 1985 chapter 26 table 5)

3.3.3 Calculation of heat gain through floor –

Q_{floor} =A .U. CLTD the value of CLTD =2.5

3.3.4 Calculation of heat gain through doors -

Q_{doors} =A .U. CLTD the value of CLTD =16.5

4. Load due to occupants

The internal cooling load due to occupants consists of both sensible and latent heat It depends the population and activity level of the occupants

4.1 Sensible heat gain from occupants-

Q S (Occupants)=No. of people x sensible heat gain /person x CLF

((CLF = 0.852 ASHRAE Handbooks 1985)

If the conditioned space temperature is higher, sensible decreases and the latent heat gain increases. CLF is determined by the time the occopats come into the building and for how long they stay in the building the value of sensible heat gain taken 70W/person

4.2 Latent heat gain from occupants

Q_L (Occupants) =No. of people x Latent heat gain /person

The value of latent heat gain taken 45 W /person

5. Heat gain through lights

Lighting adds sensible heat to the conditioned space. Since the heat transferred from the lighting system consists of both radiation and convection. Cooling Load Factor is used to account for the time lag. Thus the cooling load due to lighting system is given

$Q_{lighting}$=installed wattage x Usage factor x Ballast factor x CLF

The usage factor accounts for any lamps that are installed but are not switched on at the time at which load calculations are performed Its value depends upon the type of use usage factor taken 1 ,CLF value for class room taken o.6 for 6hrs lights on Ballast factor for fluorescent light 1.25.

6. Heat gain through appliances-

The general electric equipments, computers, printers, fax machines, projector, adds sensible heat in the air conditioning space

$Q_{equipments}$ = Total wattage x Usage factor x CLF

Table- 5 Heat Gain Rate For Classroom And Faculty Room Appliances (Watts) (Ref- ASHRAE handbook 2001)

Appliance	Average	ontinuous	Ideal
Computer --17" Monitor	90	?5	25
projector	250	?0	50
Laser printer	100	?0	10

7. Heat Gain through Infiltration

Uncontrolled entry of untreated, outdoor air directly into the conditioned space. Infiltration of outdoor air into the indoors takes place due to wind and stack effects. Control infiltration by revolving doors, use of air curtains and sealing of windows and doors. Estimate infiltration rate as it depends on type and age of the building, indoor and outdoor conditions, ACH, wind velocity and direction, outdoor temperature and humidity. (ACH=1.5)

7.1 Sensible heat transfer rate due to infiltration is given by: $Q_{S,} = m_o \ C_{pm} \ (t_o - t_I)$

7.2 Latent heat transfer rate due to infiltration is given by: $Q_{L,} = m_o \ h_{fg} \ (W_o - W_i)$

Table: Summery of cooling load

Table 6: First floor

Heat Component	A-201	A-202	A-203	A-204	A-205	A-206	A-207
Solar glass	634	2095	577	1431	356	1083	2036
Walls	3431	3310	3305	3586	3381	3530	4195
roofs	7488	8761	7047	9312	6137	7445	7047
Floor	771	0	0	0	0	0	0
Doors	179	179	179	179	179	179	179
Lights	340	240	240	240	240	240	240
Appliances'	5233	90	340	340	340	90	340
People	3085	2616	5233	5233	5233	2616	5233
Infiltration	21401	3062	3085	3707	3085	3085	3085
Total in watt	21401	20353	20006	24028	18951	18268	217845
TR	6.11	5.83	5.72	6.87	5.41	5.22	6.39

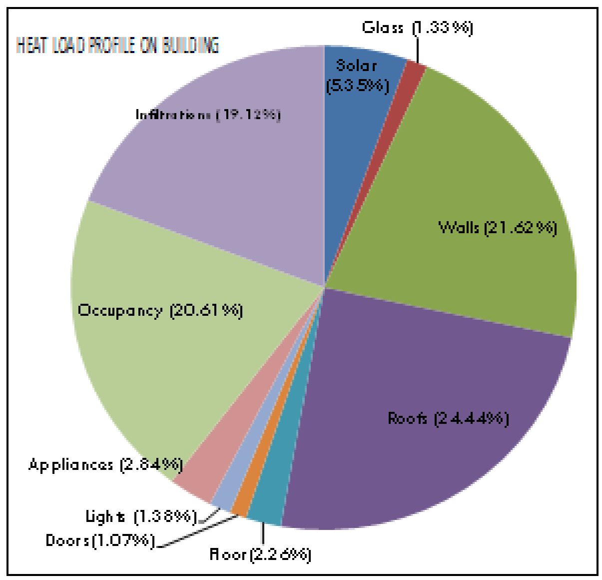
Table 7: Ground Floor

Heat source	A-101	A-102	A-103	A-104	A-105	A-107
Solar glass	634	1190	577	1534	356	2036
Walls	3134	3546	3309	5221	3246	3900
Floor	659	764	659	758	659	659
Doors	179	179	179	179	179	179
Lights	240	120	240	240	240	240
Appliances'	2500	280	370	90	530	530
People	2616	419	2616	2616	2616	2616
Infiltration	2955	3385	2955	4244	2955	2955
Total in watts	**12917**	**9883**	**10905**	**14882**	**10781**	**13115**
TR	**3.69**	**2.82**	**3.12**	**4.25**	**3.08**	**3.75**

Note-The ventilation load ignore because this load is take consider when the size of air conditioning is calculate

8. Results & Discussion

The results show that the total cooling load for the two floors is 62.24 tons, distributed between the two floors as follows ground floor 20.71 tons and the first floor 41.53 tons . The size of air conditioning system is depends on the amount of outside air taken into the system, factor of safety and by pass factor



9. Conclusion

The cooling load calculation is done for ground floor and first floor using CLTD/CLF method. Right-sizing the AC system begins with an accurate understanding of cooling loads on a space. The values determined by the cooling load calculation process dictate the equipment selection. The maximum heat load through floor about 24.44% of total heat.

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