A Case Study on Cooling Load Calculation for Lecture Halls (First Floor) of Engineering Institute

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Abstract: ***In this paper the principle concern contextual investigation on cooling load figuring and comfort for understudies of Parthivi Building Institute, focal aerating and cooling framework is a procedure of controlling the air temperature, relative moistness, ventilation, air development and air cleanliness of a given space keeping in mind the end goal to give the inhabitants an agreeable indoor temperature in address lobbies of the designing organization. The goal of this paper is to cooling load estimation of the designing establishment address corridors (first floor) and air conditionings utilized as a part of address lobbies for effectively expel from the air smaller scale life forms, tidy, and sediment. So legitimately kept up aerating and cooling framework does not bring about or advance sickness, in spite of superstitions that ventilating is genuinely perilous to one's wellbeing.***

Keywords: Cooling load, Human comfort, Lecture hall, Central Air condition, Heat gain.

1. Introduction

The cooling and air-conditioning is a procedure that all the while conditions air; circulates it consolidated with the open air to the melded space; and in the meantime controls and keeps up the required space's temperature, dampness, air development, air cleanliness, sound level, and weight differential inside foreordained points of confinement for the wellbeing and solace of the inhabitants, for item handling, or both [6].

Aerating and cooling Framework comprises of a gathering of parts or gear associated in arrangement to control the ecological parameters. An aerating and cooling framework, by ASHRAE (American Culture of Warming, Refrigerating and Ventilating Engineers) definition is a framework that should finish four destinations at the same time. These goals are to: control air temperature; control air moistness; control air course; and control air quality [2].

Solace Aerating and cooling is a procedure of controlling the air temperature, relative dampness, ventilation, air development and air cleanliness of a given space keeping in mind the end goal to furnish the inhabitants with an agreeable indoor temperature while Cooling framework comprises of a gathering of parts or gear associated in arrangement to control the natural parameters [1].

2. Research Area Details

At Bhilai (Latitude-21˚13'0N, Longitudinal-81˚25'60E, Altitude-292 meter) I have considered the temperature and relative humidity of four month March, April, May, and June. We have calculated the mean, monthly maximum dry bulb temperature and its corresponding wet bulb temp.

Outside maximum temperature (Avg.)	38^0C & 40% RH
Outside minimum temperature (Avg.)	24.5^0C & 40% RH
Average temperature of high and low	31.25^0C
Inside design condition	25^0C & 50% RH
Equivalent temperature difference	6.25^0C

In this fig.1 show the average temperature graph data for Bhilai place of Chhatttisgarh.

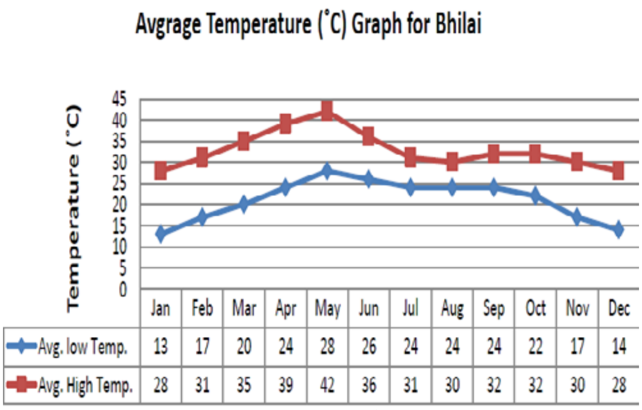

Figure 1. Average temperature (^{0}C) graph for Bhilai

The specification detail of the lecture halls (first floor level) of the engineering institute shown in table 1.

Table 1: Specification detail of first floor of the lecture halls

Lecture Hall	Area of Hall (m^2)	Capacity of Person	No. of Window and Door	No. of Fluorescents	No. of Fans
F-6	97.94	60-70	10	4	4
F-7	97.94	60-70	6	4	4
F-14	112.05	60-70	6	4	4
F-15	104.17	60-70	6	4	4
F-16	104.17	60-70	8	4	4
F-18	119.85	60-70	10	4	4
F-22	83.42	60-70	9	4	4

3. Calculation of Cooling Load for Halls

3.1 Solar Heat Gain Through Window Glass

In this section the calculating of solar heat gain through glass of window and the window area is 2.178m^2 of the lecture hall rooms. The table 2 is shown the solar heat gain calculating with the help of SHGF value different for different window face directions and SC is the shading coefficient.

Table 2: Solar heat gain through glass (windows and doors)

Room No.	No. of Windows facing	Area of window (m^2)	SHGF Value (W/m^2)	Shading Coefficient, SC	Solar Heat Gain (Watt) = A*SHGF*SC
F-6	6 SE	2.178	470.25	0.95	5838
	4 SW	2.178	470.25	0.95	3892
F-7	2 SE	2.178	470.25	0.95	1946
	4 SW	2.178	470.25	0.95	3892
F-14	6 NW	2.178	520.5	0.95	6462
F-15	2 NE	2.178	520.5	0.95	2154
	4 NW	2.178	520.5	0.95	4308
F-16	2 NE	2.178	520.5	0.95	2154
	2 SW	2.178	470.25	0.95	1946
	4 NW	2.178	520.5	0.95	4308
F-18	6 SW	2.178	470.25	0.95	5838
	4 NW	2.178	520.5	0.95	4308
F-22	5 NE	2.178	520.5	0.95	5385
	4 SE	2.178	470.25	0.95	3892
Total					**56323**

3.2 Solar Heat Gain Through Wall

In this section the calculating of solar heat gain through wall of the rooms in table 3 shown.

The above table calculating the heat gain of each room. So the total heat gain of all lecture hall room is 15307 Watt.

Table 3: Solar heat gain through wall

Room No.	Wall Face	Area of Wall A_w (m^2)	Equivalent Temp. Diff. T_w ^{0}C	Transmission coefficient U_w (Watt/m^{2}k)	Heat gain $U_w A_w T_w$ (Watt)	Total Heat Gain Room wise
F-6	NE	60.7	6.25	1.372	521.02	1783
	SE	86.3	6.25	1.372	740.7	
	SW	60.7	6.25	1.372	521.02	
	NW	86.3	0	1.372	0	
F-7	NE	60.7	6.25	1.372	521.02	1783
	SE	86.3	0	1.372	0	
	SW	60.7	6.25	1.372	521.02	
	NW	86.3	6.25	1.372	740.7	
F-14	NE	60.7	0	1.372	0	2216
	SE	98.8	6.25	1.372	847.38	
	SW	60.7	6.25	1.372	521.02	
	NW	98.8	6.25	1.372	847.38	
F-15	NE	91.8	6.25	1.372	787.79	1830
	SE	60.7	6.25	1.372	521.02	
	SW	91.8	0	1.372	0	
	NW	60.7	6.25	1.372	521.02	
F-16	NE	91.8	6.25	1.372	787.79	2618
	SE	60.7	6.25	1.372	521.02	
	SW	91.8	6.25	1.372	787.79	
	NW	60.7	6.25	1.372	521.02	
F-18	NE	91.8	6.25	1.372	787.79	2775
	SE	69.9	6.25	1.372	599.48	
	SW	91.8	6.25	1.372	787.79	
	NW	69.9	6.25	1.372	599.48	
F-22	NE	73.5	6.25	1.372	630.95	2304
	SE	60.7	6.25	1.372	521.02	
	SW	73.5	6.25	1.372	630.95	
	NW	60.75	6.25	1.372	521.02	
Total						**15307**

3.3 Heat Gain Through Roof

Roof of the class room material is used concrete. On ground floor the heat gain from the roof is zero, because equivalent temperature difference is zero. Roof thickness is 0.2032 m with plaster 0.012 m thickness.

Transmission co-efficient of roof, U_r = 1.66 W/ m^{2}K

$$U_r = \frac{1}{\frac{l_{rb}}{k_{rb}} + \frac{l_{rp}}{k_{rp}}}$$

$$U_r = \frac{1}{\frac{0.2032}{0.2910} + \frac{0.012}{0.7792}}$$

$$U_r = 1.4012 \ W/m^2.K$$

The equivalent temperature difference of roof (from table) $T_r =$ 18.25 ^{0}C. Total roof area of all first floor room (F-6, F -7, F -14, F -15 , F -16 , F -18 and F -22), $A_r =$ 719.53 m^2

Total heat gain through roof
$= U_r A_r T_r$
= 1.4012 x 719.53 x 18.25 = 18397.123 W.

3.4 Heat Gain Through Appliances

Heat gain from fluorescents
= Watts of fluorescents x 1.25 x No. of fluorescents
= 40x1.25x28 = 1400 W
Where, 1.25 is factor considering the heat gain from choke.
Heat gain from fans
= Watts of Fan x No. of Fans
= 60x28 = 1680 W
Total heat gain from Appliances (fluorescents and fans):
= 3080 W

3.5 Heat Gain from Occupancy

Number of people in each class room = 66 (Take avg.)
Number of class room = 7
Duration of occupancy = 7 hr.
Nature of activity – Study
Total number of people = 7x66 = 462
Average metabolic rate of adult male at 25^{0}C gives
Sensible heat =70 W
Latent heat = 45 W
Total sensible heat gain =70x462 = 32340 W
Total latent heat gain = 45x462 = 20790 W
Total heat gain from occupancy = 53130 W

3.6 Infiltration

Infiltration may be defined as the uncontrolled entry of untreated, outdoor air directly into the conditioned space.
Infiltration through doors:
Door size = 2.83 x 1.524 m^2
Number of doors in each room = 01
Air wind velocity = 12 km/hr
Wood door – average used
To calculate the heat gain through door, we determine m^3/min/person. From table and then psychometric chart determines sensible and latent heat.
m^3/ min/ person = 0.09912
Area of the door = 4.313 m^2
From psychrometric chart
At 25°C and 50% RH,
h_i = 51.00 kJ/kg of air
v_i = 0.86 m^3 /kg
At 38°C and 40% RH,
h_o = 80.1 kJ/kg of air
v_o = 0.90 m^3 /kg
At 31.25°C and 40% RH,
h_k = 64 kJ/kg of air
Sensible enthalpy gain $=(h_k - h_i)$ = 13 KJ/kg
Latent enthalpy gain $=(h_o - h_k)$ = 16.1 KJ/kg
Mass of infiltration air/person (m_i) = (m^3/min person)/ (v_o) = V/v_o
m_i = 0.09912/0.90 = 0.11013 kg/min
m_i = 0.001836 kg/sec

Sensible heat gain (S.H.G) $= m_i(h_k - h_i)$
= 0.001836 x 13 = 23.86 W
Latent heat gain (L.H.G) $= m_i(h_o - h_k)$
= 0.001836 x 16.1 = 29.56 W
Total sensible heat gain (T.S.H.G) = 462 x 23.86
= 11023.32 W
Total latent heat gain (T.L.H.G) = 462 x 29.56
= 13656.72 W
Total heat gain (T.H.G) = 24680.04 W
Infiltration through window:
Area of window =A_w =2.178 m^2
At 12 km/hr(200 m/min) average velocity of wind.
From table
m^3/min m^2 = 0.067
m^3/min (for 1 window) = 0.067x 2.178 = 0.146 m^3/min.
Mass flow rate due to infiltration through window (m_{iw})
= 0.146 / 0.90 = 0.162 kg/min
m_{iw} =0.0027023 kg/sec
Total number of window = 55
Total number of persons = 462
Sensible heat gain / window $= m_{iw}(h_k - h_i)$
= 0.0027023x 13 x 1000 = 35.13 W
Latent heat gain /window $= m_{iw}(h_o - h_k)$
= 0.0027023x 16.1 x 1000 = 43.51 W
Total sensible heat gain (T.S.H.G)
= 462 x 35.13 = 16230.06 W
Total latent heat gain (T.L.H.G)
= 462 x 43.51 = 20101.62 W
Total heat gain (T.H.G) = (T.S.H.G) + (T.L.H.G)
= 36331.68 W

3.7 Ventilation

The introduction of outer air for ventilation of conditioned space is necessary to dilute the odours given off by people, smoking of people and other internal air contaminants. The amount of ventilation varies primarily with total number of people, the number of people smoking and the ceiling height. People give off body odours which require minimum of 0.28 m3 /min/ person for satisfactory dilution.Number of persons = 462.
Outer air (V_o) = 462 x 0.28 = 129.36 m^3/min
From psychrometric chart
At 25°C and 50% RH,
h_i = 51.00 kJ/kg of air
v_i = 0.86 m^3 /kg
At 38°C and 40% RH,
h_o = 80.1 kJ/kg of air
v_o = 0.90 m^3 /kg
At 31.25°C and 40% RH,
h_k = 64 kJ/kg of air
OASH = Outside air sensible heat,
OALH = Outside air latent heat,
BPF = Bypass factor,
ERSH = Effective room sensible heat,
ERLH = Effective room latent heat,
ESHF = Effective room sensible heat factor.
OASH = 0.0204 x V_o (Outside temperature – Inside temperature) x BPF
= 0.0204 x 129.36 x (38-25) x 0.52
= 17.84 kW = 17840 W

From psychrometric chart
At 25°C and 50% RH,
Inside humidity ω_i = 0.010 kg/kg dry air
At 38°C and 40% RH,
Inside humidity ω_o = 0.017kg/kg dry air
OALH = 50 x V_o (Outside humidity –Inside humidity) x BPF
= 50x 129.36 x (0.017-0.010) x 0.52
= 23.54 kW = 23540 W

Type of Load (Watt)	Sensible Heat (S.H) (Watt)	Latent Heat (L.H.) (Watt)
Solar heat gain through glass by transmission	56323	
Solar heat gain through wall by conduction	15307	
Solar heat gain through roof	18397.1	
Heat gain from appliances	3080	
Heat gain from occupancy	32340	20790
Infiltration (door)	11023.32	13656.72
Infiltration (window)	16230.06	20101.62
Sub total	**152700.48**	**54548.34**
Safety factor (5%)	7635.024	2727.42
Room heat	160335.5	57275.76
Supply duct leakage losses (0.5%)	801.68	286.38
Fan HP (5%)	801608	2863.8
Effective load	**169153.98**	**60425.94**

3.8 Dehumidified Air Quantity

The calculating Dehumidified air quantity,
The value ERSH taken from above table is 169.153 kW and also taken value of ERLH is 60.425 kW
So the Effective room sensible heat factor value calculating
ESHF = ERSH/ (ERSH+ERLH)
= 169.153 / (169.153 + 60.425) = 0.737
ADP of coil = 13.5^{0}C (from psychrometric chart)
Dehumidified air quantity

$$= ERSH/\left[(T_1 - T_{ADP})(1 - BPF)0.0204\right]$$

= 169.153 / [(25-13.5) x (1-0.52) x 0.0204]
= 1502.14 $(m^3 / min)_d$

Re-circulated room air:
= $(m^3 /min)_d – (m^3 /min)_o$
= 1502.14 – 129.36 = 1372.78 m^3 /min
From psychrometric chart
At 25°C and 50% RH,
h_i = 51.00 kJ/kg of air
v_i = 0.86 m^3 /kg
At 38°C and 40% RH,
h_o = 80.1 kJ/kg of air
v_o = 0.90 m^3 /k
At 31.25°C and 40% RH,
h_x = 64 kJ/kg of air
At 18.25°C,
h_y = 37 kJ/kg of air

Mass flow rate of outside air $= \dfrac{(m^3/min)}{V_O}$

m_o = 1502.14/(0.9x60) = 27.82 kg/s
Tonnage of plant $= m_o\left(h_x - h_y\right)$
= 27.82 x (64 - 37)
= 751.07 kW = 214.59 TR

Moisture removed = 0.0115 - 0.0095 (from psychrometric chart)
= 0.002 kg/kg of air
Moisture removed = 27.82 x 3600x 0.002= 200.304 kg/hr

4. Results and Discussion

This results and discussion may be combined into a common section or obtainable separately.
In this paper the lecture hall of the engineering institute is centrally air-cooled than the students living there will feel comfortable by providing uniform comfortable ambient, their working capability will increase, consequently, this will be useful in studying for prolonged hours, which ultimately cater them good-marks and better academic output. This will prove as a boon for their career.

- The load calculation has been done for the peak load on the plant that may be encountered during the month of May as a peak summer duration.
- Only one centralized air conditioning plant for the both the floor has been suggested with the capacity of nearly 214.59 TR.

5. Conclusion

In this project the lecture hall of the engineering institute is centrally air-cooled than the students living there will feel comfortable by providing uniform comfortable ambient, their working capability will increase, consequently, this will be useful in studying for prolonged hours, which ultimately cater them good-marks and better academic output. This also useful in various departments and offices of the engineering institutes further research.

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