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*Research Article*

# Simplified Way to Calculate Air-Conditioning Cooling Load in Mahendergarh (Haryana)

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***Abstract***

*These days air conditioners become one of the essential equipments of our life, so choosing right cooling is necessary and installation of window or split AC then it is needed to know cooling load required for maintaining human comfort temperature level that is about 25°C and most of the time what people do, asked anyone who is not having any proper idea and for this installed AC either oversized or undersized that's why this paper is going to sho all details about calculating cooling load in simple way. Method used to calculate cooling load of a class room in an institute is CLTD method, CLTD method has been produced by ASHRAE. CLTD was obtained for each wall and roof makes easier to hand calculation of cooling load and gives very good satisfactory result when compared with complex cooling load calculation tools.*

***Keywords:*** *Cooling Hand, Transfer Function Method, CLTD*

## 1. Introduction

Use of air conditioners is becoming more popular in Mahendergarh district (Haryana) this is not only in malls, now days in home, office, institute, coffee shops, even in burger centers and correct load calculation is required to get proper HVAC system which is popular among all central air-conditioners. Bigger size air-conditioners is not better proper designed is required for getting more efficient operating cost and which is also important (J. Protor *et al*, 1995).Most of the time installed AC without proper calculation then it becomes difficult to maintained proper cooling if it is undersized, if it is oversized then it will consume more power means again less efficient. There are many books available to understand the concept of calculation strategy for proper calculation of heating and cooling load. But using hand calculation methods always have some error but this error can be reduced by using computer programs which is available in the market like CARRIER programs, it takes long time and of course complex data input. That is one of the big reason these type of programs is not that much popular and hand calculation method is prefer because it is easier to calculate a cooling load. A more simplified version for calculation of cooling load using the Transfer Function Method is the first step for start designing air-conditioning system the whole process is provided. The method is called Cooling Load Temperature Differences (CLTD), Cooling Load Factor (CLF) and Solar Cooling Load Factor (SCL). These all terms is usually helpful to find out cooling load of any room, office even hall, because all factors are involved in it, that is why it can able to get accuracy value and most important thing is that CLTD is easy to use and it this method make it easier to do hand calculation easily. Yes one factor need to consider that is latitude of the location because location latitude must not be less than 24$^0$N and so Mahendergarh (Haryana, India) is situated (Latitude 28$^0$ N), in this paper calculation of cooling load by using CLTD method of a class room in an educational institute.

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## 2. Methodologies used to calculate load

*2.1 Heat Gain Due to Solar Radiation*

Heat gain taking place due to solar radiation, actually when sun ray fall on the glass then what happened few rays transmitted through glass and therefore heat gain taking place, here is the formula used to calculate heat gain because of solar radiation.

Transmission heat gain through glass:

$Q = UA(CLTD)_{corr}$

By solar radiation:

$Q = A \times SHGF_{max} \times SC \times CLF$

$SHGF_{max}$ = maximum solar heat gain factor (W/m$^2$)

*SC* = shading coefficient depends on type of shading
*CLF* = cooling load factor

*2.2 Heat Gain Due to Human Beings*

The human body in a cooled space involved cooling load of sensible and latent heat. In an air conditioned room, sensible heat load and it all happened due to temperature different between body and room air. The heat gain from occupants is based on the average number of people that are expected to be present in a conditioned space. The heat load produced by each person depends upon the activity of the person. The value of heat gain increases with increase in activity of the human being.

The heat gain from occupancy or people are calculated by following equations:

Sensible heat gain from occupants
$Q_{s,\ person} = q_{s,\ person} \times N \times CLF$
Latent heat gain from occupants
$Q_{l\ ,\ person} = q_{l\ ,\ person} \times N$

Where,
N = total number of people present in conditioned space
CLF = cooling load factor
qs , person = sensible heatgain/person (W)
ql , person = latent heat gain/person (W)

*3.3 Heat Gain Due to Other Electric Equipments*

$Q_{equipement}$ = Total wattage of equipment × Use factor × CLF
CLF = 1.0, if operation is 24 hours or of cooling is off at night or during weekends.

*3.4 Heat Gain Because of Infiltration*
Amount of infiltration air
$= \frac{Volume\ of\ the\ Space\ Required\ Air-Conditioning}{60}$ m3/min

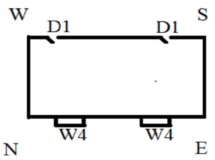
## 4. Calculation of cooling load of a class room

Now final step to calculate cooling load of a 60 seats class room, by using simple CLTD Method

**Table 1.1** Cooling load sheet of 60 seated Class Room

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | | | | Mahendergarh | | | | |
| Job No. | 1 | City | | | | MEHENDERGARH | | | | |
| Project | CLASS ROOM COOLING LOAD | Month | | | | May for Summer and July for Monsson | | | | |
| Space | 60 SEAT CLASS ROOM | Time | | | | | | | | |
| Length(m) | 9.2 | | Summer | | | | Monsoon | | | |
| Width(m) | 7.35 | CONDITION | DBT | WBT | %RH | kg/kg | DBT | WBT | %RH | kg/kg |
| Height(m) | 3.35 | Outside | 43 | 32 | 46 | 0.0248 | 36 | 33 | 84 | 0.03122 |
| Area(m2) | 67.62 | Inside | 23 | 16 | 20 | 0.00866 | 23 | 16 | 20 | 0.00866 |
| Volume(m3) | 226.5 | Difference | 20 | | | 0.0161 | 13 | | | 0.0226 |
| BPF = .12 | | No of Air Changes / Hr. = 1.00 | | | | filtrated Air(m3/min)=3.78 | | | | |
| | | | Summer | | | Monsoon | | | | |
| **SOLAR HEAT GAIN FOR GLASS** | | | | | | | | | | |
| Item | Area (sq. m) | Factor | W/m² | | W | | W/m² | | W | |
| Glass (N) | | 0.48 | 129 | | 0 | | 136 | | 0 | |
| Glass (N-E) | 7.3 | 0.13 | 527 | | 500 | | 521 | | 494 | |
| Glass (E) | | 0.11 | 631 | | 0 | | 618 | | 0 | |
| Glass (S-E) | | 0.14 | 372 | | 0 | | 360 | | 0 | |
| Glass (S) | | 0.22 | 129 | | 0 | | 129 | | 0 | |
| Glass (S-W) | | 0.52 | 372 | | 0 | | 360 | | 0 | |
| Glass (W) | | 0.52 | 631 | | 0 | | 618 | | 0 | |
| Glass (N-W) | | 0.47 | 527 | | 0 | | 521 | | 0 | |
| **SOLAR & TRANSMISSION HEAT GAIN FOR WALLS & ROOF** | | | | | | | | | | |
| Item | Area (sq. m) | Factor(W/m²-°C) | Temp Diff (°C) | | W | | Temp Diff (°C) | | W | |
| Wall (N) | | 1.07 | 23 | | 0 | | 16 | | 0 | |
| Wall (N-E) | 24 | 1.07 | 27 | | 693.36 | | 21 | | 539.28 | |
| Wall (E) | | 1.07 | 28 | | 0 | | 21 | | 0 | |
| Wall (S-E) | | 1.07 | 26 | | 0 | | 18 | | 0 | |
| Wall (S) | | 1.07 | 22 | | 0 | | 13 | | 0 | |
| Wall (S-W) | | 1.07 | 26 | | 0 | | 18 | | 0 | |
| Wall (W) | | 1.07 | 28 | | 0 | | 21 | | 0 | |
| Wall (W-N) | | 1.07 | 27 | | 0 | | 21 | | 0 | |
| Roof Sun | | 4.16 | 47 | | 0 | | 40 | | 0 | |
| **TRANSMISSION HEAT GAIN EXCEPT FOR WALLS & ROOF** | | | | | | | | | | |
| Item | Area (sq. m) | Factor(W/m²-°C) | Temp Diff (°C) | | W | | Temp Diff (°C) | | W | |
| All Glass | 7.24 | 5.6 | 20 | | 810.88 | | 13 | | 527.07 | |
| Partition 1 | 76 | 1.86 | 15 | | 2120.4 | | 8 | | 1130.88 | |
| Ceiling | 67.62 | 2.82 | 15 | | 2860.33 | | 8 | | 1525.51 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Floor | 67.62 | 4.5 | 2.5 | 760.73 | 2.3 | 699.87 |
| **HEAT GAIN DUE TO INFILTRATION** | | | | | | |
| Infiltrated Air | Bypass | Factor | Temp Diff (°C) | W | Temp Diff (°C) | W |
| 3.78 | 1 | 20.44 | 20 | 1545.26 | 13 | 1004.42 |
| **INTERNAL GAIN** | | | | | | |
| Item | | Factor | Temp Diff (°C) | W | Temp Diff (°C) | W |
| People | 60 | 70 | | 4200 | | 4200 |
| Lights(W/m2) | 15 | 123 | | 1843 | | 1843 |
| Motor (KW) | | | | 0 | | 0 |
| Equipment (KW) | | | | 0 | | 0 |
| **ROOM SENSIBLE HEAT SUBTOTAL** | | | **15333.96** | | **11964.03** | |
| S. A. heat gain, leak loss & Safety Factor (6%) | | | 1532.75 | | 1190.52 | |
| **ROOM SENSIBLE HEAT (R.S.H.) :** | | | **16866.71** | | **13154.55** | |
| **ROOM LATENT HEAT CALCULATION** | | | | | | |
| Infiltrated Air | Bypass | Factor | Diff kg/kg | w | Diff kg/kg | w |
| 3.78 | 1 | 50000 | 0.01611 | 3044.79 | 0.0226 | 4271.4 |
| ITEM | | Factor | Diff kg/kg | w | Diff kg/kg | w |
| No. Of People | 60 | 45 | | 2700 | | 2700 |
| Steam | | | | 0 | | 0 |
| Appliances | | | | 0 | | 0 |
| Vapour Trans | | | | 0 | | 0 |
| S. A. heat gain, leak loss & Safety Factor (5%) | | | 552.63 | | 664.89 | |
| **ROOM LATENT HEAT (R.L.H.) :** | | | **6297.42** | | **7636.29** | |
| | | | | | | |
| **ROOM TOTAL HEAT (R.T.H.) :** | | | **23164.13** | | **20790.84** | |
| **OUT SI DE AIR HAT :** | | | **OUTSIDE AIR SENSIBLE HEAT (OASH)** | | | |
| Outside Air | 1 - BPF | Factor | Temp Diff (°C) | W | Temp Diff (°C) | W |
| 2.5 | 0.88 | 20.44 | 20 | 883.92 | 13 | 574.55 |
| **OUTSIDE AIR LATENT HEAT (OALH)** | | | | | | |
| Outside Air | 1 - BPF | Factor | Diff kg/kg | W | Diff kg/kg | W |
| 2.5 | 0.88 | 50000 | 0.0161 | 1741.68 | 0.0226 | 2438.99 |
| **SUBTOTAL :** | | | 25789.73 | | 23804.38 | |
| R.A.heat, leak gain& Safety factor (5%) | | | 2065.48 | | 1900.44 | |
| **GRAND TOTAL :** | | | 27855.21 | | 25704.82 | |
| **TONS = {(W)/3500} :** | | | 7.96 | | 7.34 | |
| SENSIBLE HEAT FACTOR = (RSH/RTH) : | | | 0.66 | | 0.58 | |
| INDICATED ADP : | | | 8 | | 8 | |
| **SELECTED ADP :** | | | 9 | | 8 | |
| **DEHUMIDIFIED AIR QUANTITY** | | | | | | |
| Room Rise = (1 - By-pass Factor) * (Room Temp - ADP) : | | | 12.32 | | 15 | |
| DEHUMIDIFIED AIR = RSH / (20.44 * Dehumid. Rise) : | | | 61 | | 39 | |
| **Safety factor (5%)** | | | 3 | | 2 | |
| **TOTAL DEHUMIDIFIED AIR:** | | | 64 | | 41 | |




Here is the diagram of the class room with all details, consider the room latitude is 28° N, because class room location is in Mahendergarh, Data used from ASHRAE hand book for calculation.

Length of the room = 9.20 m
Width of the room = 7.35 m
Height of the room = 3.35 m
Total Area of the doors (D1) = 2.07×.944×2= 3.91m²
Total Area of glasses ($W_1$) =2.38×1.52×2=7.24m²

Partition wall areas (NW, SW, SE)= 7.35×3.35×2 +9.20×3.35-3.91= 76.12 m²
Total sun facing glass area = 7.24m²
Outside wall area (NE) = 9.20×3.35-7.24=23.58m²
Now the amount of infiltrated air through windows and walls is

$$= \frac{9.20 \times 7.35 \times 3.35}{60} = 3.78 \text{ m3/min}$$

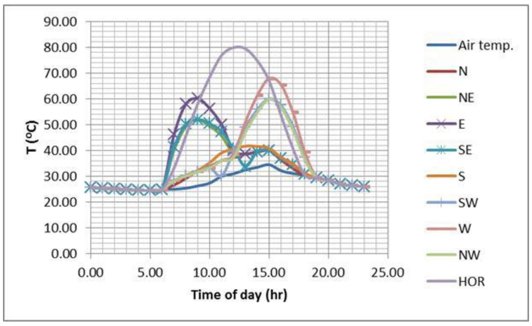
The details of cooling load calculations of the 60 seated seminar hall is given on the calculation sheet in table 1.1

## 4. Results and Conclusion

By using CLTD method calculation cooling load of a class room of an educational institutes in

Mahendergarh District, the class room required about 7.96 TR (Ton of Refrigeration) for 60 numbers of students in the class room for summer and for monsoon it required 7.34 TR other than these, also calculated total dehumidifier air that 64 $m^3$/min for summer and 41$m^3$/min for monsoon.

It is also seen there is variation in solar-air temperature for different orientation of surfaces(Uba Felix *et al,* 2013).




This paper shows the way to calculate cooling load of a class room which is made of commonly used materials and the CLTD method very easy to use to calculate more accurate cooling load. Even duct design and pressure drop is also possible with CLTD/CLF method (Deepak V K, *et al*, 2015). This will helps to find out air-condition simulation, for education purpose and system design in Mahendergarh (Haryana) to be performed more easily and more effectively.

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