

# Cooling Load Calculation of New Academic Building of Asansol Engineering College

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**Abstract:** Day by day due to increasing global temperature of the environment the demand of Air Conditioning Systems is increasing so it's very important that the right amount of Air Conditioning System is selected. This process of selecting the right amount of Air Conditioning System is done by calculating the heat loads from the various sources in the room. The calculation of Heat Load is very complex process and required a lot of complex mathematical calculation. So to simplify it various software such as HAP 4.0 etc. are used for the above said purpose. These softwares though are simple for the professionals but appear to be very complex for common people. So this projects develops an alternate excel sheet which does the same work as that of the professional softwares but in a very simple manner. This project contains a detailed cooling load calculation of "New Academic Building" of Asansol Engineering college, Asansol, West Bengal. Its covers all the aspects of solar heat gain through glass, walls, partition walls, ceilings, equipment etc. All the calculations are done in an excel sheets with all the data collected from ASHRAE and ISHRAE handbooks. The project also describes the different heat load parameters such as refrigeration, air conditioning, etc. The various assumptions and design parameters are also considered for the development of this project. The detailed calculation and the mathematics running behind the working of the excel sheet is also described in the 2nd half portion of the project [1].

**Keywords:** Cooling load calculation.

## 1. Introduction

The main objective is to calculate cooling load and find exact air-conditioning equipment and air handling unit(AHU), to obtain comfort operation and better air distribution in the air-conditioned area. In present scenario the Energy consumption problem is one of the most solemn problems. About 72% of world energy is expended by infrastructure, industry, marketable buildings, residential houses, and markets. In a large building or complex, which is air-conditioned, about 60% of the entire energy requirement in the building is allocated for the air-conditioning system installed to use the cooling purpose. Exact extrapolation of the cooling and heating load, suitable sizing of the heating ventilation air conditioning (HVAC) system and ideal control of the HVAC systems are significant to minimize energy consumption. Scheming of thermal load of building is very essential to find exact air-conditioning equipment and air

handling unit, to attain comfort maneuver and good air distribution in the air-conditioned zone. This load consists of exterior and internal loads. External heat gains arrive from the moved thermal energy from outside hot medium to the inside of the room. The heat transfer takes place from conduction through external barriers, top roof and bottom ground, solar radiation over windows and doors, ventilation and infiltration. Added sources are internal heat gain like people, electric apparatus and light [1].

## 2. Literature Review

F.A. Ansari, A.S. Mokhtar, K.A. Abbas and N.M. Adam proposed that the present effort was to find how some very public problems were made arithmetically entangled and seemed tiresome due to academic or commercial compulsions. There were some glitches in which mathematical model were established after making many simplifying molds. But, when it came to resolving these models, very sophisticated and intricate schemes were applied. For such problems, double policy did not make sense and in many scenarios the problem were attempted in a simpler way to get analogous accuracy. The existing work stated one such example. It dealt with the making and validation of an excel sheet for assessing building cooling load. The sheet was simpler to use, needed fewer input data and were more adaptable compared to any other commercially presented, exorbitantly expensive and extensively used software. The special effects of noteworthy structure constraints like orientation, window glass shade type, number of glass panes used, wall padding, roof type and floor type can be easily investigated. Effects of all these parameters had been inspected for a distinctive building block to attain at an brainy decision. With any other technique, it could not be prepared so conveniently. All the above mentioned benefits were without sacrificing accurateness and dependability.

The cooling load calculation mentioned in the present report was purely based on the rule of thumb. It might be called a digital form of cooling load estimation form. But astonishingly enough it gave very trustworthy results, which were almost the similar as those obtained by the sophisticated and inflated commercial software established and marketed by the

prominent MNCs. It was very easy to use and needed quite few number of data contribution. It was also accomplished of being used as a decent tool to make thorough investigations of dissimilar building parameters and its alignment before processing the construction [2].

S. K. Gaadhe, S. K. Chavda and R.D. Bandhiya proposed that, in order to minimize energy consumption and estimate the load for designing of an air conditioning system or the selection of the AC, cooling load must be estimated to have a comfortable conditioned space. More than 70% of energy was being utilized by various buildings, malls, factory. And approx. 60% of power in big mall or shopping complex was consumed by air conditioning system for maintaining desirable condition. Major reason that determines the cooling load was the outside weather parameters. Using false ceiling, and ceramic tile on floor as well as on roof, cooling load can be reduced. Thermal heat form surrounding gets transferred to the building by the means of conduction through roof, wall, ground; by means of radiation through windows; and by means of convection through ventilation and infiltration. Heat generated by various equipment, light and occupants was also the source of heat gain in the conditioned space. The climatic condition in winter was the temperature range of 10 -20 degree Celsius and in summer, it was between range of 28 – 42 degree Celsius. Reading hall dimension was 22.43mx 16.67mx 3.7m. outside wall was 225 mm thick including 25 mm sand cement plaster. Roof was made up of RCC slab (11.25mm)+ lime concrete on top (7.50mm)+ cement plaster (12.5mm). The glass used in windows was 50mm thick along with frame. The required condition for reading hall was assumed to temperature (21 – 26) and relative humidity (60%).

Sensible heat gain through opaque surface,  
 $Q = UA(T_{ETD})_{corr}$ .

Cooling load calculation due to wall/ceiling,  $Q = UA [FC (TETD)_{Peak} + FR (TETD)_{AVE}] W$ .

Heat gain through glass,  $Q_{glass} = A [SC\{FC(SHGF)P + FR (SHGF)A\} + U\Delta T] W$ .

Heat given by occupants = No. of occupants × Allowance Factor

Heat gain from electric light,  $Q_{Light} = \text{Total wattage of light} \times \text{Use factor} \times \text{Allowance factor}$

Heat gain from electric fan,  $Q_{Fan} = \text{Power (kW)} \times \text{Use factor} \times \text{Hours using}$

Crack Infiltration =  $q_i = (H \times L \times W \times G) / 60m^3/min$

Door Infiltration =  $\{(Door\ opening/hour) \times Factor\} / 60$

Sensible Heat Load due to Ventilation = No. of person × Factor

Latent Heat Load due to Ventilation = No. of person × Factor  
 Total Loads,  $RTHG = RSHG + RLHG$

After collecting all the necessary data, MS Excel sheet was prepared using these equations to get the cooling load of the reading hall. From this experiment, S. K. Gaadhe, S. K. Chavda and R. D. Bandhiya came to closure that the total cooling load for AC is 18.83 mtr. sq. per tons in summer which almost same

as the standard value of about 20 mtr. sq. per tons [3].

### 3. Working Principle

The working principle of the Air conditioner or AC is collecting hot air from a given space and processing it to release cool air into the same space where the hot air had originally been collected. This process is done through the 5 steps such as the evaporator, compressor, condenser, expansion valve, Refrigerant. An air conditioner is able to cool a building because it removes heat from indoor air and transfers to outdoor air. There is one chemical refrigerant in the ac system that absorbs the unwanted heat surrounding the room or office and pumps it through a system of piping to the outside coil. The main problems in the ac system are grime, dust and dirt ant that need to be handled while maintaining an ac unit.

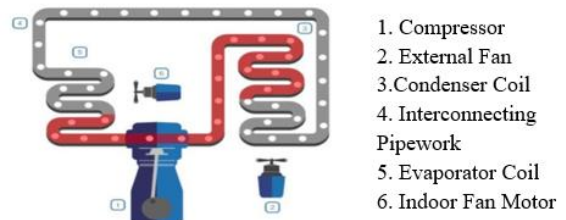


Fig. 1. A simple air conditioning unit

### 4. Data Collection Methodology and Assumptions

**BUILDING LOCATION:** The “New Academic Building” is located in Asansol at latitude of-----23o41’

**INPUT DATA:**

**OUTSIDE DESIGN CONDITIONS:**  
**FOR SUMMER (MAY)**

Dry Bulb Temperature (DBT) 40 °C  
 Wet Bulb Temp (WBT) 31 °C  
 Moisture Content (kg/kg of dry air) 0.026  
 Relative Humidity (RH %) 55%

**FOR MONSOON (JULY)**

Dry Bulb temperature (DBT) 36 °C  
 Wet Bulb Temp (WBT) 29 °C  
 Moisture Content (kg/kg of dry air) 0.023  
 Relative Humidity (RH %) 59%

**INSIDE DESIGN CONDITIONS**

**FOR SUMMER (MAY)**  
 Dry Bulb Temperature (DBT) 24 °C  
 Wet Bulb Temp (WBT) 16 °C  
 Moisture Content (kg/kg of dry air) 0.009  
 Relative Humidity (RH %) 45%

**FOR MONSOON(JULY)**

Dry Bulb Temperature (DBT) 24 °C

Wet Bulb Temp (WBT) 16 °C  
 Moisture Content (kg/kg of dry air) 0.009  
 Relative Humidity (RH %) 45%

CONSIDERATION OF U- FACTOR:

INTERNAL/PARTITION WALL

All internal or partitions walls are considered to be made of 250mm thick common brick with 13mm sand cement plaster coating on both outside and inside.

R(sq. m-K/W)

- (1) Inside air.....0.12
- (2) 13mm inside finish .....0.018
- (3) 250mm common brick .....0.279
- (4) 13mm thick outside finish .....0.018
- (5) Inside air .....0.12

TOTAL U= (1/R) ---1.800

EXTERIOR WALL

All external walls are considered to be made of 250mm thick common brick with 13mm sand cement plaster coating on both outside and inside.

R(m<sup>2</sup>-K/W)

- (1) Outside air..... 0.044
- (2) 13mm inside finish.....0.018
- (3) 250mm common brick.....0.279
- (4) 13mm thick outside finish.....0.018
- (5) Inside air.....0.12

TOTAL U= (1/R)—2.806

ROOF

Roof is considered to be made of 150mm thick light weight concrete with 13mm thick sand cement plaster on both sides i.e. outside and inside.

R (sq. m-K/W)

- (1) Outside air.....0.044
- (2) 13mm inside finish.....0.018
- (3) 150mm common brick.....0.34
- (4) 25mm expanded insulation.....0.962
- (5) Inside air.....0.16

TOTAL U=(1/R)--0.656

INDOOR GLASS WINDOW, U=2.485(m<sup>2</sup>K/W)

Sensible Heat Gain through Opaque Surface

Q =UA (CLTD)

Where

U = over all heat transfer coefficient (W/ m<sup>2</sup>-°C)

CLTD = cooling load temperature difference (°C)

A = surface area (m<sup>2</sup>)

Overall heat transfer coefficient

$$U=1/\{(1/h_o)+(x1/k1)+(1/ka)+(x2/k2)+....+(1/h_i)\}$$

Heat Gain through Glass

Transmission heat gain through glass:

Q =UA (CLTD)

By solar radiation: Q = A x SHGF x SC x CLF max

Max SHGF = maximum solar heat gain factor (W/m<sup>2</sup>)

SC = shading coefficient depends on type of shading

CLF = cooling load factor

Heat Gain from Occupants

Sensible heat gain from occupants

Q = q x N x CLF s person s person

Latent heat gain from occupants

Q = q x N

Where's person q, = sensible heat gain/person (W)

l person q = latent heat gain/person (W)

N = total number of people present in conditioned space CLF = cooling load factor

Heat Gain from Lighting Equipment

Q =Total wattage of light x Use factor x Allowance factor

Heat gain from electric equipment

Q = Total wattage of equipment x Use factor x CLF

Heat gain due to Infiltration

Amount of infiltrated air

(Vinf) = {(Volume of space) x Ac}/60 m<sup>3</sup>/min

Total loads in tons = (Total Loads in Watt) / 3500 [4]

5. Building Design



Fig:-2 New Building Design

**6. Sample Calculation**

GROUND FLOOR: For Class-IT



SOLAR TRANSMISION HEAT GAIN (for sun facing wall)

$Q=UA$  (CLDT)

(For summer)

Overall heat transfer coefficient (U) =0.48

Area=14.6304

Cooling load temperature difference (CLTD) =11

Therefore;  $Q=0.48 \times 14.6304 \times 11$   $Q= 516.9921039$

(For monsoon)

Overall heat transfer coefficient (U) =0.48

Area=14.6304

Cooling load temperature difference (CLTD) =7.17

Therefore;  $Q=0.48 \times 14.6304 \times 7.17$   $Q= 336.9848532$

SOLAR HEAT GAIN FOR GLASS

(For summer)

Area=14.6304

Factor (U) =0.48

W/ m2= 527

$Q=14.6304 \times 0.4 \times 527$

$Q= 3700.905984$

(For monsoon)

W/m2 =521

$Q=14.6304 \times 0.4 \times 521$

$Q=3658.770432$

TRANSMISSION GEAT GAIN (except outer wall) Partition wall

Area= 120.21312sq m: U-factor= 1.8

Temp diff (summer) = 21

$Q=120.21312 \times 1.8821$ ;  $Q$  (summer) =4544.055936

Temp diff (monsoon) = 17

$Q=120.213128 \times 1.8 \times 17$ ;  $Q$  (monsoon) =3678.521472

Celling

Area= 67.7418; U-factor= 0.656

Temp diff (summer) = 21

$Q=67.7418 \times 21$

$Q$  (summer) = 933.2110368

Temp diff (monsoon) = 17

$Q$  (summer) = 755.4565536

Floor

Area= 67.7418; U-factor= 0.656

Temp diff (summer) = 21

$Q$ (summer)=67.7418 0.656 21

Temp diff (monsoon) = 17

$Q=67.7418 \times 0.656 \times 17$ ;  $Q$  (monsoon) = 755.4565536

HEAT GAIN DUE TO INFILTRATION

By pass factor =1

Infiltrated Air (m3min) =6.52

Factor =20.44

Temp diff (summer) =16

$Q= 2132.3008$  Temp diff (monsoon) =12

$Q= 1599.2256$

EXTERNAL GAIN

Total Watt

People.....10500

Lights.....1125

Fans.....2400

Equipment.....1000

OUTSIDE AIR

(FOR SENSIBLE)

Outside air =2.12

BPF=0.88; Factor =20.44

Temp diff (summer) =16

$Q=2.12 \times 0.88 \times 20.44 \times 16$ ;  $Q$  (summer) =610.125824

Temp diff (monsoon) =12

$Q=2.12 \times 0.88 \times 20.44 \times 12$ ;  $Q$ (summer)=457.594368

(FOR LATENT)

Outside air =2.12

BPF=0.88

Factor =50000

Diff (Kg/Kg) (summer) =0.017

$Q=2.12 \times 0.88 \times 50000 \times 0.017$ ;  $Q$  (summer) = 1585.76

Diff (Kg/Kg) (monsoon) =0.0133

$Q=2.12 \times 0.88 \times 50000 \times 0.0133$ ;  $Q$ (monsoon)= 1240.624

ROOM LATENT HEAT CALCULATION

Number of people=60

Outside air (CMF) =6.52

By pass=1

Factor=50000

Diff (kg/kg)(summer)=0.017

Factor (people) =45

$Q= 5542$

$Q= 2700$

Diff (kg/kg) (monsoon) = 0.0133

$Q= 4335.8$

ROOM LATENT HEAT SUBTOTAL  
SUMMER

Subtotal latent heat =8242  
Leak (%5) =  $0.5 \times 8242 = 412.1$   
Room latent heat =  $8242 + 412.1 = 8654.1$

MONSOON

Subtotal latent heat =7035.8  
Leak (%5) =  $0.5 \times 7035.8 = 351.79$   
Room latent heat =  $7.35.8 + 351.79 = 7387.59$

ROOM SENSIBLE HEAT SUBTOTAL  
SUMMER

Subtotal sensible heat  
=  $3700.905984 + 516.9921039 + 4544.055936 + 933.2110368 +$   
 $933.2110368 + 2132.3008 + 4200 + 675 + 1600 + 1000610.125824$   
= 20845.80272  
Leak (%5) =  $0.5 \times 80845.80 = 10422.90$   
Room sensible heat = 21888.09286

MONSOON

Subtotal sensible heat  
 $457.594368 + 4200 + 675 + 1600 + 1000 + 1599.2256 + 1599.2256$   
 $+ 3678.521472 + 755.4565536 + 336.9848532 + 3658.770432$   
= 18717.00983  
Leak (%5) =  $0.5 \times 18717.009 = 935.8504916$   
Room sensible heat = 19652.86032

SENSIBLE HEAT FATOR

Summer=0.716650994  
Monsoon=0.726794861

ROOM TOTAL HEAT SENSIBLE+LATENT

SUMMER (RTH) = 30542.19286  
MONSOON (RTH) = 27040.45032

TONS OF REFRIGRATION (TR)

SUMMER TR =  $RTH = 30542.19286 / 3500 = 8.726340816$   
MONSOON TR =  $RTH = 27040.45032 / 3500$   
= 7.72584295

Similarly, the Calculation is carried forward for all the rooms shown in the building design and the result comes out to be:

Total T.R for Summer = 466TR  
Total T.R for Monsoon=404TR

### 7. Future Scope

The everyday rising global temperature of the environment compels us for the usage of Air Conditioning Systems. It has been a necessity for the lifestyle. So to be economically safe we need to calculate the amount of conditioning that is needed for any room and then act accordingly. So this paper helps to make that complex calculation easier. In future this can be made more simplified and instead of using the excel sheets a mobile app can be made (with collaborating with Computer Science) so that each and every person can judge and select the best amount of air conditioning required for them.

### 8. Conclusion

Now-a-days Air Conditioning System has been a need for every professional and nonprofessional organization due to the rapid increase and fluctuations of the environmental temperatures. Though Air Conditioners are the need of the hour but its cost restricts its usage, so it's very important that we calculate the exact amount of conditioning needed for our purpose and act accordingly. The paper covers the various aspects of "Heat Load Calculation" of "New Academic Building" of "Asansol Engineering College", Asansol West Bengal. The first section deals with the Introduction and also discusses the working principle and formulas that are used during the heat load calculation. The second section calculates the total TR of Air Conditioning required for various seasons which resulted as 466TR in Summer and 404TR in Monsoon.

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