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Energy Audit of an Existing Building: Cooling Load Approach

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Abstract: ***This project has been carried to perform energy audit in an office building in order to find out the energy saving measures. The objective of this project is to obtain information about the building cooling systems, lighting systems and finally to find minimal cost and building measures that can be implemented to reduce energy consumption of that building with a set of improvements of the lighting system and an extensive use of day lighting strategies. One building has been chosen for this project and a detailed energy audit has been conducted in the building with the permission from the building management. Finally there are few energy saving measures recommended for this building and the energy consumption has been found to decrease after implementing those measures in the building. The effect of significant building parameters like orientation, window glass shade type, wall insulation, roof type and floor type can be easily investigated. Effect of all these parameters have been investigated for a typical building block to arrive at an intelligent decision. Various calculations of cooling land for existing building which comes out be 404. 182 KW. After that modifications have been suggested with regard to insulation provision, reduction of quantity of air-conditioners and using double glazed glass on window panes. Cooling load calculations after modifications have been done comes out to be 247.557KW thereby saving about 38.75% of total cooling load. The objectives of the project are: 1) To achieve energy savings. 2) To provide a high quality internal environment. 3) To provide recommendations to reduce the monthly electricity bills.***

Keywords: Cooling Load Approach

1. Introduction

A building should be designed keeping in mind the health and wellbeing of the building occupants: Another important, feature of a green building should be such that its design should aim to provide comfortable and safe environment for is its inhabitants. It means that building will be pleasant and safe for human inhabitants .Materials used should be safe for humans and architecture design should also be very intuitive, so as to have provision for fresh air and and natural sunlight.

An important benefit of Green Building is its Energy Efficiency, which results in reducing energy consumption for AC's and Heating needs, It should feature elements like effective use of natural lighting, cool roof and wall panels, and green energy generating systems all aimed at reducing energy consumption', the result of using green building is clean environment and cost savings for the owners of the building.

2. Site Selection and Description

Building Characteristics

To calculate space heat gain, the following information on building envelope is required.

a) Architectural plans, sections and elevations – for estimating buildings dimensions/area/volume.
b) Building orientation (N,S,E,W,NE,SE,SW,NW,etc) location etc.
c) External/Internal shading, ground reflectance etc.
d) Materials of construction for external walls, roofs, windows, doors, internal walls, partitions, ceiling, insulating materials and thick nesses, external wall and roof colors-select and/or compute U-values for walls, roof, windows, doors, partitions, etc. Check if the structure is insulated and/or exposed to high wind.

Operating Schedules

Obtain the schedule of occupants, lighting, equipment, appliances, and processes that contribute to the internal loads and determine whether air conditioning equipment will be operated continuously or intermittently (such as, shut down during off periods, night set-back, and weekend shut down). Gather the following information.

a) Lighting requirements, types of following fixtures.
b) Appliances requirements such as computers, printers, fax machines, water coolers, refrigerators, microwave, miscellaneous electrical panels, cable etc.
c) Heat released by the HVAC equipment.
d) Number of occupants, time of building occupancy and type of building company.

The following data related to the building is:

1) Location: Latitude [32°420 N] and Longitude [7452fl E]
2) Type of building: Office
3) Total Occupants: 137 persons
4) Working Hours: 8 hrs of working -9.00 to 17.00 hrs
5) Number of floors: 3
6) Floor area: 150 ft x 53 ft = 7950 ft
7) Floor-to-floor Height: 10 ft
8) Windows: Single Regular Glass
9) Wall: Thickness = 11 inch [U= 2.77 W/m2-K]
10) Exterior wall structure:
    - Face brick = 9 inches
    - Plaster = 1 inch (on both side)
11) Roof: Thickness = 6 inch [U= 7.2 W/m2-K]
12) Roofs:
    - Facebrick=l inch
    - Concrete slab = 4 inches
    - Plaster (inside) = 1 inches 13) Exterior window:
    - Regular Single glass = 3mm

- Exterior shading coefficient (SC) = 30% of regular single glass

3. Cooling Load Calculations

Cooling load calculations may be used to accomplish one or more •of the following objectives:

a) Provide information for equipment selection, system sizing and system design.
b) Provide data for evaluating the optimum possibilities for load reduction.
c) Permit analysis of partial loads as required for system design, operation and control.

This provides a procedure for preparing a manual calculation for cooling load. A number of published methods, tables and charts from industry handbooks, manufacturer's engineering data and manufacturer's catalog data usually provide a good source of design information and criteria in the preparation of the HVAC load calculation.

For strictly manual cooling load calculation method, the most practical to use is the CLTD method as described in the 1997 ASHRAE Fundamentals. It should be noted that the results obtained from using the CLTD method depend largely on the characteristics of the space being considered and how they vary from the model used to generate the CLTD data shown on the various tables.

Table 4.2: Window GLF values for single family Detached Residence

Design Temperature	*Regular Single Glass*					
	29	32	35	38	41	43
Draperies, Ventilation blinds, translucent, roller, shades, fully grown						
North	57	60	73	85	91	104
NE and NW	101	104	120	132	136	148
East and West	142	145	158	170	173	186
SE and SW	126	129	145	155	161	173
South	85	88	104	117	120	132
Horizontal Skylight	246	249	262	271	274	284

Table 4:3: CLTD values for Single family detached residences

Daily Temperature range (deg C)	29		32		35		38		41		43	
	L	**M**	**L**	**M**	**H**	**L**	**M**	**H**	**M**	**H**	**M**	**H**
All Wall and doors												
North	4	2	7	4	2	10	7	4	10	7	10	13
NE and NW	8	5	11	8	5	13	11	8	13	11	13	16
East and West	10	7	13	10	7	16	13	10	16	13	16	18
SE and SW	9	6	12	9	6	14	12	9	14	12	14	17
South	6	3	9	6	3	12	9	6	12	9	12	14
Roofs and Ceilings												
Attic and Flat built up	23	21	26	23	21	28	26	23	28	26	28	31
Floors and Ceilings												
Under Conditioned space, over conditional room, over crawl space	5	2	7	5	2	8	7	5	8	7	8	11
Partitions												
Inside or shaded	5	2	7	5	2	8	7	5	8	7	8	11

Where:
- L=Low Daily Range, Less than 16^{0}F
- M=Medium Daily Range, 16 to 25^{0}F

Table 4.4: Formulae for Residential Cooling Load Calculations

Load Source	**Equation**
Glasses and Window Areas	q=(GLF)A
Doors	q=U_dA(CLTD)
Above e-grade exterior walls	q=U_wA(CLTD)
Ceilings and roofs	q=U_rA(CLTD)
Exposed floors	q=U_fA(CLTD)

- Where:
  q=sensible cooling load, Btu/hr
  U=Coefficient of heat transfer roof or wall or glass (W/m^2-K)
  A=Area of roof, ft^2
  CLTD=Cooling Load Temperature difference ^{0F}
  GLF=glass load factor
- **Related Terms**
  Relevant terms related to heat transmission and load calculations are defined below in accordance with ASHRAE standard 12-75.
- **Cooling Load Temperature Difference (CLTD):-** It is defined as an equivalent temperature used for calculating the instantaneous external cooling load across a wall or roof. A value used in cooling load calculations for the effective temperature difference across a wall or ceiling, which accounts for the effect of radiant heat as well as the temperature difference.
- **Heat Transfer Coefficient (U-Factor):-** It is the rate of heat flow through a unit area of building envelope material or assembly, including its boundary films, as per unit of temperature difference between the inside and outside air.
- **Thermal Resistance (R):-** It is defined as the reciprocal of a heat transfer coefficient. Thermal resistance is a heat property-and a measure of temperature difference, by which an object-or material resist a heat flow (heat per time unit or thermal resistance). For example, a wall with a u-value of 0.25 would have a resistance value of R=1/U=1/0.25=4.0.
- **Thermal Conductivity (K):-** It is defined as the ability of a material to transfer heat. Given two surface on either side of the material with a temperature difference between them, the thermal conductivity is the heat energy

transferred per unit time and per unit surface area, divided by the temperature difference.

- Example of Cooling Load Calculation:
  Consider first floor VIG Room:
  Floor to Ceiling height – 3.0048m (10ft)
  Outdoor temperature -41 deg C
  ROOF:
- **Thermal resistance of brick $R1=L_1/K_1$**
  =0.0254/0.7
  =0.036(m^2-K)/VV
- **Thermal resistance of plaster $R2=L_2/K_2$**
  =0.1016/1.5
  =0.077(m^2-K)/W
- **Thermal resistance of plaster $R3 = L_3/K_3$**
  =0.0254/0.721
  =0.035(m^2-K)/W
  U-Factor of roof =1/(R1+R2+R3)=7.2W/(m^2-K)
  Area (A)=6mx5.18m=31.08m^2
  Cooling load (KW)=U x A x CLTD
  =7.2 x 31.08 x 28
  = 6.265KW
  WALLS:
- Thermal resistance of brick R1= L1/K1
  = 0.2286/0.7
  = 0.326 (m2- K)/W Thermal resistance of plaster R2= L2/K2
  = 0.0254/0.721
  = 0.035 (m2- K)/W
  U-Factor of wall = 1/ (R1+2R2) 2.52W/(m2-K)
  South wall Area (A) = (6m x 3.048m) —(3.26 mx 1.68m) = 12.81m2
  Cooling load (kW) = U x A x CLTD
  =2.52x12.81x120.424kW
  North wall area = 16.46 m2
  Cooling load (kW) = U x A x CLTD
  = 2.52 x 16.46 x 10 = 0.454 kW
  South Window:
  Area (A) = 3.26m x 1.68m (1- 0.30) 3.83m2
  Cooling load (kW) = A x GLF
  = 3.83 x 120 = 0.459 KW
  North door:
- Thermal resistance of wood R1= L1/K1
  = 0.035/0.12
  = 0.291 (m2- K)/W U-Factor of wood = 1/ (RI) = 3.43 W/(m2-K)
  Area = 0.91m x 2m = 1.82 m2
  Cooling load (kW) = U x A x CLTD = 3.43 x 1.82 x 10 = 0.062 KW
- ALUMINIUM DOOR:
- U-factor of Aluminium = 2500W/m2-K [Assume K = 150 W/ rn-K and L = 6cm]
- U-factor of glass = 266.67 W/m2-K [Assume K = 0.8 W/ rn-K and L = 3mm]
- Q (Aluminium door) U aiXAXzT U gXAXtT
  = 2500 x 2.1 x (26— 22) - 266.67 x 0.8 x (26 - 22)
  = 20.148 KW
  Where:
  = temperature difference (deg C)
  Hall temperature = 26 deg C
  Room temperature = 22 deg C

Table 4.5: Cooling Load for First Floor without insulation for Temperature 41°C

VIG ROOM					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2$-K)	CLTD	Cooling Load (KW)
Roof	31.08		7.2	28	6.265
South Wall	12.81		2.52	12	0.387
South Window	3.83	120			0.459
North Wall	16.46		2.52	10	0.415
North Door	1.82		3.43	10	0.062

LIBRARY					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2$-K)	CLTD	Cooling Load (KW)
Roof	23.67		7.2	28	4.772
South Wall	8.45		2.52	10	0.213
South Window	3.83	91			0.348
North Wall	13.93		2.52	12	0.421
North Door	1.82		3.43	12	0.075

DGM ROOM					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2$-K)	CLTD	Cooling Load (KW)
Roof	23.67		7.2	28	4.772
South Wall	8.45		2.52	10	0.213
South Window	3.83	91			0.348
North Wall	13.93		2.52	12	0.421
North Door	1.82		3.43	12	0.075

OPEN WALL					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2$-K)	CLTD	Cooling Load (KW)
Roof	185.24		7.2	28	37.344
South Wall	25.38		2.52	12	0.767
South Window	11.5	120			1.38
North Wall	8.44		2.52	16	0.340
North Door	6.41	173			1.109

AGM ROOM					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2$-K)	CLTD	Cooling Load (KW)
Roof	31.08		7.2	28	6.265
North Wall	12.81		2.52	10	0.323
North Window	3.83	91			0.349
South Wall	16.46		2.52	12	0.498
South Door	1.82		3.43	12	0.075
East Wall	12.09		2.52	16	0.487
East Window	2.59	173			0.448

Table 4:6: Cooling Load for Second Floor without Insulation for Temperature 41^{0}C.

OPEN WALL					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2$-K)	CLTD	Cooling Load (KW)
Roof	31.45		7.2	28	6.340
North Wall	13.03		2.52	10	0.328
West Wall	12.09		2.52	16	0.487
East Wall	13.96		2.52	16	0.562
North Wall	3.83	91			0.348
West Window	2.58	173			0.446
East Door	1.82		3.43	16	0.099

HR ROOM					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	47.34		7.2	28	9.545
North Wall	16.90		2.52	10	0.426
North Window	7.66	91			0.697
South Wall	26.03		2.52	12	0.787
South Door	1.82		3.43	12	0.075

CFM ROOM					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	31.45		7.2	28	6.340
North Wall	13.03		2.52	10	0.328
North Window	3.83	91			0.348
South Wall	12.10		2.52	12	0.366
South Door	1.82		3.43	12	0.075

DGM ROOM 2					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	31.45		7.2	28	6.340
East Wall	13.03		2.52	10	0.328
East Window	12.09		2.52	16	0.487
South Wall	13.96		2.52	16	0.562
South Window	3.83	91			0.348
West Wall	2.58	173			0.446
West Door	1.82		3.43	16	0.099

CASH ROOM					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	23.68		7.2	28	4.775
North Wall	8.45		2.52	10	0.212
North Window	3.83	91			0.348
South Wall	12.10		2.52	12	0.366
South Door	1.82		3.43	12	0.075

DGM ROOM 3					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	23.68		7.2	28	4.775
West Wall	8.45		2.52	10	0.212
West Window	3.83	91			0.348
East Wall	12.10		2.52	12	0.366
East Door	1.82		3.43	12	0.075

DGM ROOM 3					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	424.46		7.2	28	85.571
South Wall	73.12		2.52	12	2.211
South Window	26.81	274			7.35
East Wall	12.17		2.52	16	0.491
East Window	3.83	173			0.662

Table 4:7: Cooling Load for Third Floor Without insulation for temperature 41^{0}C

DGM ROOM 3					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	31.08		7.2	28	6.266
South Wall	21.81		2.52	12	0.387
East Wall	11.35		2.52	16	0.457
South Window	3.83	120			0.459
East Window	3.104	173			0.536

ULDC ROOM					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	23.62		7.2	28	4.762
North Wall	11.82		2.52	10	0.298
South Wall	8.45		2.52	12	0.255
South Window	3.83	120			0.459
North Door (Al)	2.1				20.15

Server Room					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	23.62		7.2	28	4.762
North Wall	12.11		2.52	10	0.305
South Wall	8.45		2.52	12	0.255
South Window	3.83	120			0.459
North Door	1.82		3.43	10	0.062

CONFERENCE HALL					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	54.65		7.2	28	11.107
North Wall	30.85		2.52	10	0.777
South Wall	15.78		2.52	12	0.477
West Wall	11.35		2.52	16	0.457
South Window	11.49	120			1.378
West Window	4.435	173			0.767
North Door	1.37		3.43	10	0.047

AGM OFFICE					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	31.02		7.2	28	6.254
North Wall	12.81		2.52	10	0.323
South Wall	16.46		2.52	12	0.498
East Wall	11.323		2.52	16	0.456
South Door	1.82		3.43	12	0.075
East Window	4.435	173			0.767
North Window	3.83	91			0.348

ED ROOM					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	75.55		7.2	28	15.230
North Wall	21.48		2.52	10	0.541
South Wall	16.46		2.52	12	0.497
West Wall	2.66		2.52	16	0.107
North Window	7.66	91			0.697
West Window	4.435	173			0.767
South Door	1.82		3.43	12	0.075

ULDC ROOM					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	11.82		7.2	28	2.383
North Wall	8.453		2.52	10	0.213
South Wall	12.11		2.52	12	0.366
South Door	1.82		3.43	12	0.075
North Window	3.83	91			0.348

IT ROOM					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	47.253		7.2	28	9.526
North Wall	16.904		2.52	10	0.426
South Wall	26.038		2.52	12	0.787
South Door	1.82		3.43	12	0.075
North Window	7.66	91			0.697

OPEN HALL					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	327.57		7.2	28	66.04
North Wall	8.462		2.52	10	0.213
South Wall	53.247		2.52	12	1.610
East Wall	8.777		2.52	16	0.354
South Window	11.50		2.52	16	0.354
East Window	5.18	173			1.380
North Window	3.83	91			0.697

Table 4:8: Cooling Load for Appliances of First Floor

FIRST FLOOR				
Rooms	Tube light			Cooling Load (KW)
	9W	11W	36W	
VIG Room			6	0.216
AGM Room			8	0.288
CPCC Room			8	0.288
DGM Room			8	0.288
Hall			54	1.944
Total				3.024

Table 4:9: Cooling Load for Appliances of Second Floor

SECOND FLOOR				
Rooms	Tube light			Cooling Load (KW)
	9W	11W	36W	
DGM Room 1			6	0.216
HR Room			6	0.216
Union Room			8	0.288
Cash Room			8	0.288
CFM Room			8	0.31
DGM Room 2			6	0.216
DGM Room 3			6	0.216
Hall			100	3.6
Total				5.35

Table 4:10: Cooling Load for Appliances of third Floor

THIRD FLOOR				
Rooms	Tube light			Cooling Load (KW)
	9W	11W	36W	
GM Room	8		8	0.36
ULDC Room	8	8	12	0.592
Server Room		12		0.132
Conference Hall	16		20	0.864
ED Room		8	8	0.376
AGM Office		8	8	0.376
IT Room		14	8	0.313
DGM Office			8	0.218
HALL			90	3.24
TOTAL				6.47

4. Cooling Load Calculations by using insulation

By providing 5mm Fibre Glass insulation:

The Standards known to us shown that the cooling load for the given building is high. So we need to reduce this load as we are provided naturally with the day lighting. Moreover, there is no provision of insulation inside the building so if we provide 5mm fibre glass insulation (K=0.04W/m-K) to the walls and roofs of the building then therer will be new U-value of walls and roofs due to which the cooling load can be reduced.

Therefore:

R(insulation) =L/K

=0.005/0.04

=0.125m^2-K/W

New U-Factor of wall = 1/(R1+2R2+R (insulation)

=1/(0.326+2(0.0352)+0.125)=1.91W/m^2-K

New U-Factor of roof = 1/(R1+R2+R3+R(insulation)

=1/(0.036+0.067+0.035+0.125)

=3.78W/m^2-K

Table 4.11: Cooling load for first floor using fibre glass insulation

VIG ROOM					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	31.08		3.78	28	3.290
South Wall	12.81		1.92	12	0.295
South Window	3.83	120			0.459
North Wall	16.46		1.92	10	0.316
North Door	1.82		3.43	10	0.062

AGM ROOM					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	31.08		3.78	28	3.290
North Wall	12.81		1.92	10	0.245
North Window	3.83	91			0.349
South Wall	16.46		1.92	12	0.379
South Door	1.82		3.43	12	0.075
East Wall	12.09		1.92	16	0.371
East Window	2.59	173			0.448

LIBRARY					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	23,67		3.78	28	2.505
North Wall	8.45		1.92	10	0.162
North Window	3.83	91			0.348
South Wall	13.93		1.92	12	0.321
South Door	1.82		3.43	12	0.075

DGM HALL					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	23.67		3.78	28	2.505
North Wall	8.45		1.92	10	0.162
North Window	3.83	91			0.348
South Wall	13.93		1.92	12	0.321
South Door	1.82		3.43	12	0.075

OPEN HALL					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	185.24		3.78	28	19.605
South Wall	25.38		1.92	12	0.585
South Window	11.5	120			1.38
East Wall	8.44		1.92	16	0.259
East Window	6.41	173			1.109

Table 4:12: Cooling Load for Second Floor Using Fibre Glass Insulation

OPEN HALL

Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	31.45		3.78	28	3.328
North Wall	13.03		.192	10	0.250
West Wall	12.09		1.92	16	0.371
East Wall	13.96		1.92	16	0.429
North Window	3.83	91			0.348
West Window	2.58	173			0.446
East Door	1.82		3.43	16	0.099

HR ROOM

Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	47.34		3.78	28	4.612
North Wall	16.90		1.92	10	0.324
North Window	7.66	91			0.697
South Wall	26.03		1.92	12	0.600
South Door	1.82		3.43	12	0.075

UNION ROOM

Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	23.68		3.78	28	2.506
North Wall	8.45		1.92	10	0.162
North Window	3.83	91			0.348
South Wall	12.10		1.92	12	0.278
South Door	1.82		3.43	12	0.075

CASH ROOM

Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	23.68		3.78	28	2.506
North Wall	8.45		1.92	10	0.162
North Window	3.83	91			0.348
South Wall	12.10		1.92	12	0.278
South Door	1.82		3.43	12	0.073

CFM ROOM

Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	31.45		3.78	28	3.328
North Wall	13.03		1.92	10	0.250
North Window	3.83	91			0.348
South Wall	12.10		1.92	12	0.278
South Door	1.82		3.43	12	0.075

CONFERENCE HALL

Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	31.45		3.78	28	3.238
East Wall	10.31		1.92	16	0.316
East Window	3.82	173			0.660
South Wall	13.03		1.92	12	0.300
South Window	3.83	274			1.05
West Wall	13.96		1.92	16	0.429
West Door	1.82		3.43	16	0.099

DGM ROOM 3

Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	31.45		3.78	28	3.328
West Wall	12.09		1.92	16	0.371
West Window	2.58	173			0.446
East Wall	13.96		1.92	16	0.428
East Door	1.82		3.43	16	0.099

OPEN HALL

Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	424.46		3.78	28	44.924
South Wall	73.12		1.92	12	1.684
South Window	26.81	274			7.35
East Wall	12.17		1.92	16	0.374
East Window	3.83	173			0.662

Table 4:13: Cooling Load for Third Floor Using Fibre Glass Insulation

GM HALL

Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	31.08		3.78	28	3.289
South Wall	12.81		1.92	12	0.295
East Wall	11.35		1.92	16	0.348
South Window	3.83	120			0.459
East Window	3.104	173			0.536

ULDC ROOM

Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	23.62		3.78	28	2.500
North Wall	11.82		1.92	10	0.227
South Wall	8.45		1.92	12	0.194
South Window	3.83	120			0.459
North Door (Al)	2.1				20.148

SERVER ROOM

Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	23.62		3.78	28	2.450
North Wall	12.11		1.92	10	0.232
South Wall	8.45		1.92	12	0.194
South Door	3.83	120			0.459
North Window	1.82		3.43	10	0.062

CONFERENCE HALL

Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2\text{-}K)$	CLTD	Cooling Load (KW)
Roof	54.65		3.78	28	5.784
North Wall	30.85		1.92	10	0.592
South Wall	15.78		1.92	12	0.363
West Wall	11.35		1.92	16	0.348
South Window	11.49	120			1.378
West Window	4.435	173			0.767
North Door	2.74		3.43	10	0.093

AGM OFFICE					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2$-K)	CLTD	Cooling Load (KW)
Roof	31.02		3.78	28	3.283
North Wall	12.81		1.92	10	0.246
South Wall	16.46		1.92	12	0.379
East Wall	11.32		1.92	16	0.348
South Door	1.82		3.43	12	0.075
East Window	4.435	173			0.767
North Window	3.83	91			0.348

OPEN HALL					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2$-K)	CLTD	Cooling Load (KW)
Roof	75.55		3.78	28	7.966
North Wall	21.48		1.92	10	0.412
South Wall	16.46		1.92	12	0.379
West Wall	2.66		1.92	16	0.082
North Window	7.66	91			0.697
West Window	4.435	173			0.767
South Door	1.82		3.43	12	0.075

DGM OFFICE					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2$-K)	CLTD	Cooling Load (KW)
Roof	11.82		3.78	28	1.251
North Wall	8.453		1.92	10	0.162
South Wall	12.11		1.92	12	0.279
South Door	1.82		3.43	12	0.075
North Window	3.83	91			0.348

IT ROOM					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2$-K)	CLTD	Cooling Load (KW)
Roof	47.253		3.78	28	5.00
North Wall	16.904		1.92	10	0.324
South Wall	26.038		1.92	12	0.600
South Door	1.82		3.43	12	0.075
North Window	7.66	91			0.697

OPEN HALL					
Item	Net Area (m^2)	GLF (W/m^2)	U-Factor $W/(m^2$-K)	CLTD	Cooling Load (KW)
Roof	327.57		3.78	28	34.67
North Wall	8.462		1.92	10	0.162
53.247	53.247	1.92	12	12	1.227
East Wall	8.777		1.92	16	0.269
South Window	11.50	120			1.380
East Window	5.18	120			1.380
North Window	3.83	91			0.697

5. Results

5.1 Analysis of Results

The following two tables show the results obtained by calculating usual and recommended total cooling load so that we are able to compare the energy saving.

Table 5.1: Analysis of Total Cooling Load without Insulation

Floor	Roofs Walls and Doors	Windows	Appliances (Tube lights)	Total Cooling Load (KW)
First Floor	64.189	4.441	3.024	71.654
Second Floor	140.185	12.703	5.35	158.238
Third Floor	157.294	10.526	6.47	174.29
Total	361.668	27.67	14.844	404.182

Table 5.2: Analysis of Total Cooling Load without Insulation

Floor	Roofs Walls and Doors	Windows	Appliances (Tube lights)	Total Cooling Load (KW)
First Floor	34.898	4.441	3.024	42.363
Second Floor	75.651	12.703	5.35	93.704
Third Floor	94.488	10.526	6.47	111.484
Total	205.037	27.67	14.844	247.551

5.2.1 Reducing the number of Air-Conditioners Used

We can reduce the number of air conditioners by calculating the tonnage capacity per room for the given area following the tonnage calculator given by the blue star India limited.

Table 5.3: Power Consumed by Air-Conditioners (First Floor)

First Floor						
Rooms	Actual Number of AC			Recommended Number of AC		
	1.5 ton window AC	2 ton split AC	Actual power consumed (KW)	1.5 ton window AC	2 ton split AC	Recommended power consumed (KW)
VIG ROOM	1		5.28	1		5.28
AGM ROOM	2		10.56		1	7.04
CPCC ROOM		2	14.08		1	7.04
DGM ROOM	1		5.28	1		5.28
HALL	8	42.24	5			26.4
TOTAL			77.44			51.04

Table 5.4: Power consumed by Air-Conditioners (Second Floor)

First Floor						
Rooms	Actual Number of AC			Recommended Number of AC		
	1.5 ton window AC	2 ton split AC	Actual power consumed (KW)	1.5 ton window AC	2 ton split AC	Recommended power consumed (KW)
DGM Room	1		5.28	1		5.28
HR Room	1		5.28	1		5.28
Union Room	1		5.28	1		5.28
Cash Room	1		5.28	1		5.28
CFM Room	1		5.28	1		5.28
DGM Room 2	1		5.28	1		5.28
DGM Room 3	1		5.28	1		5.28
Hall	14	1	80.96	8	1	49.28
Total			117.92			86.24

Table 5.5: Power Consumed by Air-conditioners (Third Floor)

First Floor						
Rooms	Actual Number of AC			Recommended Number of AC		
	1.5 ton window AC	2 ton split AC	Actual power consumed (KW)	1.5 ton window AC	2 ton split AC	Recommended power consumed (KW)
GM Room	2		10.56	2		10.56
ULDC Room	1		5.28	1		5.28
Server Room		3	21.12	2		10.56
Conference Hall	6		31.68	4		21.12
ED Room		2	14.08		2	14.08
AGM Office	2		10.56	2		10.56
IT Room		3	21.12		2	14.08
DGM Room	1		5.28	1		5.28
Hall	8	1	49.28	8	1	49.28
Total			168.96			140.8

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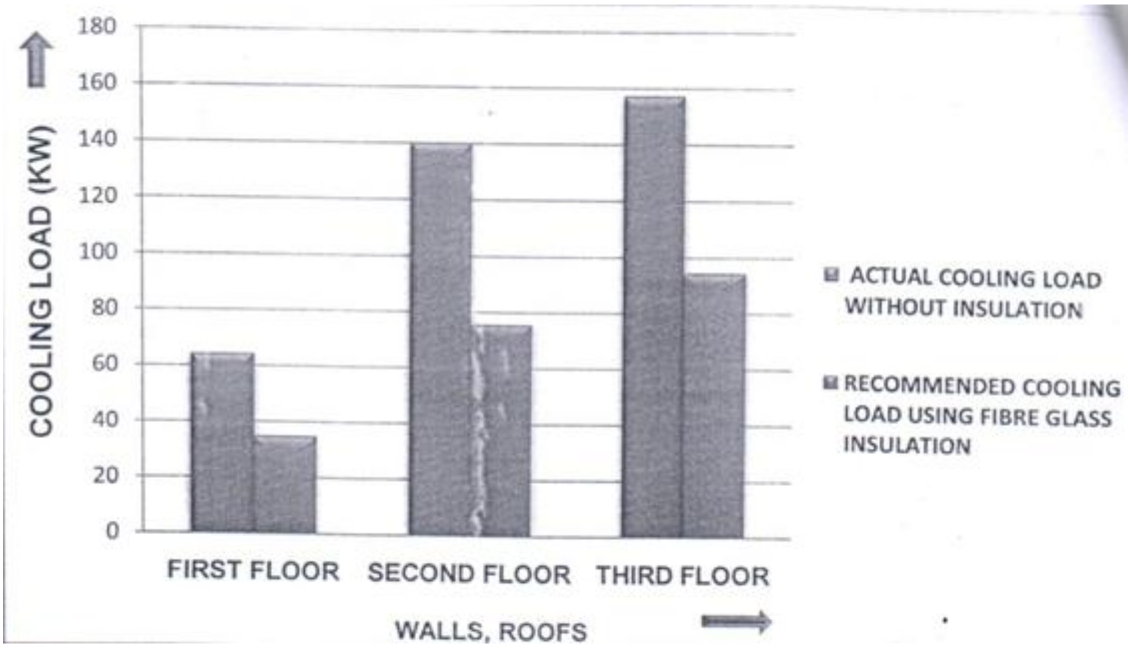

Figure 5.1: Graph showing comparison of actual and recommended total cooling load