DEVELOPMENT OF GENERALIZE SOFTWARE TO ESTIMATE COOLING LOAD FOR AIR CONDITIONING MULTI-STOREY BUILDINGS IN C++

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Abstract: In India just as much energy if not more may be used for cooling in summer the actual cooling load for multi storey building during peak load period of the month April. With large building such commericial complex auditorium,office buildings are provided with central air conditioning system.The effective design of central air conditioning can provide lower power consumption capital cost and improve aesthetics of a building. Cooling load items such as lighting heat gain,people heat gain, infiltration and ventilation heat gain can easily be putted to the computer program and find the output.The aim of this paper is to develop generally software for air conditioning system to estimate total cooling load for any rooms , lecture halls, offices of any Multi Storey buildings. In this research paper we consider a lecture hall of Baba Saheb Dr. Bhim Rao Ambedkar College of agricultural Engineering and Technology Etawah (206001) which is a part of institution. Institution is a Multi Storey building.The calculation of the total cooling load for only the lecture hall by CLTD method and also develop the software of this calculative load by flowchart of the software for the lecture hall. Similarly this procedure apply to find total cooling load of every room, halls, offices by this software in Institution and find the size of air conditioning system in every rooms, halls, offices, practical labs in institution.

Keywords:- **Cooling load, Lecture Hall, Central Air Conditioning, Heat gain, Indoor temperature, Outdoor temperature, Human Comfortness, CLTD.**

1. INTRODUCTION

The total heat required to be removed from the space in order to bring it at the desired temperature by air conditioning and refrigeration equipment is known as cooling load.The purpose of a load estimation is to determine the size of the air conditioning and refrigeration eqipment to maintain inside design conditions during period of maximum outside temperature. Cooling & heating load calculations are normally made to size HVAC (heating, ventilating, and air-conditioning) systems and their components. In principle, the loads are calculated to maintain the indoor design conditions. The first step in any load calculation is to establish the design criteria for the project that involves consideration of the building concept, construction materials, occupancy patterns, density, office equipment, lighting levels, comfort ranges, ventilations and space specific needs. Architects and other design engineers converse at early stages of the project to produce design basis & preliminary architectural drawings. The design basis typically includes information on:

1. Geographical site conditions (latitude, longitude, wind velocity, precipitation etc.)
2. Outdoor design conditions (temperature, humidity etc)
3. Indoor design conditions
4. Building characteristics (materials, size, and shape)
5. Configuration (location, orientation and shading)
6. Operating schedules (lighting, occupancy, and equipment)
7) Additional considerations (type of air-conditioning system, fan energy, fan location, duct heat loss and gain, duct leakage, type and position of air return system…)

2. OBJECTIVES

The objectives of this paper is to calculate cooling load by CLTD method and also develop software to find exact air-conditioning equipment and air handling unit, to achieve comfort operation and good air distribution in the air- conditioned zone.

3. COMPONENT 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. The load due to heat transfer through the envelope is called as **external load**, while all other loads are called as **internal loads**. The percentage of external versus internal load varies with building type, site climate, and building design. The total cooling load on any building consists of both **sensible** as well as **latent** load components. The sensible load affects the dry bulb temperature, while the latent load affects the moisture content of the conditioned space.

Heat Gain

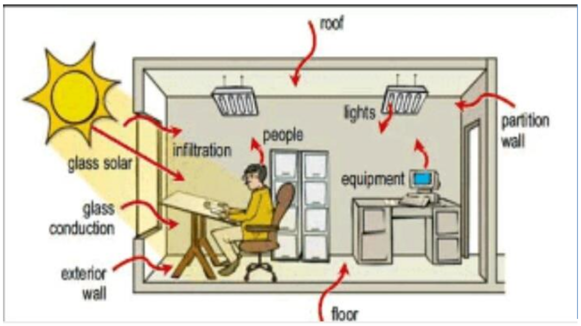

Fig.1 Sources of heat gain

4. LECTURE HALL CHARACTERISTICS

To calculate heat gain, the following information on hall envelop is required:

1. Architectural plans, sections and elevation for estimating building dimensions/area/volume.

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

3. External/internal shading, ground reflectance etc.

4. Materials of construction for external walls, roofs, windows, doors, internal walls, partitions, ceiling, insulating materials and thicknesses, external wall and roof colors select and compute U-values for walls, roofs, windows, doors, partitions, etc.

5. Amount of glass, type and shading on windows.

5. CALCULATE TR DESIGN CONDITION

The general step by step procedures for calculating the total heat load are as follows

1. Select inside design condition (Temperature, relative humidity).
2. Select outside design condition (Temperature, relative humidity).
3. Determine the overall heat transfer coefficient U_o for wall, ceiling, floor, door, windows, below grade.
4. Calculate area of wall, ceiling, floor, door, windows.
5. Calculate heat gain from transmission.
6. Calculate solar heat gain
7. Calculate sensible and latent heat gain from ventilation, infiltration and occupants.
8. Calculate lighting heat gain
9. Calculate total heat gain and
10. Calculate TR

6. COOLING LOAD ESTIMATION PRESENTED ON THE WORKSHEET

The calculations of cooling load of lecture hall is represented on as a MS EXCEL worksheet by CLTD method.

Worksheet: Cooling load sheet of 35 seated Lecture Hall

	:		Area	:	BRACAET ETAWAH	
Job No.	:	1	**City**	:	**Etawah / Uttar Pradesh**	
Project	:	**TIIR BUILDING COOLING LOAD**	**Month**	:	**April for Summer**	
Space	:	**35 SEAT LECTURE ROOM 203**	**Time**		1.00 PM	

Length	(m)	=	8.4		**Summer**				
Width	(m)	=	8.4	**CONDITION**	DBT	WBT	%RH	kg/kg	
Height	(m)	=	6.35	**Outside**	50	39	51	0.0412	
Area	(m^2)	=	70.7	**Inside**	37	30	60	0.0242	
Volume	(m^3)	=	246.9	**Difference**	13			0.017	

BPF	=	0.12	No of Air Changes / Hr.	=	1.00	**filtrated Air(m3/min)**	**7.5 7**

SUMMER

SOLAR HEAT GAIN FOR GLASS

Item	Area (sq. m)	Factor	W/m^2	W
Glass (N)		0.89	13.6	0
Glass (N-E)		0.26	52.1	0
Glass (E)	5.6	0.16	35.71	31.99
Glass (S-E)		0.33	36.0	0
Glass (S)		0.80	12.9	0
Glass (S-W)		0.59	36.0	0
Glass (W)		0.31	61.8	0
Glass (N-W)		0.22	52.1	0

SOLAR & TRANSM ISSION HEAT GAIN FOR W ALLS & ROOF

Item	Area (sq. m)	Factor(W/m^2-°C)	Temp Diff (°C)	W
Wall (N)		1.07	1.6	-
Wall (N-E)		1.07	2.1	-
Wall (E)	47.67	1.07	4.27	217.79
Wall (S-E)		1.07	1.8	-
Wall (S)		1.07	1.3	-
Wall (S-W)		1.07	1.8	-
Wall (W)		1.07	2.1	-
Wall (W-N)		1.07	21	-
Roof Sun		4.16	4.0	-

TRANSM ISSION HEAT GAIN EXCEPT FOR W ALLS & ROOF

Item	Area (sq. m)	Factor(W/m^2-°C)	Temp Diff (°C)	W
All Glass	5.6	4.47	13	325.41
Partition 1	158	1.12	4	707.84
Ceiling	70.7	2.3	4	650.44
Floor	70.7	2.75	1.35	262.47

HEAT GAIN DUE TO INFILTRATION

Infiltrated Air	Bypass	Factor	Temp Diff (°C)	W
7.5	1	20.44	13	1992.90

INTERNAL GAIN

Item		Factor	Temp Diff (°C)	W
People	35	70		2450
Lights(W/m2)	28	70		1960
Motor (KW)				0
Equipment (W/m^2)	450	70.7		31815

ROOM SENSIBLE HEAT SUBTOTAL :	**8598.84**
S. A. heat gain, leak loss & Safety Factor (6%) :	515.93
ROOM SENSIBLE HEAT (R.S.H.) :	**9114.08**

R O O M L A T E N T H E A T C A L C U L A T I O N S :

Infiltrated Air	Bypass	Factor	Diff kg/kg	W

7.5	1	50000	0.017	6375		
ITEM		Factor	Diff kg/kg	W		
No. Of People	35	45		1575		
Steam				0		
Appliances				0		
Vapour Trans				0		
S. A. heat gain, leak loss & Safety Factor (5%) :			397.5			
ROOM LATENT HEAT (R.L.H.) :			**8347.5**			
ROOM TOTAL HEAT (R.T.H.) :			**17461.58**			

OUTSIDE AIR HEAT:				
OUTSIDE AIR SENSIBLE HEAT (OASH)				
Outside Air	1 - BPF	Factor	Temp Diff (°C)	W
1.5	0.88	20.44	13	350.75
OUTSIDE AIR LATENT HEAT (OALH)				
Outside Air	1 - BPF	Factor	Diff kg/kg	W
1.5	0.88	50000	0.017	1122
SUBTOTAL :			18934.33	
R.A.heat leak gain& Safety factor (5%)			946.71	
GRAND TOTAL :			19881.04	
TONS = {(W)/3500} :			5.68	

7. FLOWCHART AND DEVELOPMENT OF SOFTWARE OF THE CALCULATIVE LOAD

The purpose of this chapter is to provide an overview of the Load analysis Program.The topics covered include input, processing and output. Cooling load estimation through computer application sounds reasonable to replace tedious and time consuming manual methods. To achieve this computer automation, software developed using "C++" programming language tool.

After all the parameters are given, the software computes cooling load according to following Flowchart

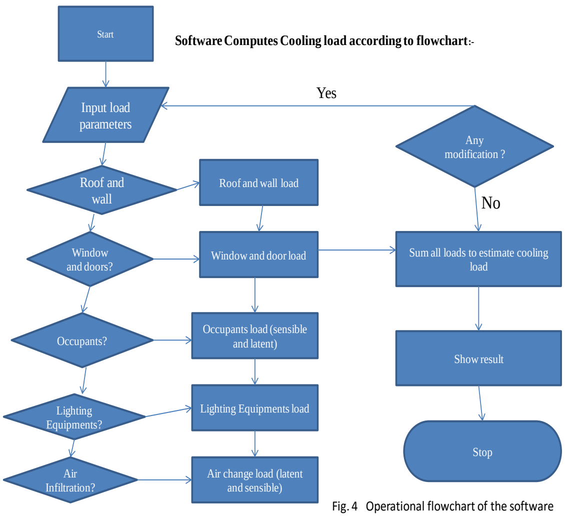

Fig. 4 Operational flowchart of the software

8. SOFTWARE PROGRAMMING OF CALCULATIVE LOAD

The purpose of this chapter is to provide an overview of the Load analysis Program.The topics covered include input, processing and output. Cooling load estimation through computer application sounds reasonable to replace tedious and time consuming manual methods. To achieve this computer automation, software is developed using "C++" programming language tool. "C++" is used in this work because of its simplicity and easily understandable by professionals. Besides, it is a versatile tool that has ability to handle large and complex problem of this kind.

a.The programing of developed generlize software following:-

```
#include <iostream>
#include<conio.h>
main()
{
using namespace std;


cout<<"          ********** lecture Hall Cooling Load***********       "<<"\n";



float area_room, vol_room, length_room, breadth_room, height_room, bpf, air_charge,infilterated_air,area_glass, number_glass;
float shading_coeff, sensible_heat_factor,SHGG, all_glass_area, overall_heat_transfer, Uglass, temp_diff_glass, heat_gain_all_glass;
float area_partition, Upartition, temp_diff_partition, heat_gain_all_partition, area_floor, Ufloor, temp_diff_floor, heat_gain_floor;
float area_cieling, Ucieling, temp_diff_cieling, heat_gain_cieling,temp_diff_infilterated,total_heat_gain_infilteration;
float number_people, use_factor, internal_heat_gain_people,number_lights, wattage_light,internal_heat_gain_light;
float sensible_heat_gain_infilteration, room_sensible_heat_subtotal, total_heat_for_except_wall_roof,total_internal_heat_gain;
float area_wall,Uexposed_wall, temp_diff_wall,solar_heat_gain_for_wallandroof, humidity_difference,latent_heat_gain_infilteration;
float outside_air_sensible_heat, outside_air, temp_diff_air, outside_air_latent_heat,room_sensible_heat, bypass_air;
float x,y,z, subtotal, grandtotal, tons,leak_loss_factor, area_exposed_wall;
float area_rom,DBT,DBTI,Humidity,HumidityI,WBT,WBTI,RH,RHI;
```

b. The programming of dimensions

```
cout<< "\n  enter dimensions in  m \n";
cout<<"\n1. Enter Length = ";
cin>>length_room;
cout<<"2. Enter Breadth = ";
cin>>breadth_room;
cout<<"3. Enter Height = ";
cin>>height_room;
vol_room = length_room * breadth_room * height_room;
cout<<"Volume of room = "<<vol_room<<" m3 \n";
area_floor = length_room * breadth_room;
cout<<" \nEnter BPF   = ";
cin>>bpf;
cout<<"Enter Number of Air Charge/hour(m3/min) = ";
cin>> air_charge;
infilterated_air = (vol_room * air_charge)/60;
cout<<"Infilterated_air = "<<infilterated_air<<" m3/min \n";
area_wall = 2 * height_room*length_room +2 * height_room * breadth_room;
cout<< "Area of walls = "<< area_wall<<" m2";
```

c. The programming of condition

```
cout<<"\n\nCondition : \nOutside DBT : ";
cin>>DBT;
cout<<"Inside DBT : ";
cin>>DBTI;
cout<<"DBT difference : ";
cout<<(DBT-DBTI);
cout<<"\nOutside Humidity : ";
cin>>Humidity;
cout<<"Inside Humidity : ";
cin>>HumidityI;
cout<<"Humidity difference : ";
humidity_difference = (Humidity-HumidityI);
cout<<humidity_difference;
cout<<"\nOutside WBT : ";
cin>>WBT;
cout<<"Inside WBT : ";
cin>>WBTI;
cout<<"Outside RH : ";
cin>>RH;
cout<<"Inside RH : ";
cin>>RHI;
cout<<"\n\n";
```

d.The programming of calculation of solar heat gain from glass:-

```
cout<<"***********Calculation of solar heat gain from glass*************\n";
cout<<" \nEnter Area of Glass(m2) = ";
cin>>area_glass;
cout<<"Enter Number of Glasses = ";
cin>>number_glass;
cout<<"Enter Shading Coefficient = ";
cin>>shading_coeff;
cout<<"Enter Sensible Heat Factor = ";
cin>>sensible_heat_factor;
SHGG = area_glass * number_glass * shading_coeff * sensible_heat_factor;
cout<<"Solar Heat Gain From Glass = "<<SHGG<<" W" ;
cout<<"\n \n";
```

e. The programming calculation of solar & transmission heat gain for walls and roof

```
cout<<"*****Calculation of Solar transmission heat gain for walls & roof****** \n";
cout<<"\n";
cout<<"Enter area of exposed wall = ";
cin>>area_exposed_wall;
cout<<"Enter U(exposed wall) = ";
cin>>Uexposed_wall;
cout<<"Enter temp_diff wall = ";
cin>>temp_diff_wall;
cout<<"Solar heat gain for wall and roof = wall area * U(exposed  wall) * Temp diff \n";
solar_heat_gain_for_wallandroof = area_exposed_wall * Uexposed_wall *temp_diff_wall;
cout<<"Solar heat gain for walls and roof = ";
cout<<solar_heat_gain_for_wallandroof<<" w";
cout<<"\n\n";
```

f. The programming of solar & tramission heat gain except wall and roof

```
cout<<"*****Calculation of transmission Heat gain Except for walls & roof*****\n";
cout<<"\n";
cout<<"Sr. No         Item \n";
cout<<"1.          All Glasses \n";
cout<<"2.          All portion \n";
cout<<"3.          All Floors \n";
cout<<"4.          Ceiling";
cout<<"\n\n";
cout<<"For All Glasses :";
cout<<"\nEnter All glass Area(m2) : ";
cin>>all_glass_area;
cout<<"Enter U(glass) : ";
cin>>Uglass;
cout<<"Enter temperature difference in degreee celcius : ";
cin>> temp_diff_glass;
cout<<"Transmission heat gain for all glass =  All Glass area * Overall heat transfer U(glass) * Temperature Diff. ";
heat_gain_all_glass = all_glass_area * Uglass * temp_diff_glass;
cout<<"\ntransmission heat gain for all glass = ";
cout<<heat_gain_all_glass<<"W";
cout<<"\n\n";
```

g.Programming for partition

```
cout<<"For all Partition wall : \n";
cout<<"Enter Area of Partition : ";
cin>>area_partition;
cout<<"Enter U(partition) : ";
cin>>Upartition;
cout<< "Enter Temp Difference in degreee celcius: ";
cin>>temp_diff_partition;
cout<<"Transmission heat gain for all partition = Area of Partition * U(Partition) * Temp Difference ";
heat_gain_all_partition = area_partition * Upartition *temp_diff_partition;
cout<<"\nTransmission heat gain for all partitions = ";
cout<<heat_gain_all_partition<<"W";
cout<<"\n";
```

h.Programming of heat gain by floor

```
cout<<"\nFor Floor : \n";
cout<<"Enter U(floor) : ";
cin>>Ufloor;
cout<<"Enter Temperature Difference in degreee celcius : ";
cin>>temp_diff_floor;
cout<<"Transmission heat gain for Floor = Area of Floor * U(floor) * Temp Difference ";
heat_gain_floor = area_floor * Ufloor * temp_diff_floor;
cout<<"\nHeat gain for floor =";
cout<<heat_gain_floor<<"W";
```

i.Programming of heat gain by ceiling

```
cout<<"\n\n For Cieling : \n ";
cout<<"Enter Area of Cieling :";
cin>>area_cieling;
cout<<"Enter U(cieling) : ";
cin>>Ucieling;
cout<<"Enter Temperature Difference in degreee celcius : ";
cin>>temp_diff_cieling;
cout<<"Transmission heat gain for cieling + Area of cieling * U(cieling) * temperature Difference  ";
heat_gain_cieling = area_cieling * Ucieling * temp_diff_cieling;
cout<<"\nheat gain cieling = ";
cout<<heat_gain_cieling<<"W";
cout<<"\n \n";
```

j. Programming of heat gain due to infilteration

```
cout<<"\n********* Calculation of Sensible heat gain due to infiltration ***************";
cout<<"\nEnter temp Difference infilterated air : ";
cin>>temp_diff_infilterated;
cout<<"Enter bypass Air = ";
cin>>bypass_air;
cout<<"Sensible Heat gain Due to infilteration : 20.44 * amount of infilterated air * bypass air * Temp. Difference  ";
sensible_heat_gain_infilteration = 20.44 * infilterated_air * temp_diff_infilterated * bypass_air;
cout<<"\nSensible heat gain due to infiltration = ";
cout<<sensible_heat_gain_infilteration<<"W";
```

k.Programming of internal heat gain

```
cout<<" \n\nInternal Heat gain : \n";
cout<<" \ni) For People : \n";
cout<<"Enter Number of People : ";
cin>>number_people;
cout<<"Enter Use Factor : ";
cin>>use_factor;
cout<<"Internal Heat Gain Due to "<<number_people<<" people = Number of people * Use Factor = ";
internal_heat_gain_people= number_people * use_factor;
cout<<internal_heat_gain_people; cout<<"W\n";
cout<<" \nii) For Light(w/m2) : \n";
cout<<"Enter Number of Lights : ";
cin>>number_lights;
cout<<"Enter Wattage of light : ";
cin>>wattage_light;
cout<<"Enter area of room : ";
cin>>area_room;
cout <<"Internal heat gain due to "<<number_lights<<" lights = Number of lights * Wattage of Light * area of room = ";
internal_heat_gain_light = number_lights * wattage_light * area_room;
cout<<internal_heat_gain_light<<"W";
cout<< "\nTotal internal Heat gain = internal heat gain due to( people + light) = ";
total_internal_heat_gain = internal_heat_gain_people + internal_heat_gain_light;
cout<<total_internal_heat_gain<<"W";
```

l.Programming of room sensible heat subtotal

```
cout<<"\n \n";
cout<<"Room Sensible Heat Sub total = Solar heat gain for glass + Solar and transmission heat gain for walls & roof ";
cout<<" + Transmission heat gain for except wall and roof + Sensible heat Gain due to infilteration + Internal heat Gain";
room_sensible_heat_subtotal = total_heat_for_except_wall_roof + SHGG +solar_heat_gain_for_wallandroof +
                              +total_internal_heat_gain + sensible_heat_gain_infilteration;
cout<<"\nRoom Sensible Heat Subtotal = "<<room_sensible_heat_subtotal;

cout<<"\n";
cout<<"Sensible average heat gain, leak loss & safety factor = (Room sensible heat subtotal * 6 )/100 = ";
leak_loss_factor = (room_sensible_heat_subtotal * 6)/100 ;
cout<<leak_loss_factor<<"W";
  cout<<"\n";

  room_sensible_heat = room_sensible_heat_subtotal + leak_loss_factor;
    cout<<"Room sensible heat = room sensible heat subtotal + leakloss & safety factor = "<<room_sensible_heat<<"W";
```

m. Programming of outside air heat, subtotal, grand total and tons

```
cout<<z<<"W";
 cout<<"\nOutside Air heat :\n";
 cout<<"Outside air sensible heat = 20.44 * outside_air * (1- BPF ) * temp_diff)";
 cout<<"\nEnter Outside air = ";
 cin>>outside_air;
 cout<<"Enter temperature differtence = ";
 cin>>temp_diff_air;
 outside_air_sensible_heat = outside_air * 20.44 * (1-bpf) * temp_diff_air;
outside_air_latent_heat = 50000 * (1-bpf) * outside_air * humidity_difference;
 cout<<"Outside Air Latent heat = 50000 *(1-bpf) * outside air * humidity difference =  "<<outside_air_latent_heat<<"W";

   cout<<"\n\n";
   cout<<"Subtotal = room sensible heat + room latent heat + outside air sensible heat + outside air latent heat = ";
subtotal = room_sensible_heat + z + outside_air_sensible_heat + outside_air_latent_heat;
cout<<subtotal<<"W";
cout<< "Subtotal leak loss = 5% = (5 * subtotal)/100 = "<<(subtotal * 5 )/100;
cout<<"\nGrand total = subtotal + subtotal leak loss( 5%) = ";
grandtotal = subtotal + (subtotal * 5)/100;
cout<< grandtotal<<"W";
tons = grandtotal/3500;
cout<<"\n\nTons ="<<tons<<"tons";
cin.get();              system("pause");
                        }
```

9. RESULT AND DISCUSSION

Load through glasss = 325.41W

Load through ceiling = 650.44W

Load through floor = 262.67W

$V_{Infilteration}$ = $7.5 m^3/min$

Room sensible heat gain = 9114.08W

Room latent heat = 8347.5W

ROOM TOTAL HEAT = 17461.58W

Outside air sensible heat gain = 350.75W

Outside air latent heat gain = 1122W

OUTSIDE AIR TOTAL HEAT = 1472.75W

GRAND TOTAL HEAT = 19881.04W

TONS OF REFRIGERATION = 5.68TR

The variation of heat gain between results obtained from two different i.e. CLTD method and software program methods are shown in Fig-1 It shows that there are little different between two methods an d result are satisfactory as ASHRAE standard .

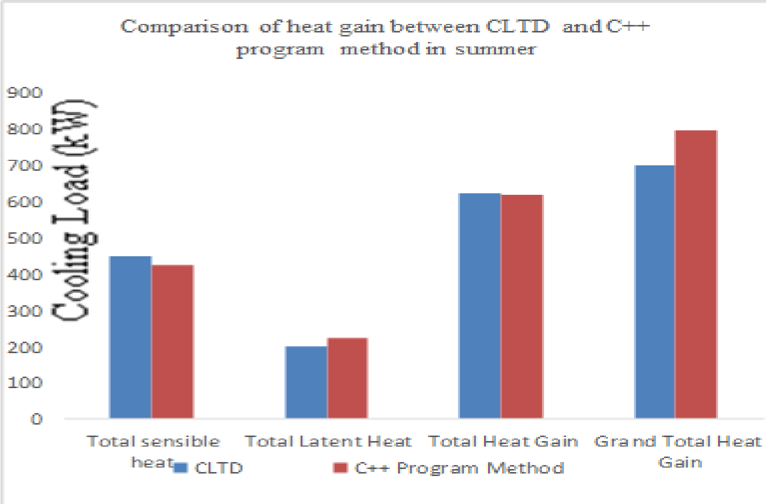

Fig-1 Variation of heat gain between CLTD and C^{++} program method for summer condition.

10. CONCLUSION

In this paper software is designed to find the cooling load estimation for any multistorey buildings easily. To find the accuracy and validity of the designed software and comparative analysis is done by world wide marketing existing software tool In this software which is more realistic, user friendly and less time consuming with accurate results. The results shows the total cooling load for the AC required lecture hall is 5.68 tons for summer (month if April). In this software to estimated cooling load for any multistorey building like institution, hospitals, flats, every type of building in which the load calculated one by one room and to add at last to calculate cooling load to multistorey buildings. This software is more realistic, user friendly and less time consuming with accurate results.

11. FUTURE SCOPE OF WORK

There are many modifications can be made to the program which are need suggestions for future modifications include the following:-

1. Improve the output using more graphics.
2. In future CLF values for lights can be evaluated from CLF tables of ASHRAE Fundamentals Handbook by providing predefined walls are available in this software. For case of use custom input methods can be introduced, vast different wall construction materials and their properties in the database.
3. Due to data unavailability the design data core used for the development of the software as Chittagong city of Bangladesh.
4. The factors that must be critically looked into during load estimation process include orientation.
5. Update the load analysis classes to latest ASCE-7 standard.

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BIOGRAPHIES

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