

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

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**ABSTRACT:-** The aim of this paper we study about the different types of review of literature in which different types cooling load estimation method manual calculation and software method based on experience of the air conditioning practitioner. the manual calculation is time consuming, less efficient and not give accurate result of estimation of cooling load of any Multi-Storey building.

In this paper we are develop a generalize software to estimate cooling load for air conditioning Multi-Storey buildings in C++. This software calculate the cooling load of room, office, of any Multi-Storey building. The result find by software is high accurate , less time consuming, more efficient.

**Keywords:-** Cooling load, Heat gain, Indoor temperature, Outdoor temperature, Human Comfortnes

### 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 equipment 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 and preliminary architectural drawings.

### 2. LITRETURE REVIEW

[1] Saifullah Zaphar<sup>1</sup>, Tekletsadik Sheworke in June 2018 analysed a computer program to estimate cooling load. According to them the energy efficiency building design the cooling load estimation plays a vital role because now a day's major part of the power is consumed to run the heating ventilation air conditioning (HVAC) system. Hence to design and development of cooling load software is mandatory to incorporate the energy efficiency features to reduce the power consumption and accurate and fast results. Previously cooling load estimation was done manually which is quite tedious, complex, time consuming and liable to error due to complex architectural design. The present endeavor to design and develop a software which has an edge over the various other complexes and costly software available in market. The present software is enhanced user friendly and minimum data input with accurate results obtained. This software is based on the carrier data book used for cooling load estimation based on cooling load transfer and solar heat gain factor method. The programming language has been done in Visual Basic 6.0 and Microsoft Access has been used to create the data base. The approach in the present work is divided in three modules and prepares the individual algorithm, flow chart, and individual form design for each part. Step by step the data input will be given as per the architecture design and finally the result sheet will come after finishing all data input. The testing & validation of this software is done by solving one sample project with this software and carrier hourly analysis program software (HAP v 4.90) which is available in world wide market. The comparative results obtained by both of the software are so close and accurate and finally the level of accuracy of present software is 98.1%.

[Ref.1

[2] **Tousif Ahmed in Dec. 2014 developed a software** load estimating for air conditioning systems is done either by manual calculation or judgmental estimation based on experience of the air conditioning practitioner. While manual calculation is laborious, estimate based on judgment is liable to error due to gigantic, complex and dynamic nature of present day architectural designs. Load estimating through computer automation is likely to make a positive impact in the dynamic nature of air conditioning applications. This study develops computer software in C# .NET (C Sharp dot NET) to handle simple and typical load estimate for air conditioning in developing country (i.e. Bangladesh). Though this study deals with simplified model of a room, this software can be improved to calculate intricate and dynamic nature of load with a very little effort. Currently, there are several commercial packages available in the market not only for the cooling load calculations, but also for other applications of heating, ventilating, and air-conditioning (HVAC) systems. But, commercial softwares for cooling load estimation and HVAC design are very costly for the peoples of developing countries like Bangladesh. The main objective of this development is to provide a free and easy way to estimate cooling load for air-conditioning. [Ref.3]

[3] **B. Kareem in May 2013** studied traditionally, load estimating for air conditioning systems is done either by manual calculation or judgmental estimation based on experience of the air conditioning practitioner. While manual calculation is laborious, estimate based on judgment is liable to error due to gigantic, complex and dynamic nature of present day architectural designs. Load estimating through computer automation is likely to make a positive impact in the dynamic nature of air conditioning applications. This study develops computer software in Basic computer programming language named Computer Aided Load Estimating for Air Conditioning- CALAC-2004 to handle simple, intricate and dynamic nature of load estimate for air conditioning in developing country. Application of the developed software to FUTA Library showed that a total load of 806.26kW was estimated for the three floors it contained. With this load it will be uneconomical and ineffective the use of window or split type of air-conditioner (a- c), instead, central a-c unit is preferable in the FUTA Library. [Ref.2]

### 3. METHODOLOGY

1) **Time of day in hours:-** Various temperatures and heat flow rates are calculated for every hour on the hour, assuming that hourly values are sufficient to define the daily profile.

2) **Calculation of outside air temperature:-**

Outside air temp=Design dry bulb temp-(Percentage fraction\*Daily range)

Design dry bulb temp from ASHRAE 1997(Chapter 26,Table 1)

Percentage fraction from ASHRAE 1997(Chapter 28,Table 2)

Daily range (Difference between average daily max and average minimum temp during warmest month) from ASHRAE 1997(Chapter 26,Table 1)

3) **Calculation of Sensible Heat Gain factor(SHGF):-**

SHGF values listed in ASHRAE 1997(Chapter 29) for different latitude and month. These SHGF values are used in calculate sol-air temp of various outside surfaces and solar heat gain through windows.

4) **Calculation of Solar-Air Temperature:-**

$$t_e = t_o + \alpha I_t / h_o - \epsilon \Delta R / h_o$$

$t_e$  = Sol-air temperature

$t_o$  = Current hour dry-bulb temp

$\alpha$  = Absorptance of surface for solar radiation

$I_t$  = Total incident solar load = 1.15(SHGF), W/m<sup>2</sup>

$h_o$  = Convection at outer surface, W/m<sup>2</sup>.K

$\epsilon$  = Hemispherical emittance of surface

$\Delta R$ =Difference between long-wave radiation incident on surface from sky and surrounding and radiation emitted by black body at outdoor air temp,  $W/m^2$  For horizontal surfaces that receive long wave radiation from the sky only, an appropriate value of  $\Delta R$  is about  $63 W/m^2$ .

Because vertical surfaces receive long wave radiation from the ground and surrounding buildings as well as from the sky, accurate  $\Delta R$  values are difficult to determine. Therefore, it is common practice to assume  $\Delta R=0$  for vertical surfaces.

### 5) Calculation of Total Equivalent Temperature Differentials (TETD):-

Hourly TETD values for each of the exposed surfaces, are calculated to incorporate individual thermal characteristics and orientation

$$TETD = t_{ea} - t_i + \lambda(t_{e\delta} - t_{ea})$$

$t_{ea}$  = 24-hour average Sol-air temperature

$t_i$  = Interior design dry bulb temp

$\lambda$  = Decrement factor from ASHRAE 1997 (Chapter 28, Table 14 or 19)

$t_{e\delta}$  = Sol-air temp at time lag hours ASHRAE 1997 (Chapter 28, Table 14 or 19).

**Roof TETD**, To calculate the TETD value for roof identify layers of roof construction from Table 11. With R-value of dominant layer, identify R-value Range number R and roof group number from Table 12. From Table 14 obtain decrement factor and time lag data with which to calculate TETD values for each sol-air temperature.

**Wall TETD**, values for the various walls were calculated by the same approach as that described for the roof. Time lag and effective decrement factors were selected from Table 19

### 6) Calculation of Instantaneous Heat Gain, W:-

#### (a) Roof and Walls

$$Q = U \cdot A \cdot (TETD)$$

U = Design heat transfer coefficient for roof or wall,  $W / (m^2.k)$

A = area of roof or wall, calculated from building plans

TETD = total equivalent temperature difference, roof or wall

#### (b) Door

Heat storage of the doors may be assumed negligible, and the heat gain, therefore, is calculated with equation as follow

$$Q = U_d A_d (t_{dt} - t_i)$$

$U_d$  = Design heat transfer coefficient for door,  $W / (m^2.k)$

$A_d$  = Area of the door

$t_i$  = inside temperature

$t_{dt}$  = Outside temperature

#### (c) Windows:-

Window heat gain – The air to air heat gain is

$$Q = U_w A_w (t_{o\theta} - t_i)$$

$U_w$  = Design heat transfer coefficient for window,  $W/(m^2.k)$

$A_w$  = Sum of area of all window

$t_{o\theta}$  = Outside temperature at hour  $\theta$

The solar radiation heat gain through windows is-

$$Q_r = A_w SC (SHGF)_\theta$$

$(SHGF)_\theta$  = Solar heat gain factor

$SC$  = Shading coefficient for window

$A_w$  = Area of windows

#### (d) Partition, Ceilings, Floors

$$Q = UA(t_b - t_i)$$

$U$  = Design heat transfer coefficient for Partition, Ceiling or Floor,  $W/(m^2.k)$

$t_b$  = temperature in adjacent space

$t_i$  = inside design temperature in conditioned space       $A$  = Area of Partition, Ceiling or Floor

#### (e) Lights

$$q_{el} = WF_{ul}F_{sa}$$

$W$  = watts input from electrical plans or lighting fixture data

$F_{ul}$  = lighting use factor

$F_{sa}$  = special allowance factor

#### (f) People

$$q_{sensible} = N * \text{Sensible heat gain (SHG)}$$

$N$  = number of people in space

$SHG$  = Sensible haet gain from ASHRAE 1997(Chapter 28,Table 3)

#### (g) Infiltration

$$Q_{sinf} = m_o C_{pm} (T_o - T_i) = V_o \rho_o C_{pm} (T_o - T_i)$$

Where  $V_o$  is the infiltration rate ( in  $m^3/s$ ),  $\rho_o$  and  $c_{p,m}$  are the density and specific heat of the moist, infiltrated air respectively.  $T_o$  and  $T_i$  are the outdoor and indoor dry bulb temperatures.

The infiltration rate depends upon several factors such as the tightness of the building that includes the walls, windows, doors etc and the prevailing wind speed and direction. Infiltration rate is obtained by using air change method.

The infiltration rate by air change method is given by:

$$V_o = (\text{ACH}) \cdot V / 60 \text{ m}^3/\text{s}$$

where ACH is the number of air changes per hour and V is the gross volume of the conditioned space in m<sup>3</sup>. Normally the ACH value varies from 0.5 for tight and well-sealed buildings to about 2.0 for loose and poorly sealed buildings. For modern buildings the ACH value may be as low as 0.2 ACH. Thus depending upon the age and condition of the building an appropriate ACH value has to be chosen, using which the infiltration rate can be calculated

$$V = (L \cdot W \cdot H) / 60$$

### (h) Ventilation

$$Q_{\text{vent}} = m_o C_{p,m} (T_o - T_i) = V_o \rho_o C_{p,m} (T_o - T_i)$$

Where V<sub>o</sub> is the ventilation rate (in m<sup>3</sup>/s), ρ<sub>o</sub> and c<sub>p,m</sub> are the density and specific heat of the moist, infiltrated air, respectively. T<sub>o</sub> and T<sub>i</sub> are the outdoor and indoor dry bulb temperatures.

### (i) Appliances

$$Q_{\text{sensible}} = q_{\text{input}} F_U F_R$$

$$Q_{\text{sensible}} = q_{\text{input}} F_L$$

q<sub>input</sub> = rated energy input from appliances from manufacturer's data

F<sub>U</sub>, F<sub>R</sub>, F<sub>L</sub> = usage factors, radiation factor, flue loss factor

### (j) Power

$$Q_p = P E_F$$

P = horsepower rating from electrical plans or manufacturer's data

E<sub>F</sub> = efficiency factors and arrangements to suit circumstances

## 7) Latent Heat Gain/Cooling Load, W:-

### (a) People

$$q_{\text{latent}} = N \cdot \text{Latent heat gain}$$

N = number of people in space

LHG = Latent heat gain from ASHRAE 1997 (Chapter 28, Table 3)

### (b) Infiltration

$$Q_{\text{Linf}} = m_o C_{p,m} (W_o - W_i) = V_o \rho_o C_{p,m} (W_o - W_i)$$

Where V<sub>o</sub> is the infiltration rate (in m<sup>3</sup>/s), ρ<sub>o</sub> and c<sub>p,m</sub> are the density and specific heat of the moist, infiltrated air, respectively. W<sub>o</sub> and W<sub>i</sub> are the outdoor and indoor specific humidity.

### (c) Ventilation

$$Q_{\text{Lvent}} = m_o C_{p,m} (W_o - W_i) = V_o \rho_o C_{p,m} (W_o - W_i)$$

Where V<sub>o</sub> is the ventilation rate (in m<sup>3</sup>/s), ρ<sub>o</sub> and c<sub>p,m</sub> are the density and specific heat of the moist, infiltrated air, respectively. W<sub>o</sub> and W<sub>i</sub> are the outdoor and indoor specific humidity.

**8) Convective Heat Gain/Cooling Load:-**

**(a) Sensible Cooling load from convective Sensible Heat gain:-**

- Direct inclusion of the instantaneous heat gain components (i.e. loads due to air to air heat gain through windows, infiltration, and ventilation)

67%, 20% and 50% of loads due to fluorescent lights appliances and people

**(b) Sensible cooling load from exposed surfaces; From Convective Heat Gain**

- 42% of loads due to windows
- 40% of loads due to roof, walls, door

**9) Total Sensible Cooling Load:-** Total sensible cooling load is the sum of the cooling load from Convective and Radiant heat gain.

**10) Total Cooling Load:-** Total cooling load is the sum of total Sensible and total Latent Cooling Load.



#### 4. CONCLUSION

In this research papers we study about different types of method and software to estimate cooling load for air conditioning system of different types buildings based on different types of review of literature.

#### REFERENCES

- [1] Saifullah Zaphar, Tekletsadik Sheworke in June 2018 'Computer Program for Cooling Load Estimation and Comparative Analysis with Hourly Analysis Program (HAP) Software' International Journal of Latest Technology in Engineering, Management & Applied Science (IJLTEMAS) Vol.NO.VII pp53-61.
- [2] B. Kareem in May 2008 'Load Estimation for Air Conditioning using Computer Software Approach.' International Journal of the Computer, the Internet and Management Vol.16 No.2 pp 35-43.
- [3] Tousif Ahmed in Dec. 2012 'Software Development for Cooling Load Estimation by CLTD method IOSR-JMCE Vol. 3 pp1-6
- [4] Cooling ASHRAE, Handbook of Fundamentals, Ch. 28. American Society of Heating, Refrigerating and Air-Conditioning Engineers, U.S.A. (1997).
- [5] Hani H. Sait, "Estimated Thermal Load and Selecting of Suitable Air-Conditioning Systems for a Three Story Educational Building" Procedia Computer Science, 2013; 19; 636 – 645.
- [6] Christian A., Gueymard and Thevenard D., "Monthly average clear-sky broadband irradiance database for worldwide solar heat gain and building cooling load calculations" Solar Energy, 2009; 83; 1998–2018.
- [7] R.S. Khurmi and J.K. Gupta, text book of "Refrigeration and Air-conditioning" published by S. Chand Publication 2012.
- [8] C.P. Arora, a text book of "Refrigeration and Air-conditioning" published by Mc Graw-Hill 2009.
- [9] Domkundwar and Arora a text book of "Refrigeration and Air-conditioning" published by Dhanpat Rai and Co. (P) Ltd.

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