Comparison of Cooling Load Estimation Method by CLTD Method and Android Application

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ABSTRACT-Rise in the temperature due to global warming and climatic changes increased the importance of air conditioning all around the world. So in the recent years there is an increased demand for heating and cooling technologies. In the past, heat load estimations were done on the basis of professional experience or by using thumb rules. But manual calculation are complex and more subjected to human error. Although computer softwares are available in the market, they are costly and some of them provide free trial versions also. In the age of smart phones which has the same performance of computers, smartphones can also be used as a tool to deliver optimal designs for air conditioning systems. In this paper HVAC toolkit android application is developed for the comparison of result by using ASHARE CLTD method, which verifies the ability of the smartphones to carry out heat load calculation.

KEYWORDS-*HVAC, CLTD method, cooling load, ASHARE*

INTRODUCTION

The importance of air conditioning is increasing day by day due to the climate changes and atmospheric pollution. By the application of air conditioning system, air freshness, temperature, humidity and air circulation can be controlled. With the proper air conditioning humans and equipment can work more efficiently. Thus designing of proper air conditioning system gains importance in the modern world. The properly designed air conditioning system can provide good comfort will reducing the overall expenditure of the project and to reduce the working and maintenance cost of the air conditioning systems.

Heating and cooling load calculation is a preliminary set in the designing of air conditioning systems. These calculation significantly affect the cost of the air conditioning project because they have a direct effect in the size of piping, ductwork and every other component of the air conditioning system. Heat load calculation thus becomes a stepping stone for air conditioning system design. Through heat load calculation we try to estimate the rate of heat should be removed to achieve the desired indoor condition. The air conditioning systems are designed to achieve this transfer. The amount of heating and cooling requirement changes with time and they depend on the internal and external factors. In most of the cases the peak load is considered for estimation of air conditioning load.

In the air conditioning industry thumb rules and industrial expertise are commonly used to design air conditioning system. These methods are prone to human errors. International organisation like ASHARE provides different methods for heat load calculations. But some of them are very complex, thus manual calculations using these methods can cause errors. Computers are used in India for heat load calculation for a long time. In the competitive market, technical sales engineers in HVAC industry should well equipped with new technologies to tackle these competition, to give more optimal solutions more effectively and fast. Smartphones have the similar capacity of computers and have more mobility. By developing an android application for this purpose both the sales person and customer can have the best solution. In this paper, the capability of using smartphones for heat load calculation is evaluated.

LITERATURE REVIEW

Cooling Load Temperature Difference method (CLTD) has been used in the past to develop computer software. Programming languages which can handle simple and dynamic calculations were used by several researchers. Qbasicsoftwares was used to develop a cooling load program called CALAC to estimate the heat load in developing countries and they used this software to estimate the heat load of FUTA library [1]. The CLTD method was used in Haryana to calculate the cooling load of a classroom [2]. CLTD method is easier for the load calculation. The computer software in C#.NET was developed to handle simple and typical load estimation for air conditioning systems in developing countries like Bangladesh [3]. Due to the high cost of commercial software for cooling load estimation, developing countries require a more cost effective and free software for heat load calculation so that they can make more cost effective and efficient air conditioning system. From the past we could be able to understand that the most effective and efficient method to convert to a computer software is CLTD method from the comparison study conducted between Elite CHVAC and ASHARE CLTD method [4]. The CLTD method helps in creating software because it is simple in calculation and require fewer input data. Thus the development and authentication of computer software for estimating building loads become easier with this method [5]. The scope and potential of CLTD method was verified in the Assembly Hall building in Jabalpur Engineering College, Jabalpur in order to replace the high power consuming air conditioner to evaporative cooling systems [6]. The computer application

was developed using Visual Basic computer programing language which uses special GUI and assumptions proposed by ASHARE in calculating the cooling load and used the program to calculate the cooling load of an actual building in University of Nigeria [7]. In the case study of finding cooling load of Computer Laboratory Room and Excellent Centre Room in Faculty of Mechanical Engineering, University Malaysia Pahang used CLTD method and the result found was satisfactory [8]. The both designing and mathematical aspects for designing the HVAC systems for proper designing of a 1000 seats auditorium situated at Vadodara, Gujarat had done in the past and the designing was an emission free HVAC system with low global warming potential and ozone depletion. The design was best for comforting condition and which reduced the duct fabrication complexity by reducing number of joints and by selecting proper duct size [9]. A MATLAB program has been developed in the past to generate the CLTD values for different building materials for the city of Kolkata, India. The CLTD values provided by the ASHARE to Indian circumstances were verified to be applicable in Indian scenarios [10]. Equal friction method for duct design is simple as compared to other duct designing methods. So CFD software has been developed to generate the more accurate duct size was tried in the past by researchers [11].

From the literature review it was found that there was a constant effort made by researchers to develop a user friendly free softwares to calculate heat load in the past. Researchers in the developing countries like Bangladesh, India, Nigeria and Malaysia have tried to develop a computer software for this purpose. Computer programming languages like Qbasic, C# dot Net, Visual basic etc. were used by several researchers to develop heat load calculation softwares. Most of then used the CLTD method proposed by ASHARE handbook. It is evident from the review of existing literature that there is a need to develop a more user friendly application for engineers. There is lack of custom tailored application for cooling load calculation. Lack of free software that meets the industrial and business needs of HVAC industry, while the manual calculation is complex, laborious and liable to errors.Mobile and Computer based automation is likely to make a positive impact in the dynamics of HVAC industry. It was also found out that most of the HVAC companies working in India has a lack of data for the designing purpose. There is no sources available that can exactly say how to design an energy efficient HVAC system. Lack of standardization in designing criteria of HVAC system. By developing an android application to calculate the heat load we could able to provide HVAC engineers a better tool for calculating heat load in the right location at the right time. Thorough this application we can provide engineers with more standard design data. Thus engineers can provide a more cost effect and energy efficient system.

COOLING LOAD ESTIMATION METHODS

Cooling load method helps in finding the size of cooling equipment. Total Equivalent Temperature Difference (TETD) was one of the first methods developed to find out the transient effect of solar radiation and thermal effects. Transfer Function Method (TFM) is the one of the method proposed by ASHARE and is considered to be one of the most accurate methods for calculating heating and cooling loads. Cooling Load Temperature Difference method is the method derived from the TFM method. The CLTD method is uses tabular data. The main difference between the TETD method and CLTD method is mainly in the way heat gains are handled to find out cooling loads. CLTD method is a simpler method which can be converted into computer programs. It may be used to approximate the cooling load corresponding to the first three modes of heat gain (conductive heat gain through surfaces such as windows, walls, and roofs; solar heat gain through fenestrations; and internal heat gain from lights, people, and equipment) and the cooling load from infiltration and ventilation.

CLTD METHOD

Cooling load estimation is the first step towards air condition. The CLTD method is the most practical method as described in ASHARE 1997 fundamentals. This method is limited to tabular data so that it makes them easier to be automated using computer software. The general procedure of the CLTD is to consider the outdoor and indoor design conditions. Selecting heat transfer coefficients for walls, glasses, floor and ceilings. Computing conduction, convection and transmission heat loss for each kind of wall, glass, floor, ceiling and roof. Calculating the heat through generated through infiltration, sensible and latent heat and also the heat generated by internal load like people, light, equipment and appliances. Thus external and internal heat loads are calculated to find out the total cooling load. [12] The sources of the space cooling load, forms of equations to use in the calculations, appropriate references, are given in Fig 1.

Type of Heat Gain	Equation Used	Sources
i) Conduction of Heat Gains Through Walls	$Q = UA(CLTD_C)$ $U = \frac{1}{\sum R}$ $CLTD_C = CLTD + (25.5 - Tr) + (Ta - 29.4)$	Table 11, Table 18 and Wall 10 Table 32, ASHRAE 1997, Chapter 28.
ii) Conduction Of Heat Gain through Glass Window	$Q = UA(CLTD_C)$ $U = 6.07$ W/m^2.°C $CLTD_C = CLTD + (25.5 - Tr) + (Ta - 29.4)$	Table 5 ASHRAE 1997, Chapter 29. Table 34 ASHRAE 1997, Chapter 28
iii) Conduction of Heat Gain through Door	$Q = UA(CLTD_C)$ $U = 2.73$ W/m^2.°C $CLTD_C = CLTD + (25.5 - Tr) + (Ta -$	Table 7 ASHRAE 1997, Chapter 29.
iv) Solar Radiation Through Glass	$Q = SC \times A \times SCL$ Shading Coefficient = 0.85	Table 11 A SHRAE 1997, Chapter 29. Zone D, Table 36 ASHRAE 1997, Chapter 28.
v) Heat Gain from Lighting	$Q = WF_a F_{ul} CLF$	Equation 9 or 46 ASHRAE 1997, Chapter 28.
vi) Heat gain from people	$Q_s = q_s \times n \times CLF$ $Q_L = q_L \times n$ [W]	Table 3 ASHRAE 1997, Chapter 28.
vii) Heat Gain from Appliances	$Q = q \times n \times$ CLF [W]	Table 8 ASHRAE 2001, Chapter 29.
viii) Heat Gain from Ventilation	$Q_s = 1210 \times \dot{Q} \times \Delta T$ [W] $Q_L = 3010000 \times \dot{Q} \times (Wo' - Wi')$ [W]	Table 2 ASHRAE Standard 62-1999.

Fig 1: Summary of Equations and sources of calculation [8]

METHODOLOGY

An android application was developed for calculating the heating and cooling loads. CLTD method was adopted to develop the heating load calculator. Android application was developed in Android Studio SDK23 and database was created using SQLite. The tabular data for the CLTD calculations are adopted from ASHARE handbook. The Fig 2 shows the flow chart of the development of application. The application take inputs like building dimensions, details about building materials, internal loads and weather conditions.

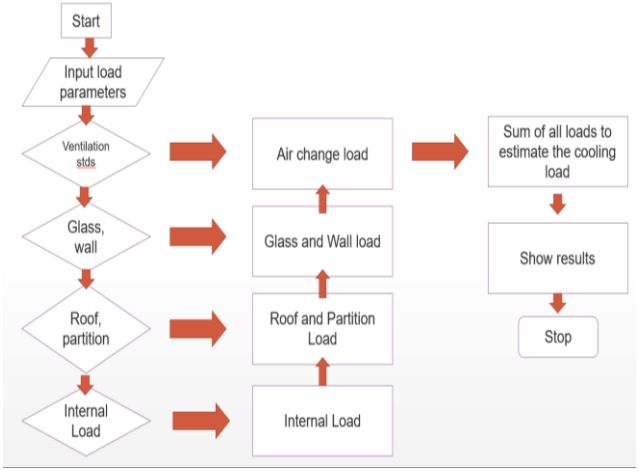

Fig2 : Flow chart of Android application

The user interface of the android application was developed by giving more importance to graphics user interface. The fig 3 shows the graphics user interface of the android application. Thus the graphics user interface helps in making the application more user friendly and makes the calculation more efficient and fast.

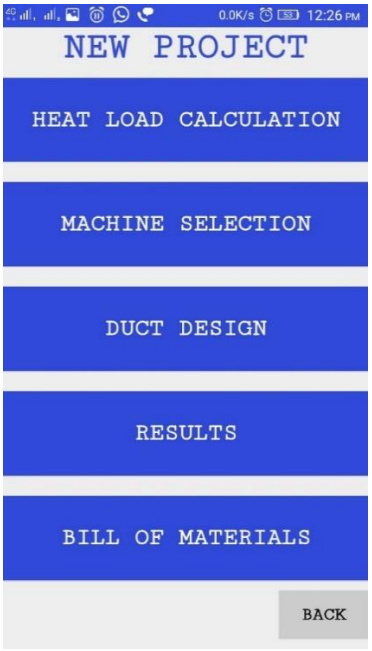

Fig 3: Graphics User Interface of android application

CASE STUDY

Following are the design parameters used to estimate the cooling load of a auditorium in order to test the accuary of the application.

- Day May 21st, time 4pm
- City Thrissur
- Inside condition required 24℃, 50% relative humidity
- Room dimensions: length 15m, breadth 17m, height 5m
- Building: single storey, exposed

Materials details

- Wall: medium construction (8” and 100 lb /sq.ft) solid brick common only, interior finished by 5/8” plaster on wall on by sand aggregate
- Roof: reinforced concrete cement (80lb/sq.ft, 6”thick) exposed roof, suspended plaster, no insulation on the top of the deck.
- Partition: 8” thick, hollow concrete block (sand and gravel aggregate) both side finished, interior finished by 5/8” plaster on the wall by sand aggregate
  - Door: wood
  - Internal load details
  - Number of people 100
  - Light 30W/sq.ft

RESULTS

TONNAGE REQUIRED	
EFECTIVE ROOM SENSIBLE HEAT	429215.45
EFECTIVE ROOM LATENT HEAT	22153.03
EFECTIVE ROOM TOTAL HEAT	451368.48
OUTSIDE AIR HEAT GAIN	68767.20
GRAND TOTAL HEAT SUB TOTAL	520135.68
Factor of Safety @ 2 %	10402.71
GRAND TOTAL HEAT	530538.39
TOTAL TONNAGE REQUIRED	44.21

Fig 3: Result obtained from the professional CLTD calculator

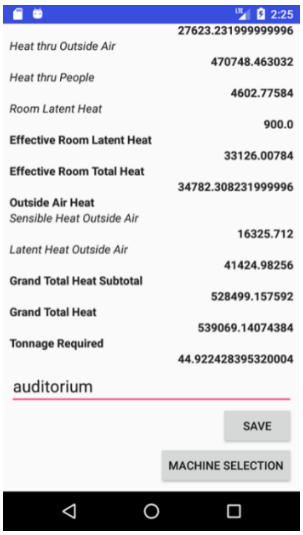

Fig 4: Result obtained from the HVAC toolkit Android Application

The result obtained from Android app was found to be 44.92TRshown in fig 4 and the result obtained using ASHARE CLTD method is 44.21TRas shown in fig 3. The result obtained using the developed android application was found to be good agreement with the ASHARE CLTD method. Marginal difference between the results because of consideration of factor of safety.

CONCLUSION

Android application was developed to help the heating and cooling load calculation. This application can be used by both the sales person and customers to find out the proper capacity of the machine required. By using the cooling load calculation methods proposed by ASHARE, by the application of scientific methodsto find out the proper load. Thus we couldbe able to design a proper air conditioning system to the requirement. Energy efficient system can be developed through proper calculation. Properly designed air conditioning system can reduce the running cost of the equipment to a great extent.

Smartphones can be adopted as a tool for HVAC engineers to make their job easier. With the mobility of smartphones technical sales personals can provide optimal solutions at the right place at the right time. Thus HVAC industry can make monetary benefits by providing timely solutions to their customers by using smartphones for designing air conditioning systems. This application can be used as a reference for the further developments in air conditioning sector.

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