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

UG Sourabh Choudhary UG Shantnu Sharma UG Sayak Saha UG Sanu Kumar UG Sanjeev Kumar UG Rohit Vishwas Asst. Prof. Kaushal Kishore

Department of Mechanical Engineering
Asansol Engineering College, Asansol, West Bengal, India

***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 software's though are simple for the professionals but appear to be very complex for common people. So this projects develops a alternate excel sheet which does the same work as that of the professional software's 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.**

***Keywords*- Air Conditioning System, Heat Load, ASHRAE and ISHRAE handbooks.**

I. 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.

II. LITERATURE REVIEW

Et al 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

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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.[1]

Et al 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(TETD)corr.
Cooling load calculation due to wall/ceiling, Q = UA [FC (TETD)Peak + FR (TETD)AVE] W.
Heat gain through glass, Qglass = A [SC{FC(SHGF)P + FR (SHGF)A} + UΔT] W.
Heat given by occupants = No. of occupants × Allowance Factor Heat gain from electric light, QLight = Total wattage of light × Use factor × Allowance factor
Heat gain from electric fan, QFan= Power (kW) × Use factor × Hours using Crack Infiltration = qi=(HxLxWxG)/60 m 3 /min Door Infiltration ={ (Door opening/hour)xFactor}/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, Etol 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.[2]

Et al ZhaoxiaWang , Yan Ding , Huiyan Deng , Fan Yang and Neng Zhu proposed that sustained upgrading in the thermal performance of building envelopes, the greatest impact on building loads and energy consumption was caused by the occupant activities. In this paper, the accurate calculation of interior load during design stage was stressed, and a new method was proposed. Interior occupants were considered as the core of interior disturbances, and the association with other interior disturbances was explored. The interior heat release was subjectively combined with the representative cooling load to be consumed in building

cooling load calculation. In three typical university buildings field surveys were conducted: an office building, a teaching building, and a library, located in a university in Tianjin, China. The huge chillier supplying cooling for the buildings resulted from the over-estimating of the indoor occupant number and the power consuming electric machines. Through calculable analysis, it was observed that the maximum representative interior loads were 196.43, 329.94, and 402.58 W/person, respectively, for the case buildings, at least 50% less than the experimental design data. Associated to the measured cooling load during the testing period, the accuracy of the altered cooling load was greater than 90%. This research was intended to served as a reference for calculating and optimizing the design loads of cooling systems.[3]

Et. Al. This paper presents and enhances the annual heating, cooling and lighting energy consumption coupled with applying different types and properties of window systems in a building envelope. With the help of building simulation modeling, varied window properties like as U-value, solar heat gain coefficient (SHGC), and visible

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transmittance (Tvis) were evaluated with different window wall ratios (WWRs) and positioning in five typical Asian climates: Manila, Taipei, Shanghai, Seoul and Sapporo. Windows, which can provide light, view and fresh air to the resident, play the most significant role in a building's energy consumption. Choosing window size is one of the important issues for a window system, not just for design purposes, but also when considering energy performance. Buildings are accountable for between 25 to 40 per cent of all primary energy use, greenhouse gas emissions, and waste generation. In a typical building, lighting, heating, and cooling represent most of the total energy use.

In resident buildings, heating is the largest consumer of energy; on the other hand, for commercial buildings, lighting is the main consumer. The amount of energy consumed through heating, cooling or lighting in a building is mainly influenced by its window system. Since the overall heat transfer coefficient (or U- value) of windows is normally five times greater than those of other components of a building's envelope (e.g. walls, doors, etc.), and about 21 to 40% of energy in a building is wasted through openings, the design and selection of a proper window system is one of the important strategies for effectively conserving the energy of a building. Recently, abundant research has been accompanied into the effect on building energy load reduction and on human comfort levels of applying low emissivity coating, gas fills like Argon and spacers in window glass. Thus, the starting point of this study was to developed easy charts of building energy consumption associated with the window properties and according to variations of climate, particularly in Asian regions.

To evaluate the suitable performance norms for glazing systems in buildings, a computer simulation software (COMFEN) was used for the design and selection of window systems. Climate statistics was one of the important variables to determine building energy consumption, and is well defined by ASHRAE standards. Manila has a low direct solar radiation level of less than 20 kWh/per year, where as radiation in all other locations is larger than 20 kW h.Based on the simulation results, the subsequent design guidelines are offered. According to installation effect, in the 4 cities other than Taipei, positioning a 25 per cent WWR window in the south face seems to be effective. In case of Manila, Taipei, placement of a window system on the north face offers the highest improvement for total energy savings, followed by placement on the south, west and east faces. In case of Shanghai, Seoul, Sapporo, the south face has the greatest advantage for total energy savings, followed by the north, west and east faces..[4]

Et.al. Nan Wang, Jiangfeng Zhang, Xiaohua Xia proposed that energy saving in air conditioners is a main concern in building projects, since a large quantity of the energy consumption in building service equipment is caused by air conditioners. The energy-saving research in air conditioners focuses mostly on the chiller system and the connected control strategies. For air conditioners in buildings, the thermal control strategy to adjust the temperature set point is very easy to implement and very effective in energy saving. In recent years, the energy consumption in data centers has been growing. The U.S Environmental Agency reports that the energy used up by Air Conditioning (ACs) and the lighting systems is almost same to the energy consumed by the Information Technology (IT) Equipment. Therefore, it is very important to reduce the energy consumption of the data centres. Developing of new energy- efficient equipment, such as, applying complex control strategies, or using the solar energy are some of the ways for savings energy in ACs. Like energy saving in packaged unit AC by adding an indirect evaporative cooling system or temperature and humidity control strategy or a thermostat setting scheme to preserve the indoor temperature and humidity.

Whether using a variety of control strategies, renewable energy, or adding new equipment, the cost was much higher than that of temperature set point adjustment. A data center is a facility used to house computer systems and associated components, such as telecommunications and storage systems. The people will enter the data center occasionally while the computer and other equipment need to be maintained. The indoor temperature set point of the computer room can be raised to 28 ◦C without causing any adverse effect on computers. Therefore, increasing the temperature set point of ACs in the data center by one degree is a simple but effective method. The energy consumption of ACs in data centers can be lowered by this method.[5]

Et. al. Menghao Qin, RafikBelarbi, AbdelkarimAït-Mokhtar, Francis Allard proposed that the instantaneous heat and moisture spread in the building envelope has an significant effect on the interior environment and the overall performance of buildings. Both heat and moisture allocation in the structure envelope and indoor air were concurrently measured; their connections were established. The united model takes into account the main hydrothermal effects, like wetness sources and sinks inside the room, moisture transfer through the cover, vapor sorption-desorption at the external and interior barrier surfaces, heat sources and sinks inside the room, heat involvement from the envelope, the solar energy input over walls and windows, and hydrothermal sources or sinks due to the air-conditioning system. The innovative model was executed in MATLAB-Simulink, and was validated by using a series of testing and authentication tools. The new database was applied to examine the moisture transmission effect on indoor air humidity and building energy ingesting under unlike

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climates. The results show that the use of more comprehensive imitation routines can result in advancesto the building's design for energy optimization through the choice of proper hygroscopic materials, which would not be shown by modest calculation methods.[6]

Et al ChadiYounes, Caesar AbiShdid and GirmaBitsuamlak studied and examined that infiltration is a chief aspect of heat load calculations. Air seepage over the building wrapping into the building interiors has a general influence on the energy loads and as a result energy demand and energy costs of buildings. Air infiltration along with ventilation, has a major impact on a building and its inside environment. Humidity carried by infiltrating air effects the long-term act of the building material and the structural reliability of the building. Normally they deliberated inside and outside air temperature difference. But this occurs due to outside airflow into the building, when outside air came inside the pressure difference occurs through the building resulting the difference between inside and outside temperature. There studies estimate that infiltration accounts for 25%–50% of the heating load in both residential and profitable buildings. Caffey (1979) recognized 40% of the heating load in houses to infiltration. Similarly, Persily (1982) determined that one-third of the heating loads in a building are due to infiltration. The National Institute of Standards and Technology (NIST, 1996) approximations that 15% of the heating loads in commercial buildings is caused by air entrance.

According to ASHRAE, infiltration, besides ventilation, are categorized under air interchange of exterior air with a building's indoor air. On the other hand, infiltration is defined by ASHRAE as 'the flow of outdoor air into a construction through cracks and other unintentional openings and through the usual use of exterior doors for entrance and egress'. Infiltration is either driven by natural or artificial pressure alterations. ASHRAE, with reference to Dicker off et al. (1982) and Harrje and Born (1982), approximates the percentage distribution of infiltration air outflow by building constituents like Walls: 18%–50%, with an average of 35%. Ceiling 3%–30%, with an average of 18%. In their study they have some housing calculation model like Empirical model, Multimode models, Single zone models and Superposition of wind and stack effect. They face habitually difficulty of measuring infiltration in buildings, which limits the investigational database available for use in developing infiltration evaluation techniques and methods. They developed the air infiltration calculation procedures. Air infiltration in buildings has been demonstrated over and over again to be a major load in building energy demand.[7]

Et. al. Hani H. Sait projected that conniving thermal load of building is important to seek out correct Air Conditioning equipment and air handling unit, for smooth operation and better air distribution in the air-conditioned region. It ought be taking under consideration the highest temperature in summer and also the lower of winters that happens in this region. For estimation of actual thermal load, Building's location, construction's material another interior's load should be considered. All equations required for warmth transfer through the building and for the interior's load were used to get the thermal load. Then, all of these equations were inserted in a personal program like M.S. Excel, to get the results. Some other software like HAP 4.2 and Elit "RHVAC" were used as alternative way. Here hand calculations were used to approximate the thermal load for existing building and the results were compared by the outcomes from software HAP 4.2. It has been shown that

there was little difference between these two results due to defining the thermal resistance for the materials used for the wall, roof, and windows. Also the sources of constants used for the equations don't seem to be an equivalent.[8]

Items needed for analyzing the thermal load of an area
Areas of envelopes and glass
U-factors for the envelopes Glass transmission factors
Lighting density and connected factors
Motors and different heat sources with connected factors
Number of persons and kind of activities
Ventilation rate and air enthalpy within and outdoors.

Et al Mehmet AzmiAktacir, OrhanBüyükalaca, TuncayYılmaz studied and detected that how thermal insulation of building can influence the cooling load and air-conditioning system in hot humid region. This journal was constructed on case study in Turkey. In this case an all- air conditioning system was estimated for a trial building located in Adana (Turkey), constructed on the results of three different types of insulation according to the energy efficiency index defined in the Thermal insulation guideline used in Turkey. Results showed that both the initial and the operating costs of the air-conditioning system were reduced considerably for all three insulation thickness.

However, the best results in view of economic dimensions were obtained for a C-type building. Air Conditioning system is determined according to the total cooling load of building consisting of heat grains through external surface, fenestration areas of building and architectural and physical properties of building ,such as mass structural material and its shape are the most important parameters, which impact the cooling load, also its depend on local climate. To reduce the cooling load in Air conditioning system, different actual methods are

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there such as free cooling, natural ventilation and night cooling. From these performances we can save energy more than 50% as compared to an existing building. By using their performances and use of thermal insulation reduce the annual energy consumption of the cooling system in hot and humid regions. Building characteristics also influence on cooling load of any building, there a sample building was taken for study of thermal insulation.

To benefit from solar energy and light typical window areas of building were mostly designed larger than the standard which affect in air conditioning system. According to the different building features, different thickness of thermal insulation is used to reduce the cooling load in Air conditioning system. Different layers of thickness is applied as per condition, generally three dissimilar layer of thickness is applied. To know the insulation thickness for any building there is a normal calculation technique. After the calculation of insulation thickness for a particular building different cost would be introduced like thermal insulation cost, operating cost and initial cost of installation. According to this Air conditioning system would be designed. By using of thermal insulation we can reduce or

cooling load of any building also they can reduce the all costs so the thermal insulation is directly on air-conditioning system in the hot and humid regions.[9]
ET ol Dean Plager, Lewis G.Harriman III, Douglas Kosar, realized that, there was need of maintaining and controlling air quality not only in the houses but also in different industries and buildings. Willis Carrier , American Engineer best known for the invention of modern air conditioning system by dehumidifying a printing plant.

To solve the issue of excess moisture in the indoor AC system, the HVAC system was equipped with the equipment that can regulate ventilation air and remove sensible heat load and latent (moisture) load efficiently. In order to counter the problem of larger ventilation load, technologies like subcool/reheat and heat pipe reheat were being deployed which increases latent capacity of cooling-based systems by reducing their sensible capacity. Beside this, discccant wheel also provide deeper drying by utilizing thermal energy to remove latent load.
To assist engineer to design the HVAC system by estimating ventilation load for the different climatic and geographical condition, “Ventilation Load Index” (VLI) has been introduced.“Ventilationload index” (VLI) is the sum of load generated by one cubic foot per minute of fresh air brought from the weather to space-neutral conditions over the course of one year.
Ventilation Load Index consist of two components, dehumidification (latent) and cooling (sensible) components.

For calculating VLI, one should compare the temperature & humidity level in the outside weather as compared conditioned space and the calculation were made for every hour of the year. While calculating index, hours when no load exist was not considered as in the case when temperature/humidity of conditioned spaced was equal to the outside weather condition.
Advantages of VLI were that it represents cumulative annual load rather than representing load for the peak design condition. By calculating the sensible annual load and latent annual load, its provide the designer to design ventilation system that was capable of controlling temperature and humidity independently as per the weather variations.

For estimating index, one method was the TMY-2 data set which contains complete record for 239 place of the USA. And the second way is to estimate annual load of a HVAC system using BIN calculation program which consider temperature, dew point and wind speed. To validate the result produce by BIN program, a separate check program run by second user and was being verified with the data produced by the BIN program. For most of the cases, Latent load and sensible load were never being equal for a specific location, they even differ by at least 3:1. Except desert, annual latent loads always exceed the annual sensible load. Thinking of its implication, where ever there is commercial aspects just like the places such as classroom, theatre where ventilation air was in the high proportion of the total air flow, then the latent load should be given more priority in the design of the ventilation system.[10]

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