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COOLING LOAD CALCULATIONS

Some Concepts & Mis-concepts

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Energy saving and energy efficiencies are the key factors which an air conditioning engineer looks into while evaluating or specifying the plant sizes.

Most of the time the engineer concentrates on energy-efficient equipment. However, there are many aspects of the basic air conditioning load calculation which should be looked into and which could give a properly-sized plant to meet the requirements.

We have come across a number of instances where evaluated plant capacities are not fully utilized and quite a large part of the plant remains unutilized. This could be considered as an inefficient system. On analyzing such systems, it is observed that the assumptions made while evaluating the loads are not as per the specified procedures given in handbooks and literature.

The proper sizing of air conditioning equipment depends on the proper evaluation of air conditioning load. Certain mis-concepts have also entered in the practice of load calculation.

This article is an attempt to clear the mis-concepts. What is being written here is not new. It is already there in various handbooks and literature.

Ambient design conditions

Mis-concept: The design conditions introduced recently through WeDCo¹ and adopted by BIS (Bureau of Indian Standards) are wrong.

Concept : For evaluating the air conditioning loads, we require simultaneous dry-bulb and co-incident wet-bulb temperature. Carrier Handbook gives such values for cities in USA and Canada under two categories – Normal and Maximum. That means, even decades ago, the systems were not evaluated for only maximum conditions. ASHRAE until 1997 gave options under 1%, 2% and 5% for different applications. The main concept being that occasionally, inside conditions may be allowed to exceed the required value for short durations. Depending on the application one could use the particular column value. In 1997, ASHRAE revised the definition and gave values under 0.4%, 1% and 2% columns.

In India, engineers had no scientifically evaluated data on ambient design conditions. The detailed information was also not available to find coincidental values of dry-bulb and wet-bulb temperatures. Engineers thus depended on the Red Book published by IMD (Indian Meteorological Department) and used their own judgment in establishing the values. In the process, very often the values taken for dry and wet-bulb temperature were not coincidental. For example, the summer value for Mumbai is 95°F (35°C)DB and 83°F (28.3°C) WB. For monsoon the values are 85°F (29.4 °C)DB and 82°F (27.8°C)WB. One would expect the monsoon wetbulb temperature will be higher than the summer wet-bulb temperature. Even if one believes that such combinations could occur, then what is the frequency of such occurrence? Is it correct to use a value that may occur less than 0.4 % of the time!

Today we have the data that was scientifically evaluated and values obtained as per ASHRAE definitions. The values are published by BIS. Engineers are scared to use the scientifically evaluated values and still use the values established and used earlier as “guess work” without any scientific basis.

Solar gains through glass

Mis-concept : The solar gain through glass will be more for Indian tropical conditions.

Concept : The values given in handbooks are valid for latitudes upto 40° north and 40° south. Correction factors should be used as per notes given along with the tables. The

values are valid for all locations around the world. The value changes with latitude of the place and the time of day. Maximum value and time will not be the same for locations in south, central and north India.

Even shade factors, internal and external are well documented for all types of combinations. These can be safely used.

Equivalent Temperature Difference

Mis-concept : Temperature difference and equivalent temperature difference are the same. In other words, taking any of the values makes no difference.

Concept : Temperature difference is straight difference between two temperatures, for example, outside dry-bulb temperature and inside dry-bulb temperature.

Equivalent temperature difference is the evaluated difference. This takes into account orientation of the surface, i.e., wall or roof, the mass of the wall or roof, time of the day. This is to be applied only to sun-exposed surfaces. Carrier introduced this method. Subsequently, ASHRAE has introduced advanced methods like, TETD, TFM, CLTD etc. Since Indian engineers are accustomed to the Carrier method, we can limit ourself to this method.

Here also well-documented tables are available.

Tables are also available which give 'U' values for different types of wall and roof / ceiling construction. The 'k' values of different building materials, including those used in India are also available. The 'U' value can be easily calculated if the table does not have the particular construction in the list.

Ventilation - Fresh Air

Mis-concept : As per current practice of taking outdoor air, ASHRAE standard 62-1999, the quantity of air has increased to nearly double of what was being taken earlier as per Carrier Handbook. This increases the load.

Concept : It is true that the fresh air requirement has increased. But the engineers are improperly following the per-person rate for all types of applications. If one looks correctly at the standard, there are number of high occupancy applications where the rate specified per unit-area basis. For example, for malls, shopping complexes, certain areas of hotels, the specified rate is per unit area. For such areas, the increase is not exorbitant. One should refer to the notes given along with the tables to properly interpret the numbers.

Occupancy

Mis-concept : The densities have increased. As such, space per person has reduced to 2-3 m²/person or even less.

Concepts : It is true that for some applications like, call centers and communication centers the densities have gone up. But for general areas, the densities are not high. While evaluating the occupancy, an average should be used and not blindly apply the high-density rate for all the office spaces. This unnecessarily increases the occupancy load and fresh air load.

Lights

Mis-concept : Lighting densities have gone up. For offices it can be 20- 30 W/m². For shopping complexes it may be 60 W/m².

Concept : It is true that the lighting densities are high. One should check whether the figures given are for connected load or operating load. The air conditioning load depends on the operating load and not on connected load. One has to apply a load factor, usage factor etc. to arrive at the operating load. Since this is one of the major contributors to the air conditioning load, one should be careful. Our observations are that, most of the times, these values are for connected load. Appropriate load factor and usage factor must be applied. Use of efficient lighting fixtures can be considered.

Appliances

Mis-concept : Appliances densities have gone up due to use of computers and other office equipment. For offices it can be 20-60 W/m².

Concept : True. The densities are high. But again, in most of the cases, it may be the connected load. The operating load can be low. All the equipment does not run all the time. The load factor or diversity may be 50% or even less.

Plant Capacity

Mis-concept : The plant capacity is the sum total of all the floors of multi-floor complexes. While calculating the individual floor load, it is assumed that either the floor or ceiling is adjoining a non-air conditioned space.

Concept : This is a wrong concept. Block load of the building will be the load when all the floors are air conditioned. One may use the method mentioned above to size the air-

handling system for the floor. But as far as plant capacity is concerned, it is the block load that is required.

In a recent study for a mall, it was found that there was a reduction of nearly 680 tons in a load of 4329 tons when it was correctly assumed that all the floors are airconditioned. For an office block the reduction was 327 tons in a total load of 2100 tons.

Diversity

The air conditioning load is calculated taking peak design conditions, occupancy, lights and appliances. All the loads do not peak simultaneously. Handbooks recommend using a diversity factor. This may vary from 70-80 % of the block load.

Conclusion

Considering the high energy cost, which will keep increasing every year, it is very important that air conditioning loads are properly evaluated for sizing the equipment. Only using efficient equipment is not adequate. Efficient system evaluation is more important.

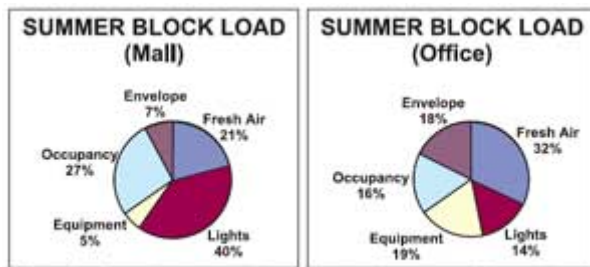


Figure 1 : Proper load evaluation helps select the right equipment. See concluding paragraph.

The load should be also analysed component wise. For a typical mall and office block the break-up of summer load (location New Delhi) is shown in **Figure 1**. It can be seen that different components predominate in the two different applications.