ENERGY EFFICIENCY AND THERMAL CONTROLS IN A BUILDING

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Abstract
Urbanization and ever-changing environment call for the demand of energy efficient buildings with thermal comfort of humans. In this paper, an attempt is made to focus on the concept of energy efficiency in buildings as well as aids for thermal comfort keeping in mind the human behavioural pattern.

Keywords: *Energy, Efficiency, Thermal, Controls*

INTRODUCTION

Energy efficiency in buildings basically means utilization of less energy for providing the same level of comforts and services in it. By increasing the energy efficiency, initial costs of the building might increase but in majority of cases this invested capital makes the building economical in long run.

Humans spend more than 90% of their time in buildings, thus it is very important to study the heat exchange parameters of buildings in consideration with the effect of climatic conditions on our body and its dependence on appropriate thermal conditions.

THERMAL BALANCE IN HUMAN BODIES

The normal temperature of human body is around 98.6°F i.e. 37°C. It is very important to maintain this temperature as there is continuous heat gain from internal body processes and must be balanced by continuous heat loss. The human body has the ability to adjust to varying environmental conditions, but to a certain range of atmospheric conditions; with a distinct feeling of discomfort. So, it becomes important to know the human behavioural pattern with respect to the surrounding environment to design effectively. The following discussion helps to understand how atmospheric conditions affect the body's ability to maintain a heat balance.

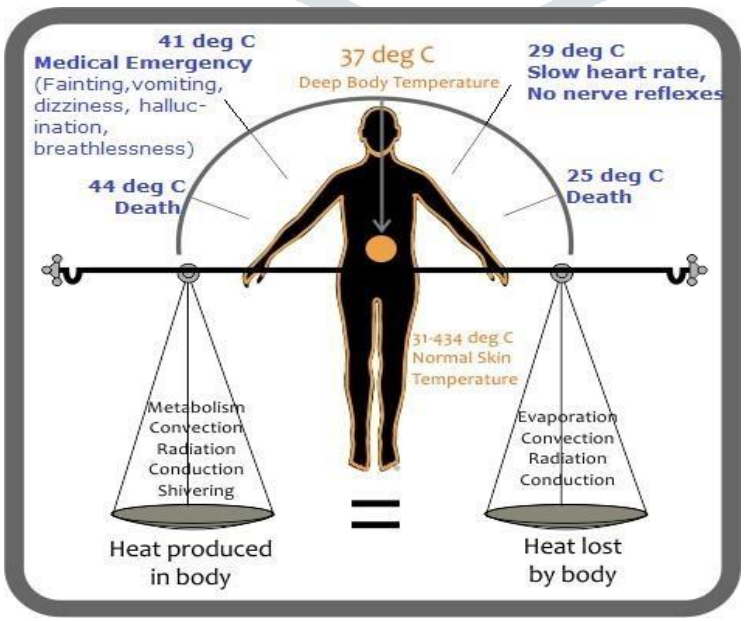

Fig.1: Thermal Balance of the Body[5]

Table 1: *Body's heat gains/losses*

	Mode of action
Metabolism	Biochemical process involved in tissue building and energy conversion and muscular work.
Radiation	Transfer of heat from hot object to cold through air
Conduction	Transfer of heat when in contact with each other
Convection	Movement of air in which the warmer air is replaced by colder air
Evaporation	Change of liquid to vapor accompanied by cooling
Shivering	Body's way of producing heat by sudden contraction and relaxation when it feels cold

BODY'S HEAT GAINS

The human body gains heat by metabolism, radiation, convection, conduction and shivering. The human body receives heat from those surroundings that have a temperature higher than body surface temperature as heat always travels from higher temperature areas to lower temperature areas.

BODY'S HEAT LOSSES

The human body losses heat by convection, radiation, evaporation and conduction. All the surplus heat of the body needs to be dissipated to the environment in order to maintain the deep body temperature at around 37°C.

The thermal balance of the body is shown by Fig.1 and can be expressed by an equation [1]. If the heat gain and heat loss factors are:

Gain: Met = Metabolism
Cnd= Conduction
Cnv= Convection
Rad= Radiation

Loss: Cnd= Conduction
Cnv= Convection
Rad= Radiation
Eva= Evaporation

Then thermal balance exists when,

$Met - Evp \pm Cnd \pm Cnv \pm Rad = 0$.

In this section, we considered the human body as a defined unit for analysing its heat exchange processes with the environment. For maintaining the core body temperature to its normal value, the room temperature should be roughly around 24°C. So, for providing a pleasant indoor atmosphere, we need to understand the heat exchange processes of the building by considering it as a defined unit.

HEAT EXCHANGE IN BUILDING

The main aim is to study the heat flow due to the temperature difference between the outer surrounding and indoor of the building. Whenever there is a temperature gradient the heat flows from the higher temperature areas to the lower temperature areas. The three most common way of heat transfer in the building are conduction, convection and radiation. Apart from these, internal heat gain adds the heat whereas evaporation removes the heat from the building envelope. There is also an artificial way of heat exchange and that is by using mechanical means of heat transfer which are responsible for adding up the heat when the surrounding is colder and vice versa.

Energy Efficient Building aims to reduce the energy consumption of the building which can only be achieved by lowering the mechanical mean of heat exchange. It is the best outcome if the artificial energy consumed is zero, but it is not always possible to achieve this as the varying environmental conditions hinders the heat balance and demands other than natural means to control and balance the heat exchange in the building.

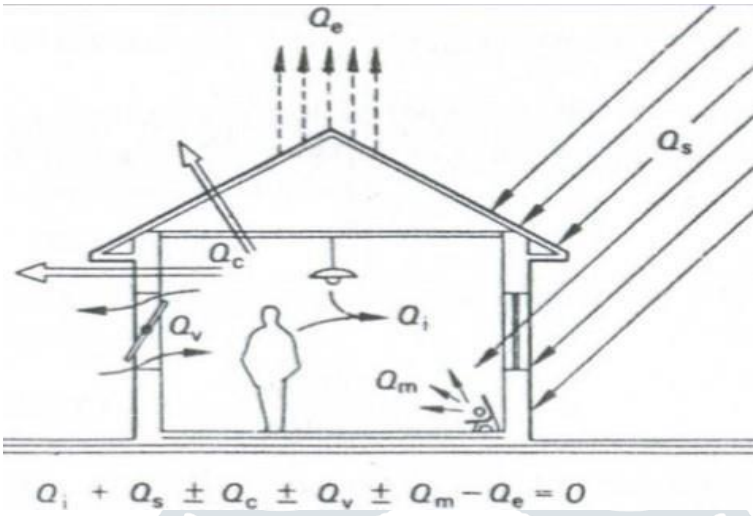

Fig.2: Heat Exchange in the Building

The thermal balance of the building or the existing thermal condition of the building is maintained if equation shown below satisfies [1],

Qi + Qs ± Qc ±Qv ± Qm – Qe = 0
Where, Qi = Internal heat gain
Qs = Solar heat gain
Qc =Heat exchange due to conduction
Qv = Heat exchange due to convection
Qm= Mechanical heat exchange
Qe =Heat exchange due to evaporation

For a pleasant indoor atmosphere with energy efficiency, the building should be provided with effective thermal controls.

THERMAL CONTROLS

Thermal comfort can be provided with the help of ventilation and air movement, mechanical controls and structural controls. Ventilation and air movement can be effective by provision of proper orientation, external features, position and size of openings. Mechanical controls like heating and cooling systems, dehumidifiers, ACs, blowers, exhausts etc. can be used to maintain the comfort levels.

But to achieve the desired thermal comfort conditions, it is crucial to achieve these conditions with minimum mechanical aid. Thus, the structural controls are designed with the aim to eliminate the mechanical control or reduce it to the minimum. The various structural controls are thermal insulations, orientation and window size, internal blinds and curtains, special glasses, shading devices etc. This paper deals specifically with thermal insulations and special glasses.

THERMAL INSULATION

The terms Conduction, Convection and Radiation are very important as they are the only controllable heat exchange parameters. Thus, controlling these parameters by using suitable insulators will reduce the load on the heating and cooling systems.

1. **Conduction:** It is the transfer of heat from one solid particle to another solid particle. Conductance is the word used for the heat transfer from the opaque and the solid object. Thus, in a building, the transfer of heat through any of the solid material

(mainly wall) is termed as conduction. To control the conduction heat, flow the material with low conductance value should be replaced with the conventional material which will act as a thermal insulator. Special foam insulation can also be used between two layers of the wall to act as a better insulator. Here some experimental combinations are used and correspondingly the conductance value of the whole system is obtained as shown in Fig.3.

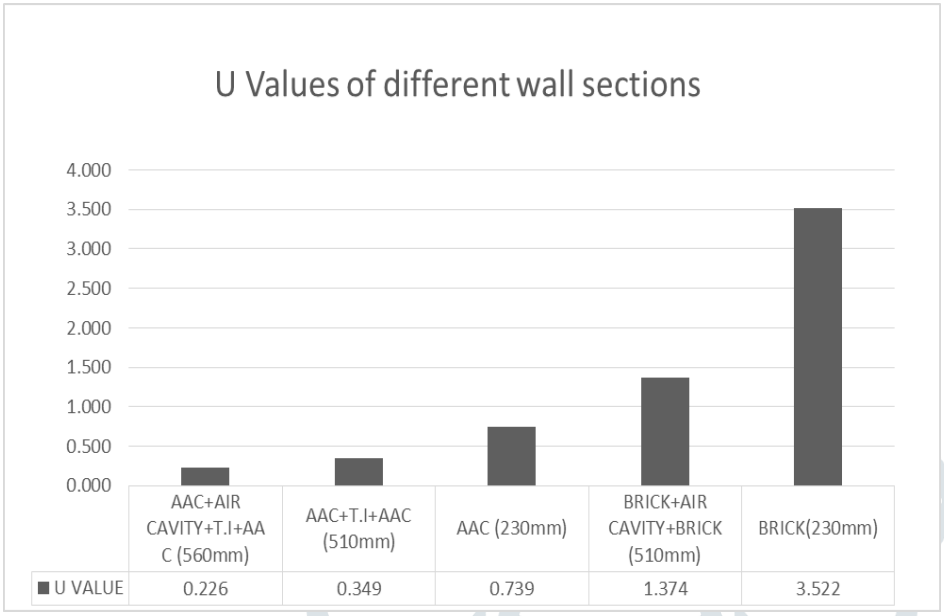

Fig.3: U-values for different wall sections

Note: The thermal insulation used in the cavity is Polyisocyanurate (type of foam) and is used as a rigid thermal insulation. The thermal conductivity of this foam is as low as 0.16 W/m^2K[3].

The equation for the heat exchange in through conduction is given by Q_c.

$Q_c = A*U*T$

Where, A= Surface area
U= Conductance value
T= Temperature difference

From the equation we can deduce that heat exchanged is directly proportional to the conductance value of the material. Now if we compare the conductance value of the conventional brick section and the thermally insulated section with cavity the heat conducted by the thermally insulated section with cavity is 17 times less than the conventional wall section. Thus, the load on the Q_m is reduced by 16 times the conducted value of the conventional wall section. By replacing normal bricks with aerated autoclaved concrete blocks also reduces the load on Q_m by more than 6 times. Hence, the building material plays an important role in the energy efficient building.

2. **Convection:** In a building, the ventilation system results in the movement of air and thus exchanges heat by convection. The air movement in the building is important because it is necessary to remove the still, moist and saturated air out of the building and sometimes we need heavy mechanical equipments to push the air for circulating it into whole building. Thus, provision of proper openings for ventilation will prove to be effective.

3. **Radiation:** Heat exchange through radiation is directly proportional to the temperature of the emitting body. The heat gained or lost in a system depends on the properties such as absorbance, emissivity and transmittance of the material. Thus, the heat exchanged can be reduced by using materials having less transmittance for hot climate and material of high transmittance for colder climate to receive more heat from the natural source.

SPECIAL GLASSES

In an opaque surface the incident solar radiations are partly absorbed and partly reflected i.e. a+r=1. In transparent surfaces, the incident rays are partly absorbed, reflected and transmitted i.e. a+r+t=1. An ordinary glass transmits large solar energy i.e. large solar gain; thus, the transmittance of glass can be changed by varying the material of the glass and hence reducing the solar gain.

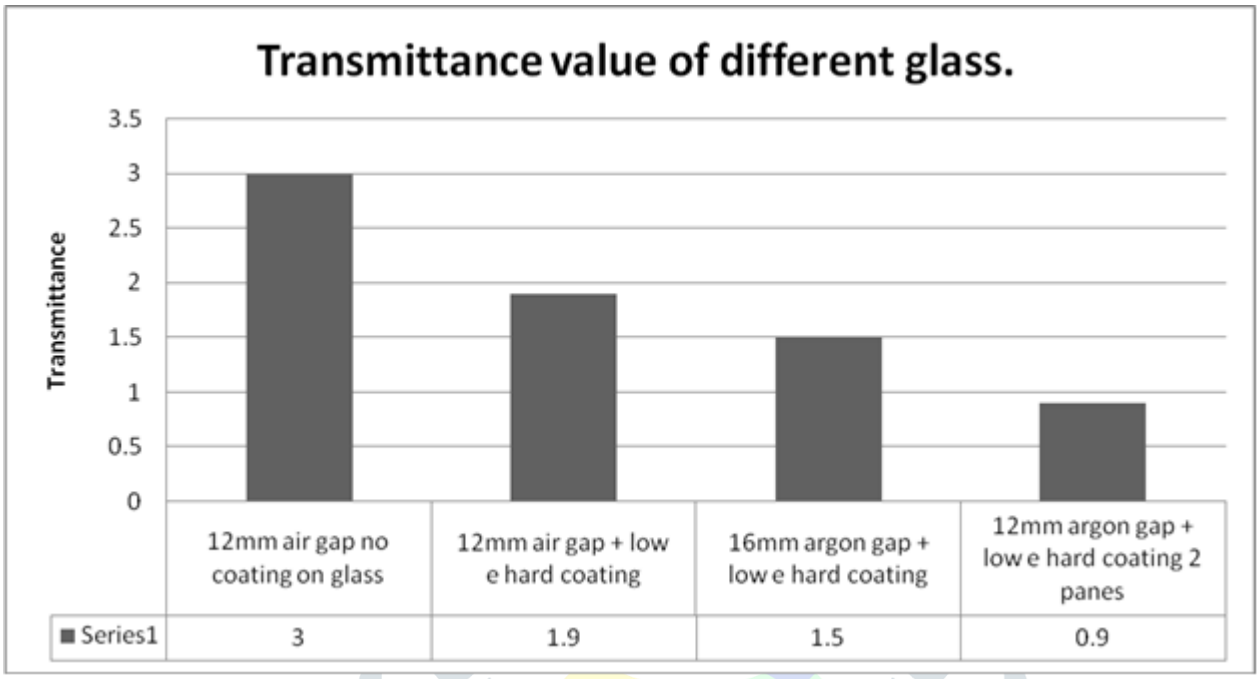

Fig.5: Transmittance values of different glasses

Fig.5 shows the transmittance values of different glass[4]. Lower the transmittance value indicates less transfer of heat and thus lower solar gain. The solar gain value of the 12mm argon gap + low e hard coating 2 panes (triple glazed glass is 58% less than the ordinary glass. The solar gain value of the first three glass as shown in the figure.5 are 0.78 (22% less), 0.72 (28% less) and 0.58 (42% less) respectively. Thus, the coating on the glass and the air gap between the glasses reduces the heat flow and thereby maintain the indoor temperature.

CONCLUSION

Scientifically evaluating the energy efficient buildings by gaining knowledge through literature, it is evident that one can bring down the energy consumption by efficient planning and by incorporating simple energy efficient measures. They prove to be economical in the long run, thereby satisfying the human comfort in the designed environment. Its dependence on non-renewable resources such as oil, natural gas and coal can be reduced.

By means of Thermal Control, thermal comfort is achieved by maintaining the indoor temperature; Size of installations required is less; Power consumption by temperature regulating devices is reduced.

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