1.4 THERMAL PERFORMANCE OF BUILDINGS

The thermal performance of a building refers to the process of modeling the energy transfer between a building and surroundings.Various heat exchange processes are possible between a building and the external environment.

Heat flows by conduction through various building elements such as walls, roof, ceiling, floor, etc. Heat transfer also takes place from different surfaces by convection and radiation.Besides, solar radiation is transmitted through transparent windows and is absorbed by the internal surfaces of the building.These are shown in Fig.1.5

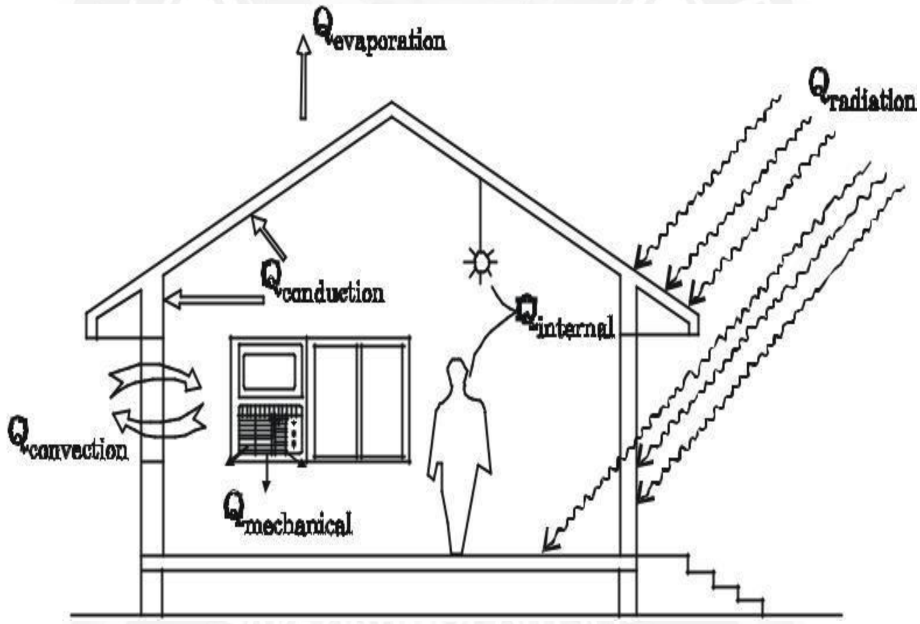

Fig 1.4.1- Thermal performance of a building

There may be evaporation of water resulting in a cooling effect. Heat is also added to the space due to the presence of human occupants and the use of lights and equipments.Due to metabolic activities, the body continuously produces heat, part of which is used as work, while the rest is dissipated into the environment for maintaining body temperature. The body exchanges heat with its surroundings by convection, radiation, evaporation and conduction.If heat is lost, one feels cool. In case of heat gain from surroundings, one feels hot and begins to perspire. Movement of air affects the rate of perspiration, which in turn affects body comfort.

The interaction between a human body and the indoor environment is shown in

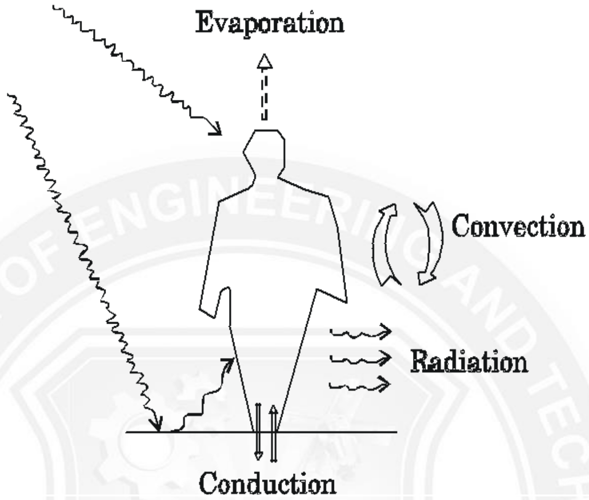

Fig 1.4.2- interaction between a human body and the indoor environment

FACTORS AFFECTING THERMAL PERFORMANCE OF BUILDINGS

The thermal performance of a building depends on a large number of factors. They can be summarised as

- design variables (geometrical dimensions of building elements such as walls, roof and windows, orient a tion, shading devices, etc.;
- material properties (density, specific heat, thermal conductivity, transmissivity
- weather data (solar radiation, ambient temperature, wind speed, humidity, etc.)
- a building's usage data (internal gains due to occupants, lighting and equipment, air exchanges, etc..

A block diagram showing various factors affecting the heat balance of a building is presented in Fig 1.4.3

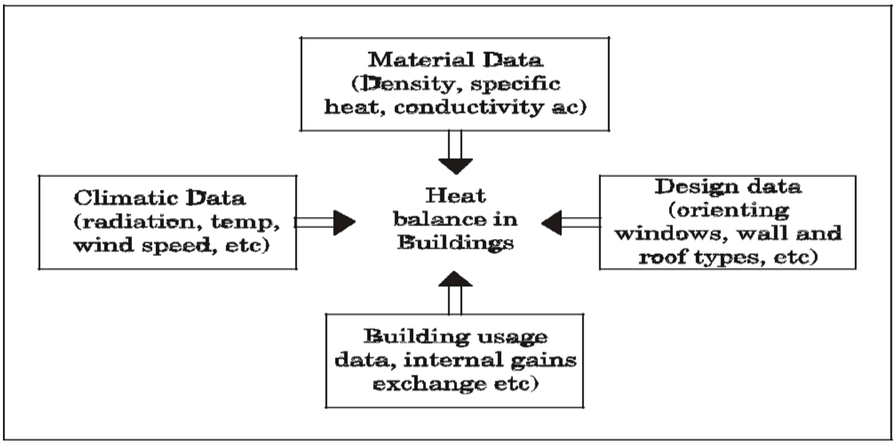

Fig 1.4.3- Heat balance of a building

THERMAL MEASUREMENTS

Every material used in an envelope assembly has fundamental physical properties that determine their energy performance like conductivity, resistance, and thermal mass.Understanding these properties will help are chose the right materials to manage heat flows

- **Thermal conductivity (K)**
- **Thermal conductance (C)**
- **U-Factor (U)**
- **Thermalresistance (R-VALUE)**
- **Thermal mass**
- **Density(ρ)**
- **Specificheat (C)**
- **Thermalcapacity or Thermal mass**

1.Thermal Conductivity (*k*)

A material's ability to conduct heat is known as thermal conductivity.

$$Q = \frac{KA\Delta T}{L}$$

Where Q=Resultant heat flow (watts)

k=thermal conductivity (W/mK)

A=surface area (m^2)

ΔT=temp diff between warm and cold sides (K)

L= thickness or length of material (m)

2.<u>Thermal Conductance (*C*)</u>

Conductivity per unit area for a specified thickness is known as thermal conductance.

For such common materials, it is useful to know the rate of heat flow for that standard

thickness instead of the rate per inch. Unit W/m^2K

3.<u>*U* – Factor (U)</u>

U factor is the overall coefficient of thermal transmittance. Unit W/m^2K.Lower *U*-factors mean less conduction, which means better insulation. (U=1/R)

Q= U TA

$U = \frac{Q}{TA} = W/Km^2$

4.<u>Thermal Resistance (*R*- value=1/U)</u>

A material's ability to resist heat flow is known as R value. Thermal resistance indicates how effective any material is as an insulator.The reciprocal of thermal conductance.unit- m^2K/W

5.<u>Thermal Mass</u>

Thermal mass **is the ability of a material to absorb and store heat energy**. It is a material's resistance to change in temperature as heat added or removed, and is a key factor in dynamic heat transfer interactions within a building.

$Q = C\Delta T$

$C = Q/\Delta T$ J/°C

The four factors to understand are density, specific heat and thermal capacity.

Density (ρ)

Dense materials usually store more heat.Density is the mass of a material per unit volume.

$$\rho = \frac{m}{v} = \text{Kg/m}^3$$

Specific Heat (C)

High specific heat requires a lot of energy to change the temperature. Specific heat is a measure of the amount of heat required to raise the temperature of given mass of material by 1^{o} K. Unit J/Kg K.

$$C=\frac{Q}{m\Delta T} \quad \text{(J /Kg k)}$$

Q=heat energy, ΔT= change in temperature , m= mass

Thermal Capacity

Thermal capacity is the energy required to raise the temperature by 1^{o} K. It is an indicator of the ability of a material to store heat per unit volume.

Density x **Specific heat = heat is stored per unit volume.**

$$C=\frac{Q}{\Delta T} \quad \text{(J/k)}$$

Other important devices for measuring temperature include:

Thermocouples

Thermistors

Resistance temperature detector (RTD)

Pyrometer

Other thermometers