Week 4_Qureshi, Nahid

Question 1
A wood frame wall that is built around 38-mm 90-mm wood studs with a center-to-center distance of 400 mm. The 90-mm-wide cavity between the studs is filled with urethane rigid foam insulation. The inside is finished with 13-mm gypsum wallboard and the outside with 13-mm plywood and 13-mm 200-mm wood bevel lapped siding. The insulated cavity constitutes 75 percent of the heat transmission area while the studs, plates, and sills constitute 21 percent. The headers constitute 4 percent of the area, and they can be treated as studs. Find the R-values ?

Also, determine the rate of heat loss through the walls of a house whose perimeter is 50m and wall height is 2.5m in Las Vegas, Nevada, whose winter design temperature is -2 C. Take the indoor design temperature to be 22C and assume 20 percent of the wall area is occupied by glazing.

Answer :

	Wood	Insulation
Outside air	0.03	0.03
Wood bevel (13-mm 200-mm)	.14	0.14
Plywood (13mm)	.11	0.11
Urethane rigid foam insulation (90mm)	no	0.98*90/25= 3.528
Wood studs (90mm)	.63	no
Gypsum board (13mm)	.079	0.079
Inside surface	.12	0.12

$$R'_{withwood} = (0.03 + .14 + .11 + .63 + .079 + .12)\, m^2{}^\circ\frac{C}{W} = 1.109 m^{2\circ}\frac{C}{W}$$

$$R'_{withinsulation} = (.03 + .14 + .11 + 3.\mathring{5}28 + .079 + .12) m^2{}^\circ\frac{C}{W} = 4.007 m^{2\circ}\frac{C}{W}$$

$$U_{wood} = \frac{1}{R'_{withwood}} = \frac{1}{1.109\frac{m^{2\circ}C}{W}} = 0.9017\frac{W}{m^{2\circ}C}$$

$$U_{insulation} = \frac{1}{R'_{withinsulation}} = \frac{1}{4.007\frac{m^{2\circ}C}{W}} = .2496\frac{W}{m^{2\circ}C}$$

$$\frac{1}{R_{total}} = \frac{1}{R_{wood}} + \frac{1}{R_{insulation}}, R = \frac{R'}{A}\ i.e.\ \frac{1}{R} = \frac{A}{R'}$$

$$\frac{A_{total}}{R'_{total}} = \frac{A_{wood}}{R'_{wood}} + \frac{A_{insulation}}{R'_{insulation}}$$

$$U=\frac{1}{R'}$$

i.e. , $A_{total} * U_{total} = A_{wood} * U_{wood} + A_{insulation} * U_{insulation}$

Both sides of the equation divided by U_{total}:

$$U_{total} = U_{wood} * \frac{A_{wood}}{A_{total}} + U_{insulation} * \frac{A_{insulation}}{A_{total}}$$

= (21%+4%) $*U_{wood}$+(75%) $*U_{insulation}$

= 25%*$0.9017\frac{W}{m^{2\circ}C}$ + 75% * $.2496\frac{W}{m^{2\circ}C}$

= $0.4126\frac{W}{m^{2\circ}C}$

The overall unit thermal resistance $R_{value} = \frac{1}{U_{total}} = \frac{1}{0.4126\frac{W}{m^{2\circ}C}} = 2.4237\frac{m^{2\circ}C}{W}$

The rate of heat loss through the walls

$\dot{Q} = U_{total} * A_{total} * \Delta T$

= $0.4126\frac{W}{m^{2\circ}C} * 50m * 2.5m\ (1 - 20\%) * 22C - (-2^{\circ}\text{C}\ )$ = 990.24W

Q2 SUMMARY ABOUT RADIATION AND RADIATIVE HEAT TRANSFER

Heat radiation is the emission of electromagnetic waves from all matter that has a temperature greater than absolute zero, it is due to the heat of the material, the characteristics of which depend on its temperature. The first result on thermal radiation were given by Joseph Stefan, Ludwig Boltxzmann and Wilhelm Wien.

Heat radiation happens almost in all objects, regardless of the material form of the object, whether it is solid, liquid or gas, basically everything around us keeps emitting thermal radiation to its surroundings.

Conduction and convection require material medium to transfer heat. Heat radiation does not need the presence of a material medium to take place. Radiation is a method of heat transfer that does not depend on any contact between the heat source and the heated object. Heat can be transmitted through empty space by thermal radiation. Most common example : we feel the heat of the sun in daylight time even it is far away and we are not touching it.

Objects emit radiation when high energy electrons in a higher atomic level fall down to lower energy levels. The energy lost is emitted as light or electromagnetic radiation. All objects absorb and emit radiation. When the absorption of energy balances the emission of energy, the temperature of an object stays constant. If the absorption of energy is greater than the emission of energy, the temperature of an object rises. If the absorption of energy is less than the emission of energy, the temperature of an object decreases.

A medium that emits radiation that can be visible is called a light source. The biggest and most important natural light source is the Sun and it represents the primary light source. Electromagnetic radiation that Sun produces is also known as solar radiation.

The majority of the solar radiation is light (visible) and other parts include ultraviolet and infrared light.

The radiation emitted by bodies at room temperature falls into the infrared region of the spectrum, which extends from 0.76 to 100 um.

Black Body

The thermal radiation is continually emitted from every part of the surface of the object that has a temperature greater than absolute zero into every direction.

Surfaces emit thermal radiation and reflect electromagnetic waves at the same time. If we assume an object that emits radiation but does not reflect any electromagnetic waves, it is a "black body", which is an idealized body that doesn't exist in real life. A blackbody emits the maximum amount of radiation by a surface at a given temperature, and absorbs all incident radiation, regardless of wavelength and direction.

Amount of emission, wavelength and temperature

The emitted radiation is a continuous function of wavelength. At any specified temperature, it increases with wavelength, reaches a peak, and then decreases with increasing wavelength. At any wavelength, the amount of emitted radiation increases with increasing temperature.