WEEK 4

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**Question 1:**

Determine the overall unit thermal resistance (the R-value) and the overall heat transfer coefficient (the U-factor) of a wall frame wall that is built around 38-mm 90-mm wood studs with a centre-to-centre distance of 400mm. The 90-mmwide cavity between the studs is filled with urethane rigid foam. The inside is filled with 13-mm gypsum wallboard and outside with 13-mm plywood and 13-mm 200-mm wood bevel lapped siding. The insulated cavity constitutes 75% heat transmission area while the studs, plates, and sills constitute 21%. The header constitutes 4% of the area, and they can be treated as studs.

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. Take the indoor design temperature to be 22 and assume 20% of the wall area is occupied by glazing.

**Answer:**

|  |  |  |
| --- | --- | --- |
|  | **Wood** | **Insulation** |
| Outside air | 0.13 | 0.13 |
| bevel wood (13\*200mm) | 0.14 | 0.14 |
| Plywood (13mm) | 0.11 | 0.11 |
| Urethane Rigid foam Ins (90mm) | no | 0.98\*90/25=3.528 |
| Wood studs (90mm) | 0.63 | no |
| Gypsum board (13mm) | 0.079 | 0.079 |
| Inside surface | 0.12 | 0.12 |

R’with wood = (0.03 + 0.14 + 0.11 + 0.63 + 0.079 + 0.12) = 1.109 m2 Co/w

R’with insulation = (0.03 + 0.14 + 0.11 + 3.528 + 0.079 + 0.12) = 4.007 m2 Co/w

Uwood = = = 0.9017 W/m2 C

Uinsulation = = =0.2496 W/m2 C

= + , R = i.e = = =

= +

U =

i.e Atotal \* Utotal = Awood \* Uwood + Ainsulation \* Uinsulation

*Both sides of the equation divided by Utotal,*

Utotal = Uwood \* + Uinsulation \*

= ( 21% + 4% ) x Uwood + 75% x Uinsulation

= 25% x 0.9017 w/ m2 Co + 75% x 0.2496 w/ m2 Co

= 0.4126 w/ m2 Co

*The overall unit thermal resistance Rvalue*= = = 2.4237 m2 Co/w

*The rate of heat loss through walls*

Qtotal = Utotal \* Atotal \*

= 0.4126 w/ m2 Co x 50 m x 2.5 m x (1-20%) x 22o C – (-2o C)

= 990.24 W

**Summary about radiation and radiative heat transfer**

**Definition:**

**Electromagnetic waves**

Electromagnetic waves are oscillating particle waves that are generated by the electric field and magnetic field in the same phase and perpendicular to each other. They are electromagnetic fields that propagate in the form of waves.

The process of relying on electromagnetic wave radiation to achieve heat transfer between hot and cold objects is a noncontact heat transfer that can also be carried out in a vacuum. The electromagnetic waves emitted by the object are theoretically distributed over the entire spectrum, but in the temperature range encountered in the industry, the practical significance is the thermal radiation with a wavelength between 0.38 and 1000 , and most of them are located in the infrared (again It is called the heat ray) in the range of 0.76 to 20 . The so-called infrared heating is to use the thermal radiation of this section.

**Thermal Radiation**

Radiation is a phenomenon in which energy is transmitted by electromagnetic waves. The process in which radiant energy is emitted due to heat is called thermal radiation.

Thermal radiation is the emission of electromagnetic waves from all matter that has a temperature greater than absolute zero, i.e., 0 K or −273.15 ℃, it is due to the heat of the material, the characteristics of which depend on its temperature. The type of electromagnetic radiation that is pertinent to heat transfer is the thermal radiation emitted as a result of energy transitions of molecules, atoms, and electrons of a substance. That explains the temperature in the physical field: temperature is a measure of the strength of these activities at the microscopic level, and the rate of thermal radiation emission increases with increasing temperature. Since absolute zero is an idealized physical condition, thermal 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. A significant difference between thermal radiation and other mechanisms of heat transfer is, thermal radiation does not need the presence of a material medium to take place. So thermal radiation can occur in vacuum.”

**Emission, absorption and reflection; definition of a 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.