Weekly Submission 4

Part I

A wood frame wall that is built around 38mm 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 gypsum mm wallboard and the outside with 13 mm plywood and 13mm 200mm wood bevel lapped siding. The insulated cavity constitutes 75% of heat while the studs, plates, and sills constitute 21%. The headers constitute 4% of the area, and they can be treated as studs, which means 75% of the area is insulation and 25% can be considered wood.

Find the two R-unit values, determine overall unit thermal resistance (R-value), and the overall heat transfer coefficient (U-factor). Then determine the rate of heat loss through the wall of a house, whose perimeter is 50m and the wall height is 2.5m, in Las Vegas, Nevada, whose winter design temperature is -2C. The indoor temperature design is 22 C and assume 20% of the wall area is occupied by glazing.

	Wood	Insulation
Outside Air	0.03	0.03
Wood Bevel(13mm*200mm)	0.14	0.14
Polywood(13mm)	0.11	0.11
Urethane Rigif 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 m2C/W

R'with insulation = 0.03 + 0.14 + 0.11 + 3.528 + 0.079 + 0.12 = 4.007 m2C/W

Uwood = 1/ 1.109 = 0.9017 W/m2C

Uinsulation = 1/ 4.007 = 0.2496 W/m2C

1/ Rtotal = 1/ Rwood = 1/ Rinsulation

R = R'/A --> 1/R = A/R'

Atotal/R'total = (Awood/R'wood) + (Ainsulation/R'insulation)

U = 1/R'

Atotal (Utotal) = (Awood x Uwood) + (Ainsulation x Uinsulation)

Utotal = Uwood (Awood/Atotal) + Uinsulation (Ainsulation/Atotal)

Utotal = (21% + 4%) x Uwood + 75% x Uinsulation
= (25%)(0.9017) + (75%)(0.2496)
= 0.4126 W/m2C

Overall unit thermal restsistance Rvalue = 1/Utotal = 1/0.4126 = 2.4237 m2C/W

Rate of Heat Loss through the Walls
Qtotal = Utotal (Atotal) (Delta T)
= (0.4126)(50)(2.5)(1-20%)(22C)-(-2C)
= 990.24 W

Part II
Summary of Radiation and Radiative Heat Transfer

Heat is transferred from one place to another through conduction, convection, or radiation. However, radiation is the only method of heat transfer that does not rely on any contact between the heat source and the heated object. Radiation is the emission or transmission of energy in the form of waves or particles.

Thermal radiation is electromagnetic radiation generated by thermal motion of particles in matter. It is characterized by frequency and wavelength. The frequency and wavelength are inversely proportional, meaning the shorter the wavelength, the higher the frequency. And the longer the wavelength, the lower the frequency. All electromagnetic waves, including thermal radiation, travel at the speed of light. A great example is the sun, or solar radiation, which heats our planet Earth. Thermal radiation is the emission of electromagnetic waves from all matter with a temperature greater than absolute zero. As well, thermal radiation is continually emitted from every part of the surface of an object, with a temperature greater than absolute zero.

Any object is capable of radiating heat and absorbing external radiation. Therefore, any two objects in the same space can exchange radiate heat with one another. When two objects have the same temperature, but are in equilibrium, radiation transfer still exists. From this comes the notion of the Blackbody, or any object that emits radiation, but does not reflect electromagnetic waves.

The electromagnetic waves of the blackbody is different for each band, making it so there is a spectral distribution. The spectral distribution is related to the temperature and the nature of the object itself. Therefore, a blackbody emits the maximum amount of radiation at a given temperature, absorbing all incident radiation, regardless of wavelength or direction. The blackbody, as an ideal object, is defined as the standard object of study for thermal radiation.

Emissive power is when the space above the surface intercepts the radiation being emitted from the surface. Emissive power also depends on the wavelength and the temperature, with the intensity depending on the direction of the radiation emitted from the surface.
In order to calculate the radiation heat transfer between surfaces, it is necessary to find the total radiation energy emitted and reflected.