WEEK 4 YANG DICHENG

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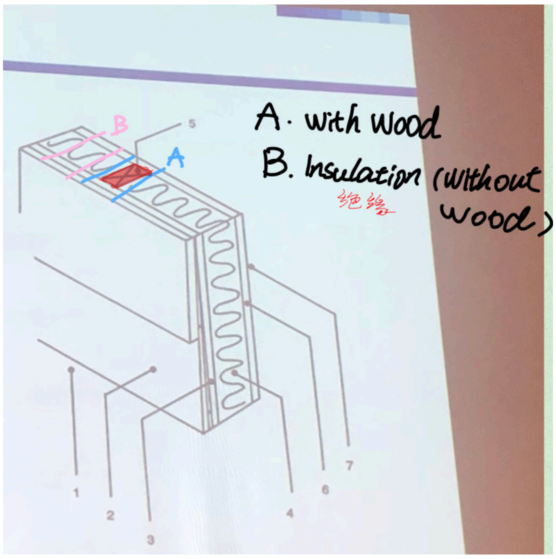

Determine the overall unit thermal resistance (the R value) of a wood frame wall that is built around 38-mm 90-mm wood studs with a center-to-center distance of 400 mm. The 90-mm-wide cavity between the studs is filled with urethane rigid insulation. The inside is finished with 13-mm gypsum wallboard 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. Also, determine the rate of heat loss through the walls of a house whose perimeter is 50 m and wall height is 2.5 m in Las Vegas, Nevada, whose winter design temperature is -2 C. Take the indoor design temperature to be 22 C and assume 20 percent of the wall area is occupied by glazing (glass) (Wall without glass 80%).

Unit Thermal Resistances

$R' = R \times A$ $R = R' \cdot A$

Unit thermal resistance (the *R*-value) of common components used in buildings

R

Component	R-Value $m^2 \cdot °C/W$	R-Value $ft^2 \cdot h \cdot °F/Btu$
Outside surface (winter)	0.030	0.17
Outside surface (summer)	0.044	0.25
Inside surface, still air	0.12	0.68
Plane air space, vertical, ordinary surfaces ($\varepsilon_{eff} = 0.82$):		
13 mm ($\frac{1}{2}$ in)	0.16	0.90
20 mm ($\frac{3}{4}$ in)	0.17	0.94
40 mm (1.5 in)	0.16	0.90
90 mm (3.5 in)	0.16	0.91
Insulation, 25 mm (1 in)		
Glass fiber	0.70	4.00
Mineral fiber batt	0.66	3.73
Urethane rigid foam	0.98	5.56
Stucco, 25 mm (1 in)	0.037	0.21
Face brick, 100 mm (4 in)	0.075	0.43
Common brick, 100 mm (4 in)	0.12	0.79
Steel siding	0.00	0.00
Slag, 13 mm ($\frac{1}{2}$ in)	0.067	0.38
Wood, 25 mm (1 in)	0.22	1.25
Wood stud, nominal 2 in × 4 in (3.5 in or 90 mm wide)	0.63	3.58

Component	R-Value $m^2 \cdot °C/W$	R-Value $ft^2 \cdot h \cdot °F/Btu$
Wood stud, nominal 2 in × 6 in (5.5 in or 140 mm wide)	0.98	5.56
Clay tile, 100 mm (4 in)	0.18	1.01
Acoustic tile	0.32	1.79
Asphalt shingle roofing	0.077	0.44
Building paper	0.011	0.06
Concrete block, 100 mm (4 in):		
Lightweight	0.27	1.51
Heavyweight	0.13	0.71
Plaster or gypsum board, 13 mm ($\frac{1}{2}$ in)	0.079	0.45
Wood fiberboard, 13 mm ($\frac{1}{2}$ in)	0.23	1.31
Plywood, 13 mm ($\frac{1}{2}$ in)	0.11	0.62
Concrete, 200 mm (8 in)		
Lightweight	1.17	6.67
Heavyweight	0.12	0.67
Cement mortar, 13 mm (1/2 in)	0.018	0.10
Wood bevel lapped siding, 13 mm × 200 mm (1/2 in × 8 in)	0.14	0.81

Thought the Fourm of Unit Thermal Resistance

	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)	/	3.528
Wood Studs(90mm)	0.63	No
Gypsum Borad(13mm)	0.079	0.079
Inside Surface	0.12	0.12

$R'\_withwood$ =0.03+0.14+0.11+0.63+0.079+0.12=1.109 $m^2 ℃/W$
$R'\_withins$ =0.03+0.14+0.11+3.528+0.079+0.12=4.007 $m^2 ℃/W$

$$R'_{tot} = R * A$$

R' .

$$R = \frac{R_{tot}}{A}$$

$$R_{unit} = \frac{1}{U}$$

$$U = \frac{1}{R_{unit}}$$

$$\frac{1}{R_{tot}} = \frac{1}{R_{ins}} + \frac{1}{R_{wood}} \quad -\to \quad \frac{A_{tot}}{R'_{tot}} = \frac{A_{ins}}{R'_{ins}} + \frac{A_{wood}}{R'_{wood}}$$

$$U_{tot} * A_{tot} = U_{ins} * A_{ins} + U_{wood} * A_{wood}$$

$$U_{tot} = \frac{A_{wood}}{A_{tot}} * U_{wood} + \frac{A_{ins}}{A_{tot}} * U_{ins}$$

$$U_{tot} = 25\% * U_{wood} + 75\% * U_{ins} \quad (Proportion\ of\ Areas)$$

$$U_{tot} = 0.25 * \frac{1}{R'_{wood}} + 0.75 * \frac{1}{R'_{ins}} = 0.25 * 0.7252 + 0.75 * 0.2496$$

$$U_{tot} = 0.3685\ \ m^2\,°C/W$$

$$A_{tot} = 50 * 2.5 * 80\% \ (\ 80\%\ wall\ without\ glass) = 100\ m^2$$
$$\Delta T = 22 - (-2) = 24$$

$$\dot{Q}_{tot} = U_{tot} * A_{tot} * \Delta T = 884.4W$$

THE RADIATION AND THE RADIATIVE HEAT TRANSFER

Hermal radiation, the phenomenon of electromagnetic waves radiated by an object due to its temperature. One of the three ways that heat is transferred. Any object whose temperature is higher than absolute zero produces heat radiation. The higher the temperature, the greater the total energy emitted, and the more short-wave components there are. The spectrum of thermal radiation is a continuous spectrum, and the wavelength coverage range can theoretically be from 0 to infinity. Because electromagnetic waves travel without any medium, thermal radiation is the only way to transfer heat in a vacuum.

As a body radiates outward, it absorbs energy from other bodies. The amount of energy an object radiates or absorbs depends on its temperature, surface area, and blackness. But at thermal equilibrium, the ratio of lambda-r（λ，T） to its spectral absorptivity-a（λ，T） is only a function of the wavelength and temperature of the radiation, not its actual nature.

$$V = \frac{c}{\lambda}$$

Higher is the wave frequency value, smaller its wavelength is, so the speed of light is constant for every electromagnetic radiation in a vacuum.

Light waves, usually visible light in the electromagnetic spectrum. Visible light usually refers to electromagnetic wave whose frequency range is 3.9×1014~7.5×1014Hz, and the wavelength in vacuum is about 400~760nm. The speed of light propagation in vacuum is c=3×108m/s, which is the fastest speed of matter movement in nature. Light waves are shear waves in which electric field intensity E and magnetic induction intensity B (or magnetic field intensity H) are perpendicular to each other and to the direction of propagation.

The so-called absolute black body, is refers to such an object, it can at any temperature any wavelength of radiation to its surface energy absorbed.