WEEK 4

2019年10月29日　　19:10

QUESTIONS

Task 1: you should complete the modified example of simplified wall calculations that you went through in the assignment of week 3 and find the total heat transfer through wall

Task 2: In 2 pages you shoudl write a summary (in your own word!, in your own words !!) of what you have learnt in this session about radiation and radiative heat transfer

ANSWER

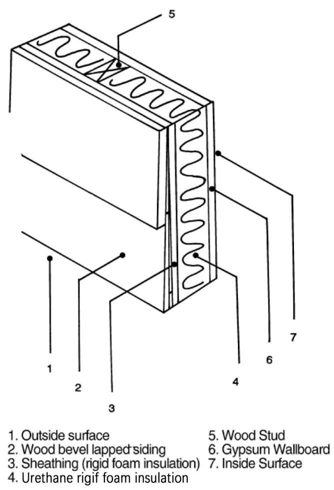
1. **Simplified wall calculation**

- Determine the overall unit thermal resistance (the R-value) and the overall heat transfer coefficient (the U-factor)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 rigif 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.
- 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.

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

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



	Wood stud	Insulation
Outside air	0.03	0.03
Wood bevel lapped siding	0.14	0.14
Plywood (13mm)	0.11	0.11
Urethane rigif foam insulation (90mm)	/	0.98*90/25=3.528
Wood studs (38-mm 90-mm)	0.63	/
Gypsum wallboard (13mm)	0.079	0.079
Inside surface	0.12	0.12

$$R'_{withwood} = 0.03 + 0.14 + 0.11 + 0.63 + 0.079 + 0.12 = 1.109° C/W$$

$R'_{withinsulation} = 0.03 + 0.14 + 0.11 + 3.528 + 0.079 + 0.12 = 4.007° \, C/W$

*R' is overall unit thermal resistance, R' =R*A*

$\because \frac{1}{R_{total}} = \frac{1}{R_{wood}} + \frac{1}{R_{ins}}$

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

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

$= \frac{1}{1.109} * 25\% + \frac{1}{4.007} * 75\%$

$= 0.902 * 0.25 + 0.250 * 0.75 \approx 0.413 \, W/(°C * m^2)$

$\dot{Q}_{total} = U * A_s * (T_i - T_o) = 0.413 * 50 * 2.5 * 80\% * 24 = 991.2 \, W$

2. Summary of radiation and radiative transfer

Definition

- Radiation is a method of heat transfer that does not rely upon any contact between the heat source and the heated object. For example, we feel heat from the sun even though we are not touching it. Heat can be transmitted though empty space by thermal radiation. Thermal radiation is a type electromagnetic radiation (or light). Radiation is a form of energy transport consisting of electromagnetic waves traveling at the speed of light. No mass is exchanged and no medium is required.
- 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. Energy that is absorbed by an atom causes its electrons to "jump" up to higher energy levels. 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 falls.

classification

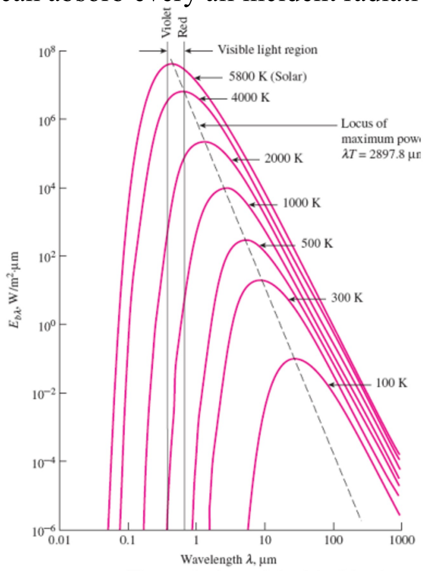
- Infrared region → λ: *0.76~100μm*
- Ultraviolet rays → λ: *0.01~0.40μm* → which kills people, needed to avoid.

Blackbody

- A blackbody is an emitter and also an absorber which can absorb every all incident radiative energy.
- The emissive power of blackbody :

$E_b(T) = \sigma T^4$

a. In a specific zone of wavelength, the emittive power increase rapidly at first, after a high point, it dicreases to zero.
b. Under the same wavelength, higher the temperature, higher the emitted power, until the wavelength arrives to a certain number, the emitted power stays zero.



The variation of the blackbody emissive power with wavelength for several temperatures.