Week3 Assignment

Question1：

A 3m high and 5m wide wall consists of long 16cm 22cm cross section horizontal bricks（k=0.72W/m •℃）separated by 3cm thick plaster layers（k=0.22W/m •℃）.There are also 2cm thick plaster layer on each side of the brick and a 3-cm-thick rigid foam （ k=0.026W/m • ℃ ） on the inner side of the wall. The indoor and outdoor temperatures are 20℃ and 10℃, and the convection heat transfer coefficients on the inner and outer sides are h1=10W/㎡ • ℃ and h2=40W/㎡ • ℃, respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.

Answer：

$$R_{\text{wall.}Total} = 6.81(°C/W)$$

$$\dot{Q} = \frac{T_{\infty 1} - T_{\infty 2}}{\mathrm{R}_{\text{wall.total}}} = \frac{40-10}{6.81} \approx 4.4053(\mathrm{W})$$

Question2:

While the thickness of the brick is increased to 32cm, determine the rate of heat transfer through the wall and comment on the results.

Answer：

$$R_{conv.1} = \frac{1}{h_1 A} = \frac{1}{10 \times 0.25} = 0.4(°C/W)$$

$$R_{\text{foam}} = \frac{L_{foam}}{\mathrm{k}_{\text{foam}} A} = \frac{0.03}{0.026 \times 0.25} \approx 4.6154(°C/W)$$

$$R_{\text{plaster, left}} = R_{\text{plaster, right}} = \frac{L_{\text{plaster}}}{\mathrm{k}_{\text{plaster}} A} = \frac{0.02}{0.22 \times 0.25} \approx 0.3636(°C/W)$$

$$R_{\text{plaster, up}} = R_{\text{plaster, down}} = \frac{L_{\text{plaster}}}{\mathrm{k}_{\text{plaster}} A} = \frac{0.32}{0.22 \times 0.015} \approx 96.9697(°C/W)$$

$$R_{\text{brick}} = \frac{L_{\text{brick}}}{\mathrm{k}_{\text{brick}} A} = \frac{0.32}{0.72 \times 0.22} \approx 2.0202(°C/W)$$

$$\frac{1}{R_{\text{Total}}} = \frac{1}{R_{\text{plaster.up}}} + \frac{1}{R_{brick}} + \frac{1}{R_{\text{plaster.}down}} = \frac{1}{96.9697} + \frac{1}{2.0202} + \frac{1}{96.9697} \approx 0.5156(°C/W)$$

$$R_{\text{Total}} = \frac{1}{0.5156} \approx 1.9395(°C/W)$$

$$R_{conv.2} = \frac{1}{h_2 A} = \frac{1}{40 \times 0.25} = 0.1(°C/W)$$

$$R_{\text{wall}.Total} = R_{conv.1} + R_{foam} + R_{plaster.left} + R_{Total} + R_{plaster.right} + R_{conv.2} = 0.4 + 4.6154 + 0.3636 + 1.9395 + 0.3636 + 0.1 = 7.7821(°C/W)$$

$$\dot{Q} = \frac{T_{\infty 1} - T_{\infty 2}}{\mathrm{R}_{\text{wall.total}}} = \frac{40 - 10}{7.7821} \approx 3.855(\mathrm{W})$$

Comparing the two results of the heat transfer, we can find that increase the thickness of the brick, the heat transfer changes a little. So the thick of the brick is not a very important factor affecting the rate of heat transfer.

Question3:

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 rigid foam. 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. You should solve again the simplified wall calculation procedure and find the two R-unit values.

Answer：

Wood:		**Insulation:**	
Outside Surface :	0.03	Outside Surface:	0.03
Wood Bevel:	0.14	Wood Bevel:	0.14
Plywood:	0.11	Plywood:	0.11
Urethane Rigid Foam:	No	Urethane Rigid Foam:	0.98*90/25=3.528
Wood Studs:	0.63	Wood Studs:	No
Gypsum Wallboard:	0.079	Gypsum Wallboard:	0.079
Inside Surface:	0.12	Inside Surface:	0.12

$$R_{\text{wood.unit}} = 0.03 + 0.14 + 0.11 + 0.63 + 0.079 + 0.12 = 1.109(°C/W)$$

$$R_{\text{insulation.unit}} = 0.03 + 0.14 + 0.11 + 3.528 + 0.079 + 0.12 = 4.007(°C/W)$$