

Week assignment 3

Question 1.

3 meter high and 5 meter wide wall consists of long 32cm x 22cm cross section horizontal brick ($k=0.72 \text{ W/m} \cdot ^\circ\text{C}$) separated by 3cm thick plastic layers ($k=0.22 \text{ W/m} \cdot ^\circ\text{C}$). Thickness of plaster layers on the each side of brick are 2cm and 3cm-thick rigid foam ($k=0.026 \text{ W/m} \cdot ^\circ\text{C}$) standing by the wall. Indoor temperature is 20°C and outdoor temperature is -10°C . Amount of convention heat transfer on the inner and the outer sides are $h_1= 10 \text{ W/m}^2 \cdot ^\circ\text{C}$ and $h_2= 40 \text{ W/m}^2 \cdot ^\circ\text{C}$. L_{foam} . Determine resistances and the rate of heat transfer through the wall.

Solution:

$$R_{\text{con1}} = \frac{1}{h_1 \times A_1} = \frac{1}{10 \frac{\text{W}}{\text{m}^2 \cdot ^\circ\text{C}} \times 0.25\text{m} \times 1\text{m}} = 0.4 \frac{^\circ\text{C}}{\text{W}}$$

$$R_{\text{foam}} = \frac{L_f}{k_f \times A_1} = \frac{0.03\text{m}}{0.026 \frac{\text{W}}{\text{m} \cdot ^\circ\text{C}} \times 0.25\text{m} \times 1\text{m}} = 4.61 \frac{^\circ\text{C}}{\text{W}}$$

$$R_{\text{plaster.up}} = R_{\text{plaster.down}} = \frac{L_{p1}}{k_p \times A_p} = \frac{0.032\text{m}}{0.22 \frac{\text{W}}{\text{m} \cdot ^\circ\text{C}} \times 0.015\text{m} \times 1\text{m}} = 96.97 \frac{^\circ\text{C}}{\text{W}}$$

$$R_{\text{brick}} = \frac{L_b}{k_b \times A_b} = \frac{0.032\text{m}}{0.72 \frac{\text{W}}{\text{m} \cdot ^\circ\text{C}} \times 0.22\text{m} \times 1\text{m}} = 2.02 \frac{^\circ\text{C}}{\text{W}}$$

$$\frac{1}{R_{\text{total.paralel}}} = 2 \times \frac{1}{R_{\text{plaster.up/down}}} + \frac{1}{R_b} = 2 \times \frac{1}{96.97 \frac{^\circ\text{C}}{\text{W}}} + \frac{1}{2.02 \frac{^\circ\text{C}}{\text{W}}}$$

$$\frac{1}{R_{\text{total.paralel}}} = 0.52 \frac{\text{W}}{^\circ\text{C}}$$

$$R_{\text{total.parallel}} = \frac{1}{0.52 \frac{\text{W}}{^\circ\text{C}}} = 1.93 \frac{^\circ\text{C}}{\text{W}}$$

$$R_{\text{plaster.left}} = R_{\text{plaster.right}} = \frac{L_{p2}}{k_p \times A_1} = \frac{0.02\text{m}}{0.22 \frac{\text{W}}{\text{m} \cdot ^\circ\text{C}} \times 0.25\text{m} \times 1\text{m}} = 0.36 \frac{^\circ\text{C}}{\text{W}}$$

$$1. R_o = \frac{1}{h_2 \times A_1} = \frac{1}{40 \frac{\text{W}}{\text{m}^2 \cdot ^\circ\text{C}} \times 0.25\text{m} \times 1\text{m}} = 0.1 \frac{^\circ\text{C}}{\text{W}}$$

$$R_{\text{wall}} = R_{\text{con}} + R_{\text{foam}} + R_{\text{total.parallel}} + R_{\text{plaster.left}} + R_{\text{plaster.right}} + R_o$$

$$R_{\text{wall}} = 0.4 + 4.61 + 1.93 + 0.36 + 0.36 + 0.1 = 7.76 \frac{^\circ\text{C}}{\text{W}}$$

Heat transfer

$$\dot{Q} = \frac{T_1 - T_\infty}{R_{wall}} = \frac{20^\circ\text{C} - (-10^\circ\text{C})}{7.76^\circ\text{C}/\text{W}} = 3.866 \text{ W}$$

When we consider situation of 16cm brick and compare that answer with results of 32cm brick, we can see that brick-thickness duplication inside the composite wall doesn't make big difference. Wall thermal-resistance doesn't get increased significantly and wall heat-transfer rate doesn't decrease much. We can conclude from this informations:

$$\begin{aligned} 1. R_{wall.32\text{cm}} &= 0.4 + 4.61 + 1.93 + 0.36 + 0.36 + 0.1 = 7.76 \frac{^\circ\text{C}}{\text{W}} \\ R_{wall.16} &= 6.81 \frac{^\circ\text{C}}{\text{W}} \\ 2. \dot{Q}_{32\text{cm}} &= \frac{T_1 - T_\infty}{R_{wall}} = \frac{20^\circ\text{C} - (-10^\circ\text{C})}{7.76^\circ\text{C}/\text{W}} = 3.866 \text{ W} \\ \dot{Q}_{16\text{cm}} &= 4.41 \text{ W} \end{aligned}$$

Task 2

A wood frame wall that is bulid 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 foad insulation. The inside is finished with 13-mm gypsum wallboard and the outside with 13-mm polywood and 13 mm 200mm wood bevel lapped siding. The insulated cavity constitutes 75 percent of the heat transimission 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.

- Find the two R_{unit} values.

	Wood	Insulation
Outside air	0.03	0.03
Wood Bevel	0.14	0.14

Urethane Rigid Foam	/	$(0.98/25) \times 90 = 3.53$
Polywood	0.11	0.11
Gypsum Board	0.079	0.079
Inside surface	0.12	0.12
Wood Studs	0.63	/

$$1. R'_{\text{wood}} = 0.03 + 0.14 + 0.11 + 0.079 + 0.12 + 0.63 = 1.109 \frac{\text{m}^2 \cdot ^\circ\text{C}}{\text{W}}$$

$$2. R'_{\text{insulation}} = 0.03 + 0.14 + 3.53 + 0.11 + 0.079 + 0.12 = 4.007 \frac{\text{m}^2 \cdot ^\circ\text{C}}{\text{W}}$$