

Week -3

Dariush

Ahrari

A 3 m high and 5 m wide wall consists of long 32 cm 22 cm cross section horizontal bricks ($k = 0.72 \text{ W/m} \cdot ^\circ\text{C}$) separated by 3 cm thick plaster layers ($k = 0.22 \text{ W/m} \cdot ^\circ\text{C}$).

There are also 2 cm thick plaster layers on each side of the brick and a 3-cm-thick rigid foam ($k = 0.026 \text{ W/m} \cdot ^\circ\text{C}$) on the inner side of the wall. The indoor and the outdoor temperatures are 20°C and -10°C , and the convection heat transfer coefficients on the inner and the outer sides are $h_1 = 10 \text{ W/m}^2 \cdot ^\circ\text{C}$ and $h_2 = 40 \text{ W/m}^2 \cdot ^\circ\text{C}$, respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.

$$R_i = \frac{1}{h_1 \times A} = 0.4 \text{ } ^\circ\text{C/W}$$

$$R_f = \frac{L_f}{k_f \times A} = 4.615 \text{ } ^\circ\text{C/W}$$

$$R_{p_{\text{plaster upper}}} = R_{p_{\text{plaster down}}} = \frac{L_{p_{c1}}}{k_p \times A_{p_{c1}}} = \frac{0.03}{0.22 \times 0.015} = 96.97 \text{ } ^\circ\text{C/W}$$

$$R_{\text{brick}} = \frac{L_b}{k_b \times A_b} = \frac{0.32}{0.72 \times 0.22} = 2.02 \text{ } ^\circ\text{C/W}$$

$$\frac{1}{R_{\text{tot parallel}}} = \frac{1}{R_{\text{brick}}} + \frac{1}{R_{p_{\text{plaster upper}}}} + \frac{1}{R_{p_{\text{plaster down}}}} = \frac{1}{2.02} + 2 \times \left(\frac{1}{96.97} \right) = 0.516 \text{ } ^\circ\text{C/W}$$

$$\rightarrow \frac{1}{R_{\text{tot parallel}}} = 0.516 \text{ } ^\circ\text{C/W} \Rightarrow \frac{1}{R_{\text{tot parallel}}} = 0.516 \text{ } ^\circ\text{C/W}$$

$$R_{p_1} = R_{p_2} = \frac{L_{p_1}}{k_p \times A_{p_1}} = \frac{0.02}{(0.22 \times 0.25)} = 0.363 \text{ } ^\circ\text{C/W}$$

$$R_{p_2} = \frac{1}{h_2 \times A} = \frac{1}{40 \times 0.25} = 0.1 \text{ } ^\circ\text{C/W}$$

$$R_{\text{total}} = R_i + R_o + 2 \times R_{p_1} + R_{\text{tot parallel}} + R_{\text{foam}}$$

$$R_{\text{total}} = 7.781 \text{ } ^\circ\text{C/W}$$

$$\dot{Q} = \frac{\Delta T}{R_{\text{Tot}}} = \frac{30}{7.781} = 3,855 \text{ W}$$

Previous question with the same case with the difference of 16 cm bricks had the

$$R_{\text{total}} = 6.81 \text{ }^{\circ}\frac{C}{W}$$

$$\dot{Q} = \frac{\Delta T}{R_{\text{Tot}}} = \frac{30}{6.81} = 4,4052 \text{ W}$$

Comparing these two results will give the outcome that: doubling the brick thickness will not be equal to doubling the thermal resistance.

- 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 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.

	Wood Section	Insulation Section
Outside Air	0.03	0.03
Wood Bevel (13mm*200mm)	0.14	0.14
Plywood (13mm)	0.11	0.11
Urethane Rigid Foam Insulation (90mm)	-	$(90*0.98) / 25 = 3.528$
Wood Studs (90mm)	0.63	-
Gypsum Board (13mm)	0.79	0.79
Inside surface	0.12	0.12

$$R'_{\text{withWood}} = 0.03 + 0.14 + 0.11 + 0.63 + 0.079 + 0.12$$

$$= 1.109 \text{ m}^2 \cdot ^{\circ}\frac{C}{W}$$

$$R'_{\text{withIns}} = 0.03 + 0.14 + 0.11 + 3.528 + 0.079 + 0.12$$

$$= 4.007 \text{ m}^2 \cdot ^{\circ}\frac{C}{W}$$