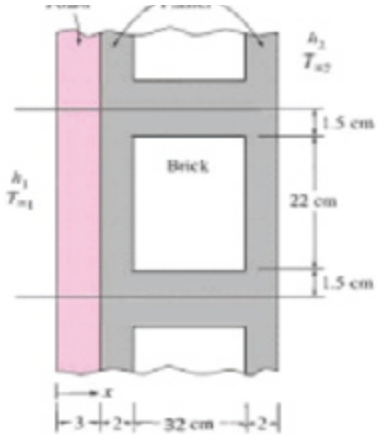
Question1

Heat loss through a composite wall

A 3−m high and 5−m wide wall consists of long 32cm−22cm cross section horizontal bricks(k=0.72 W/m.℃). There are also 3cm thick plaster layers(k=0.22 W/m.℃). There are also 2cm thick plaster layers in each side of the brick and a 3cm thick rigid foam(k=0.026 W/m.℃) on the inner side of the wall. The indoor and the outdoor temperatures are 20 ℃ and 10 ℃ , and the convection heat transfer coefficients on the inner and the outer sides are h1=10 W/ ㎡ .℃ ,and h2=40 W/ · ㎡, respectively. Assuming one−dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.



$$R_{air,1} = \frac{1}{h_{air,1} \times A} = \frac{1}{10 \times (0.015 + 0.22 + 0.015) \times 1} = 0.4°C/w$$

$$R_{foam} = \frac{1}{h_f \times A} = \frac{0.03}{0.026 \times (0.015 + 0.22 + 0.015) \times 1} 4.615°C/w$$

$$R_{plaster,1} = \frac{1}{h_{p1} \times A} = \frac{0.02}{0.22 \times (0.015 + 0.22 + 0.015) \times 1} \approx 0.3636°C/w$$

$$R_{plaster,2} = \frac{1}{h_{p2} \times A} = \frac{0.032}{0.22 \times 0.015 \times 1} \approx 96.9697°C/w$$

$$R_{brick} = \frac{1}{h_b \times A} = \frac{0.32}{0.72 \times 0.22 \times 1} \approx 2.0202°C/w$$

$$R_{air,2} = \frac{1}{h_{air,2} \times A} = \frac{1}{40 \times (0.015 + 0.22 + 0.015) \times 1} = 0.1°C/w$$

$$R_{parallel} = \frac{1}{\frac{1}{R_{p2}} + \frac{1}{R_b} + \frac{1}{R_{p2}}} = \frac{1}{\frac{1}{96.9697} + \frac{1}{2.0202} + \frac{1}{96.9697}} \approx 1.9394°C/w$$

$$R_{total} = R_{air,1} + R_{foam} + R_{plaster,1} + R_{parallel} + R_{plaster,1} + R_{air,2} \approx 7.781($$

$$\dot{Q} = \frac{\Delta T}{R_{total}} = \frac{20 - 10}{7.7816} \approx 1.29W$$

The R_{total} while the thickness of brick in this composite wall is 16mm, $R_{total} \approx$

So, $\dot{Q} = \frac{\Delta T}{R_{total}} = \frac{20-10}{6.8118} \approx 1.47W$

Conclusion:

Only increasing the thickness of the brick in the composite wall can not significantly improve the thermal resistance of the whole wall.

Question2

Determine the overall unit thermal resistance(the R–value) and the overall heat transfer coefficient(the U–factor) of a wall frame wall that is built around 38–mm 90–mm wood studs with a center–to–center distance of 400mm. The 90–mm–wide cavity between the studs is filled with urethane rigif foam. The inside is filled with 13–mm gypsum wallboard and outside with 13–mm plywood and 13–mm 200–mm wood bevel lapped siding. The insulated cavity constitutes 75% heat transmission area while the studs, plates, and sills constitutes 21%. The headers constitutes 4% 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(13mm-200mm)	0.14	0.14
Plywood(13mm)	0.11	0.11
Urethane rigif foam insulation(90mm)	×	$\frac{0.98}{25} \times 90 = 3.528$
Wood studs(90mm)	0.63	×
Gypsum board(13mm)	0.079	0.079
Inside surface	0.12	0.12

$$R_{total,wood} = 0.03 + 0.14 + 0.11 + 0.63 + 0.079 + 0.12 = 1.109°C/w$$
$$R_{total,ins} = 0.03 + 0.14 + 0.11 + 3.528 + 0.079 + 0.12 = 4.007°C/w$$