WEEK 3 YANG DICHENG

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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·°C). There are also 3cm thick plaster layers(k=0.22 W/m·°C). There are also 2cm thick plaster layers in each side of the brick and a 3cm thick rigid foam(k=0.026 W/m·°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 W/m^2·°C and h_2=40 W/m^2·°C, respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.

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

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

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

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

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

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

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

$$R_{total} = R_{air,1} + R_{foam} + R_{plaster,1} + R_{parallel} + R_{plaster,1} + R_{air,2} \approx 7.7816°C\frac{}{w}$$

$$\dot{Q} = \frac{\Delta T}{R_{total}} = \frac{20 - (-10)}{7.7816} \approx 3.855W$$

The R_{total} while the thickness of brick in this composite wall is 16mm, $R_{total} \approx 6.8118°C/w$

So, $\dot{Q} = \frac{\Delta T}{R_{total}} = \frac{20-(-10)}{6.8118} \approx 4.404W$

Conclusion:

The thickness of a brick does NOT significantly affect the total thermal resistance of the composite wall.

The R-value

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)	$\times$	$\frac{0.98}{25} \times 90 = 3.528$
Wood studs(90mm)	0.63	$\times$
Gypsum board(13mm)	0.079	0.079
Inside surface	0.12	0.12

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