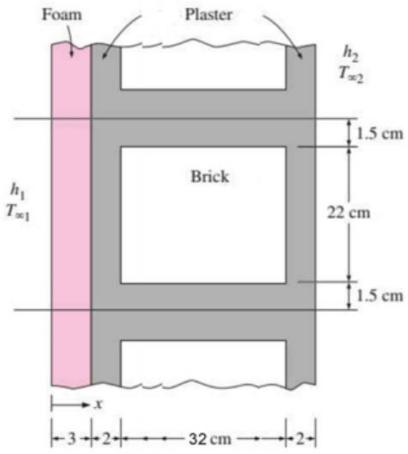
Question1

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 =10 W/ · and =40 W/m²*℃, respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.



$$R_{\mathrm{i}}=\frac{1}{\mathrm{h_i}\times \mathrm{A}}=\frac{1}{10\times 0.25}=0.4℃/W$$

$$R_{\mathrm{f}}=\frac{\mathrm{L_f}}{\mathrm{k_f}\times \mathrm{A}}=\frac{0.03}{0.026\times 0.25}=4.615℃/W$$

$$R_{\mathrm{p1}}=R_{\mathrm{p2}}=\frac{\mathrm{L_{p1}}}{\mathrm{k_p}\times \mathrm{A_{p1}}}=\frac{0.02}{0.22\times 0.25}=0.363℃/W$$

$$R_{\mathrm{o}}=\frac{1}{\mathrm{h_o}\times \mathrm{A}}=\frac{1}{40\times 0.25}=0.1℃/W$$

$$R_{\mathrm{pc1}}=R_{\mathrm{pc2}}=\frac{\mathrm{L_{pc1}}}{\mathrm{k_p}\times \mathrm{A_{pc}}}=\frac{0.32}{0.22\times 0.015}=96.97℃/W$$

$$R_{\mathrm{b}}=\frac{\mathrm{L_b}}{\mathrm{k_b}\times \mathrm{A_b}}=\frac{0.32}{0.72\times 0.22}=2.02℃/W$$

$$\frac{1}{R_{\mathrm{tot}.p}}=\frac{1}{R_b}+\frac{1}{R_{pc1}}+\frac{1}{R_{pc2}}=\frac{1}{2.02}+2\times\frac{1}{96.97}=0.516℃/W$$

$$R_{\mathrm{tot}.p}=\frac{1}{0.516}=1.94℃/W$$

$$R_{total}=R_i+R_f+R_{p1}\times 2+R_o+R_{tot.p}=0.4+4.615+2\times 0.363+0.1+1.94=7.781℃/W$$

$$\dot{Q}=\frac{T_1-T_\infty}{R_{total}}=\frac{20+10}{7.781}=3.856W$$

When the thickness of brick in this composite wall is 16mm: $R_{\mathrm{total}}=6.81℃/W$

$$\dot{Q}=\frac{T_1-T_\infty}{R_{total}}=\frac{20+10}{6.81}=4.405W$$

Conclusion:

Increasing the thickness of the brick in the composite wall has little effect on improving the thermal resistance of the entire 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 I.	0.14	0.14
Plywood(13mm)	0.11	0.11
Urethane Rigid Foam	No	0.98*(90/25)=3.528
Wood Stud	0.63	No
Gypsum Board	0.079	0.079
Inside Surface	0.12	0.12

$$R'_{with.wood} = 0.03 + 0.14 + 0.11 + 0.63 + 0.079 + 0.12 = 1.109 m^2 * ℃/W$$

$$R'_{with.\text{insulation}} = 0.03 + 0.14 + 0.11 + 3.528 + 0.079 + 0.12 = 4.007 m^2 * ℃/W$$