1)Heat loss through a composite wall

A 3 m high and 5 m wide wall consists of long 32 cm 22 cm cross section horizontal bricks (k =0.72 W/m ·°C) separated by 3 cm thick plaster layers (k =0.22 W/m ·°C).There are also 2 cm thick plaster layers on each side of the brick and a 3-cm-thick rigid foam (k0.026 W/m ·°C) on the inner side of the wall. The indoor and the outdoor temperatures are20°C and 10°C, and the convection heat transfer coefficients on the inner and the outer sides areh1=10W/m2 ·°C andh2 =25 W/m2 ·°C, respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.

The answer:

$A = (0.015 + 0.22 + 0.015) * 1 = 0.25m2$

$$R1, conv. = \frac{1}{h1 * A1 - dimen} = \frac{1}{10 * 0.25} = 0.4\ \frac{C}{W}$$

$$Rfoam = \frac{\text{Lfoam}}{Kfoam * A1 - dimen} = \frac{0.03}{0.026 * 0.25} = 4.615 \frac{C}{W}$$

$$Rplaster.up = Rplaster.down = \frac{\text{Lfp. up or down}}{Kp * Ap.up\ or\ down} = \frac{0.32}{0.22 * 0.15 * 1} = 96.97\ \frac{C}{W}$$

$$Rbrick = \frac{\text{Lbrick}}{Kbrick * Abrick} = \frac{0.32}{0.72 * 0.22 * 1} = 2.02\ \frac{C}{W}$$

$$\frac{1}{Rtotal.parallel} = \frac{1}{96.97} + \frac{1}{2.02} + \frac{1}{96.97} = 0.516\ \frac{C}{W}$$

$$R\ total.parallel = \frac{1}{0.516} = 1.94\ \frac{c}{w}$$

$$Rplaster.left = Rplaster.right = \frac{\text{Lp. lft or right}}{Kp * Ap.lt\ or\ rt} = \frac{0.02}{0.22 * 0.25 * 1} = 0.363\ \frac{C}{W}$$

$$R2, conv. = \frac{1}{h2 * A1 - dimen} = \frac{1}{40 * 0.25} = 0.1\ \frac{C}{W}$$

R wall.total =0.4+4.615+0.363+1.94+0.363+0.1=7.781 $\frac{c}{w}$

The rate of heat transfer loss:

$$\dot{Q} = \frac{\text{T1} - \text{T}\infty}{Rwall.total} = \frac{20 - (-10)}{7.781} = 3.86\ W$$

AND

R wall.total =6.81 $\frac{c}{w}$ *Thickness of brick=16 mm*

SO, *the heat transfer rate is:*

$$\dot{Q} = \frac{\text{T1} - \text{T}\infty}{Rwall.total} = \frac{20 - (-10)}{6.81} = 4.41\ W$$

By comparing the two results, we found that: double the thickness of a brick inside a composite wall doesn't significantly increase the thermal resistance of a whole wall, so the rate of heat transfer doesn't significantly decrease.

2. R-values

	A wood	B Insulation
Outside Air	0.03	0.03
Wood Bevel	0.14	0.14
13mm Plywood	0.11	0.11
Urethane Rigid Foam	NA	0.98x(90/25)=3.528
Wood Studs	0.63	NA
Gypsum Board	0.79	0.79
Inside Surface	0.12	0.12

$$R'_{with\ wood} = 0.03 + 0.14 + 0.11 + 0.63 + 0.79 + 0.12 = 1.82\ m^2.\frac{℃}{W}$$

$$R'_{with\ insulation} = 0.03 + 0.14 + 0.11 + 3.528 + 0.79 + 0.12 = 4.718\ m^2.\frac{℃}{W}$$