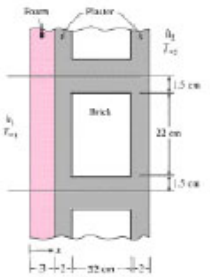
Question1

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 h_1=10 W/m^2·℃ and h_2=40 W/ ·℃,respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.

A=(0.22+0.015+0.015)*1=0.25m^2



R_{air1}=1/(h_{air1}*A)=1/(10*0.25)=0.4℃/W

R_{foam}=L/(h_f*A)=0.03/(0.026*0.25)=4.615℃/W

$R_{plaster1}$=$R_{plaster2}$= L/($k_{plastic}$*A)=0.002/0.25=0.363℃/W

$R_{plaster3}$=$R_{plaster4}$= L/($k_{plastic}$*$A_{plastic}$)=0.32/(0.22*0.015*1)=96.97℃/W

R_{brick}=L/($k_{brick} * A_{brick}$)=0.32/(0.72*0.22*1)=2.02℃/W

1/$R_{parellel}$=1/$R_{plaster3}$+1/$R_{plaster4}$+1/R_{brick} ≈0.516W/℃

$R_{parellel}$=1/0.516≈ 1.94℃/W

R_{air2}=1/(h_{air2}*A)=1/(40*0.25)=0.1℃/W

R_{total}=$R_{air1} + R_{air2} + R_{parellel} + R_{foam}$=7.781℃/W

$\dot{Q}$=($T_1 - T_2$)/ R_{total}=20-(-10)/7.781≈ 3.86W

When the thickness of brick is 16mm, R_{total}=6.81℃/W

In this condition, the heat transfer rate is:

$\dot{Q}$=($T_1 - T_2$)/ R_{total}=20-(-10)/6.81≈ 4.41W

Then, we can have the conclusion:

Increasing the thickness of the brick cannot decrease the rate heat transfer, because the thermal resistance increases also.

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 plywoodand 13-mm and 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 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(90mm)	NO	0.98/25*90=3.528
Wood studs(90mm)	0.63	NO
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℃/W

$R_{total,ins}$=0.03+0.14+0.11+3.528+0.079+0.12=4.007℃/W