# WEEK 3

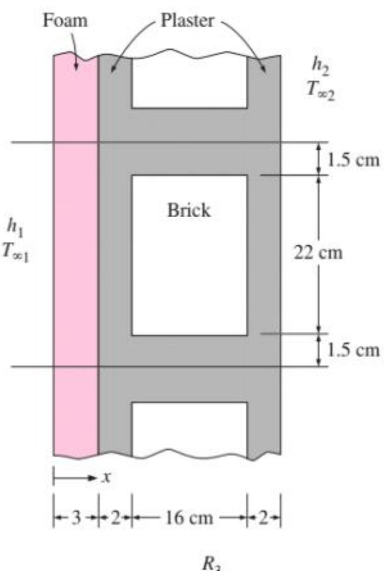
Tuesday, October 22, 2019 6:14 PM

In this week's assignment you should

1. finalize the composite wall question by finding the heat transfer rate,
2. and then solve the same question while the thickness of the brick is increased to 32 cm and comment on the results
3. You should solve again the simplified wall calculation procedure replacing the glass fiber one with urethane rigif foam and while replacing the fiberboard with plywood and find the two R_unit values

## QUESTION 1

A 3 m high and 5 m wide wall consists of long 16 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 (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 h1=10 W/m2 · °C and h2 =40 W/m2 · °C, respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.




## ANSWER 1

We should first calculate the total resistance;

$$R_{total} = R_i + R_{foam} + R_{tot_{parallel}} + 2 * R_{P_1} + R_o$$

$$R_i = \frac{1}{h_i \times A} = \frac{1}{10 * 0.25} = 0.4\ °C/W$$

$$R_{foam} = \frac{L_f}{k_f \times A} = \frac{0.03}{0.026 * 0.25} = 4.615\ °C/W$$

$$\frac{1}{R_{tot_{parallel}}} = \frac{1}{R_b} + \frac{1}{R_{p_{c_1}}} + \frac{1}{R_{p_{c_2}}}$$

$$R_{p_{c_1}} = R_{p_{c_2}} = \frac{L_{p_{c_1}}}{k_p \times A_{p_{c_1}}} = \frac{0.16}{0.22 * 0.015} = 48.48\ °C/W$$

$$R_b = \frac{L_b}{k_b \times A_b} = \frac{0.16}{0.72 * 0.22} = 1.01\ °C/W$$

$$\frac{1}{R_{tot_{parallel}}} = \frac{1}{R_b} + \frac{1}{R_{p_{c_1}}} + \frac{1}{R_{p_{c_2}}} = \frac{1}{1.01} + 2 * \left(\frac{1}{48.48}\right) = 1.03\ °C/W$$

$$\rightarrow \frac{1}{R_{tot_{parallel}}} = 1.03\ W/°C \longrightarrow R_{tot_{parallel}} = \frac{1}{1.03} = 0.97°C/W$$

$$R_{P_1} = R_{P_2} = \frac{L_{p_1}}{k_p \times A_{p_1}} = \frac{0.02}{(0.22*0.25)} = 0.363\ °C/W$$

$$R_o = \frac{1}{h_0 \times A} = \frac{1}{40 * 0.25} = 0.1\ °C/W$$

$$R_{total} = R_i + R_{foam} + R_{tot_{parallel}} + 2 * R_{P_1} + R_o$$

0.4 + 4.615 + 0.97 + 2*0.363 + 0.1 = $6.81\ °C/W$

$$\dot{Q} = \frac{\Delta T}{R_{Tot}} = \frac{30}{6.81} = 4.405\ W$$

QUESTION 2

solve the same question while the thickness of the brick is increased to 32 cm and comment on the results.

ANSWER 2

$$R_b = \frac{L_b}{k_b \times A_b} = \frac{0.32}{0.72 * 0.22} = 2.02\ °C/W$$

$$\frac{1}{R_{tot_{parallel}}} = \frac{1}{R_b} + \frac{1}{R_{p_{c_1}}} + \frac{1}{R_{p_{c_2}}} = \frac{1}{2.02} + 2 * \left(\frac{1}{48.48}\right) = 0.536\ °C/W$$

$$\rightarrow \frac{1}{R_{tot_{parallel}}} = 0.536\ W/°C \longrightarrow R_{tot_{parallel}} = \frac{1}{0.536} = 1.86\ °C/W$$

$$R_{total} = R_i + R_{foam} + R_{tot_{parallel}} + 2 * R_{P_1} + R_o$$

0.4 + 4.615 + 1.86 + 2*0.363 + 0.1 = $7.701\ °C/W$

$$\dot{Q} = \frac{\Delta T}{R_{Tot}} = \frac{30}{7.701} = 3.895\ W$$

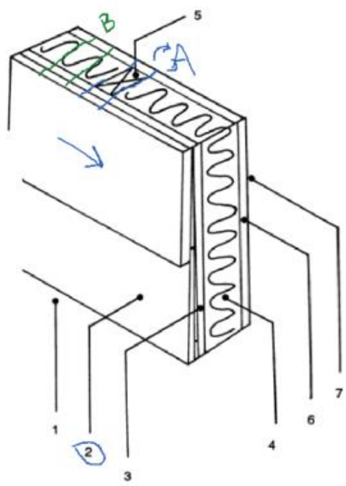
In conclusion even if we use twice time thickness brick inside of the composite wall There is not significant change in the thermal resistance of the wall, and the rate of heat transfer.

QUESTION 3

You should solve again the simplified wall calculation procedure replacing the glass fiber one with urethane rigif foam and while replacing the fiberboard with plywood and find the two R_unit values

Determine the overall unit thermal resistance (the *R*-value) and the overall heat transfer coefficient (the *U*-factor) of a wood frame wall that is built around 38-mm 90-mm wood studs with a center-to-centre distance of 400 mm. The 90-mm-wide cavity between the studs is filled with urethane rigid foam insulation. The inside is finished with 13-mm gypsum wallboard and the outside with 13 mm plywood and 13-mm 200-mm wood bevel lapped siding. The insulated cavity constitutes 75 percent of the heat transmission area while the studs, plates, and sills constitute 21 percent. The headers constitute 4 percent of the area, and they can be treated as studs.
Also, determine the rate of heat loss through the walls of a house whose perimeter is 50 m and wall height is 2.5 m in Las Vegas, Nevada, whose winter design temperature is -2 C. Take the indoor design temperature to be 22 C and assume 20 percent of the wall area is occupied by glazing.

| | Wood | Insulation |
|---|---|---|
| Outside Air | 0.03 | 0.03 |
| Wood bevel l. | 0.14 | 0.14 |
| Plywood (13mm) | 0.11 | 0.11 |
| Urethane rigif foam | No | 0.98*90/25=3.52 |
| Wood studs | 0.63 | No |
| Gypsum board | 0.079 | 0.079 |
| Inside surface | 0.12 | 0.12 |




$R'_{withWood}$ = 0.03 + 0.14 + 0.11 + 0.63 + 0.079 + 0.12
= 1.109 $m^2.\ °C/W$

$R'_{withIns}$ = 0.03 + 0.14 + 0.11 + 3.52 + 0.079 + 0.12
= 3.999 $m^2.\ °C/W$