ASSIGMENT 3 (WEEK 3)

1. Three meter high and five meter wide wall consists of long 32cm x 22cm cross section horizontal brick (k=0.72 W/m · °C) separated by 3cm thick plastic layers (k=0.22 W/m · °C). Thickness of plaster layers on each side of brick are 2cm and 3cm-thick rigid foam (k=0.026 W/m · °C) standing by the wall. Indoor temperature is 20°C and outdoor temperature is -10°C. Amount of convention heat transfer on the inner and the outer sides are $h_1$= 10 W/m$^2$ · °C and $h_2$= 40 W/m$^2$ · °C. $L_{foam}$

Question 1:

Determine resistances and the rate of heat transfer through the wall.

Solution:

1. $R_i = \frac{1}{h1 \text{ x } A1} = \frac{1}{10\,\frac{W}{m2\cdot °C} \text{ x } 0.25m \text{ x } 1m} = 0{,}4\,\frac{°C}{W}$
2. $R_f = \frac{Lf}{kf \text{ x } A1} = \frac{0.03m}{0.026\,\frac{W}{m\cdot °C} \text{ x } 0.25m \text{ x } 1m} = 4{,}61\,\frac{°C}{W}$
3. $R_{plaster.up} = R_{plaster.down} = \frac{Lp1}{kp \text{ x } Ap} = \frac{0.32m}{0.22\frac{W}{m\cdot °C} \text{ x } 0.015m \text{ x } 1m} = 96.97\,\frac{°C}{W}$

   $Rb = \frac{Lb}{kb \text{ x } Ab} = \frac{0.32m}{0.72\,\frac{W}{m\cdot °C} \text{ x } 0.22m \text{ x } 1m} = 2.02\,\frac{°C}{W}$

   $\frac{1}{Rtotal.paralel} = 2 \text{ x } \frac{1}{Rplaster.up/down} + \frac{1}{Rb} = 2 \text{ x } \frac{1}{96.97\,\frac{°C}{W}} + \frac{1}{2.02\,\frac{°C}{W}}$

   $\frac{1}{Rtotal.paralel} = 0.52\,\frac{W}{°C}$

   $R_{total\ parallel} = \frac{1}{0.52\,\frac{W}{°C}} = 1.93\,\frac{°C}{W}$

4. $R_{plaster\ left} = R_{plaster\ right} = \frac{Lp2}{kp \text{ x } A1} = \frac{0.02m}{0.22\frac{W}{m\cdot °C} \text{ x } 0.25m \text{ x } 1m} = 0.36\,\frac{°C}{W}$
5. $R_o = \frac{1}{h2 \text{ x } A1} = \frac{1}{40\,\frac{W}{m2\cdot °C} \text{ x } 0.25m \text{ x } 1m} = 0.1\,\frac{°C}{W}$

   $R_{wall} = R_i + R_f + R_{total.parallel} + R_{plaster.left} + R_{plaster.right} + R_o$

   $R_{wall} = 0.4+4.61+1.93+0.36+0.36+0.1 = 7.76\,\frac{°C}{W}$

Final answer:

**Heat transfer** is $\dot{\mathbf{Q}} = \frac{T1-T\infty}{Rwall} = \frac{20°C-(-10°C)}{7.76\ °C/W}$ = **3.866 W**

If we look at the situation of 16cm brick and compare the results with 32cm brick, we can conclude that brick thickness inside the composite wall doesn't make big difference. Wall thermal resistance doesn't get increased significantly and wall heat transfer rate doesn't decrease much. We found that by these calculations:

1. $R_{wall.32cm} = 0.4+4.61+1.93+0.36+0.36+0.1 = 7.76\ \frac{°C}{W}$

   $R_{wall.16} = 6.81\ \frac{°C}{W}$

2. $\dot{Q}_{32cm} = \frac{T1-T\infty}{Rwall} = \frac{20°C-(-10°C)}{7.76\ °C/W} = 3.866$ W

   $\dot{Q}_{16cm} = 4.41$ W

2. A wood frame wall that is built around 38-mm 90-mm wood studs with a center to center 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 200mm wood bevel lapped siding. The insulted 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.

Question 1:

Find the two $\mathbf{R_{unit}}$ values.

Solution:

| | **Wood** | **Insulation** |
|---|---|---|
| Outside air | 0.03 | 0.03 |
| Wood bevel | 0.14 | 0.14 |
| Urethane rigid foam | / | (0.98/25)x90 = 3.53 |
| Plywood | 0.11 | 0.11 |
| Gypsum board | 0.079 | 0.079 |
| Inside surface | 0.12 | 0.12 |
| Wood studs | 0.63 | / |

1. $R'_{wood} = 0.03+0.14+0.11+0.079+0.12+0.63 = 1.11\ \frac{m2 \cdot °C}{W}$
2. $R'_{insulation} = 0.03+0.14+3.53+0.11+0.079+0.12 = 4.01\ \frac{m2 \cdot °C}{W}$