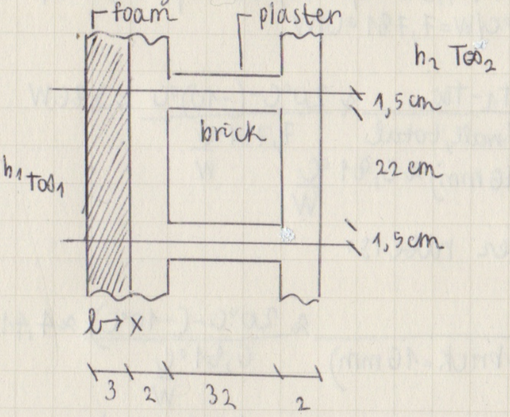
Assignment week 3 _ Aiuti Francesca

23/10/19

Question 1: Heat loss through a composite wall.

A 3m high and 5m wide wall consists of long 32 cm and 22 cm cross section horizontal bricks ($K = 0{,}72\ W/m°C$), separated by 3cm 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 $h_1 = 10\ W/m^2 \cdot °C$ and $h_2 = 40\ W/m^2 \cdot °C$, respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.



$$R_{1conv.} = \frac{1}{h_1 \cdot A_{1-dim.}} = \frac{1}{10\ \frac{W}{\cancel{m^2}°C} \cdot (0{,}015 + 0{,}22 + 0{,}015)\cancel{m} \cdot 1\cancel{m}} = 0{,}4\ °C/W$$

$$R_{foam} = \frac{L_{foam}}{K_{foam} \cdot A_{1-dim.}} = \frac{0{,}03\ \cancel{m}}{0{,}026\ \frac{W}{\cancel{m}°C} \cdot (0{,}015 + 0{,}22 + 0{,}015)\cancel{m} \cdot 1\cancel{m}} \cong 4{,}615\ \frac{°C}{W}$$

$$R_{plaster.up} = R_{plaster,down} = \frac{L_{p\,up\ or\ down}}{k_p \cdot A_{p.up\ or\ down}(1\text{-dim.})} = \frac{0{,}32m}{0{,}22\ \frac{W}{m°C} \cdot 0{,}015m \cdot 1m} \approx 96{,}97\ \frac{°C}{W}$$

$$R_{brick} = \frac{L_{brick}}{K_{brick} \cdot A_{brick}(1\text{-dim.})} = \frac{0{,}32m}{0{,}72\ \frac{W}{m°C} \cdot 0{,}22m \cdot 1m} \approx 2{,}02\ \frac{°C}{W}$$

$$\frac{1}{R_{total-parallel}} = \frac{1}{R_{plaster,up}} + \frac{1}{R_{brick}} + \frac{1}{R_{plaster,down}} \approx \frac{1}{96.97\ \frac{°C}{W}} + \frac{1}{2{,}02\ \frac{°C}{W}} + \frac{1}{96{,}97\ °C/W} \cong 0{,}516\ W/°C$$

i.e., $R_{total\text{-}parallel} = \frac{1}{0{,}516\ W/^\circ C} \approx 1{,}94\ ^\circ C/W$

$R_{plaster.left} = R_{plaster.right} = \frac{L_{p.lt\ or\ rt}}{k_p \cdot A_{p,lt\ or\ rt}(1\text{-dim.})} = \frac{0{,}02\,m}{0{,}022\frac{W}{m^\circ C}\cdot(0{,}015+0{,}22+0{,}015)m\cdot 1m} = 0{,}363\ \frac{^\circ C}{W}$

$R_{2\,conv.} = \frac{1}{h_2 \cdot A_{1\text{-dim.}}} = \frac{1}{40\frac{W}{m^2\,^\circ C}\cdot(0{,}015+0{,}22+0{,}015)m\cdot 1m} = 0{,}1\ \frac{^\circ C}{W}$

$R_{wall,total}(1\text{-dim.}) = R_{1\,conv.} + R_{foam} + R_{plaster.left} + R_{total\text{-}parallel} + R_{plaster.right} + R_{2\,conv.} \approx 0{,}4^\circ C/W + 4{,}615\ ^\circ C/W + 0{,}363\ ^\circ C/W + 1{,}94^\circ C/W + 0{,}363^\circ C/W + 0{,}1^\circ C/W = 7{,}781\ ^\circ C/W$

⇒ The heat transfer rate is : $\dot{Q} = \frac{T_1 - T_\infty}{R_{wall,total}} \approx \frac{20^\circ C-(-10)^\circ C}{7{,}781^\circ \frac{C}{W}} \approx 3{,}86W$

$R_{wall\ total}$ (thickness of the brick = 16 mm) $\approx 6{,}81\ \frac{^\circ C}{W}$

⇒ In this condition, the heat transfer rate is:

$\dot{Q}' = \frac{T_1 - T_\infty}{R_{wall,total}(\text{thickness of the brick} = 16mm)} \approx \frac{20^\circ C-(-10^\circ C)}{6{,}81^\circ \frac{C}{W}} \approx 4{,}41W$

⇒ The conclusion is that the presence of a double brick thickness inside a composite wall doesn't significantly increase the thermal resistance of the whole wall, and the heat transfer rate doesn't significantly decrease.

Question 2 : A wood frame wall that is built around 38/90 mm wood studs with a center-to-center distance of 400mm. the 90 mm wallboard and the outside with 13 mm polywood and 13 mm/200 mm wood bevel lapped siding. The insulated cavity constitutes 75% of the heat transmission area, while the studs, plates and sills constitute 21%. the headers constitute 4% of the area, and they can be treated as studs. Find the Runits values.

	Wood	Insulation
Outside air	0,03	0,03
Wood bevel (13·200mm)	0,14	0,14
Polywood (13mm)	0,11	0,11
Urethane Rigid foam (90mm)	/	0,98·90/25 = 3,528
Wood Studs (90mm)	0,63	/
Gypsum Board (13mm)	0,079	0,079
Inside surface	0,12	0,12

R' with wood $= (0{,}03+0{,}14+0{,}11+0{,}63+0{,}079+0{,}12)\,m^2\,\frac{^\circ C}{W} = 1{,}109\ \frac{m^2\,^\circ C}{W}$

R' with insulation $= (0{,}03+0{,}14+0{,}11+3{,}528+0{,}079+0{,}12) = 4{,}007\ \frac{m^2\,^\circ C}{W}$