Week 3 assigments:

In this week's assignment you should first define the composite wall question by finding the heat transfer rate, and then solve the same question while the thickness of the brick is increased to 32 cm and comment on the results:

- You should solve again the simplified wall calculation procedure replacing the glass fiber one with urethane rigid foam and while replacing the fiberboard with plywood and find the two R_{unit} values

Exercise

Question 1 - *Heat transfer rate through a composite wall*

A 3 m high and 5 m wide wall consists of long 32 cm and 22 cm cross section horizontal brick with k= 0,72 W/m°C, divided by 3 cm of plaster layers with k= 0,22 W/m°C) There are also a layers of plaster on each side of the brick and a 3 cm thick rigid foam on the inner side of the wall with k= 0,026 W/m°C. The indoor and the outdoor temperature are respectively 20 and - 10 degrees and the convection heat transfer coefficients are h_1 = 10 W/m^2 (inner surface) and h_2 = 40 W/m^2 (external surface). Assuming one dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.

$R_{1,conv} = 1/h_1 * A_{1-dim} = 1/10 * (0{,}015 + 0{,}22 + 0{,}015) * 1 = 0{,}4\ °C/W$

$R_{foam} = L_{foam}/K_{brick} * A_{1-dim} = 0{,}03/0{,}026 * (0{,}015 + 0{,}22 + 0{,}015) * 1 = 4{,}615\ °C/W$

$R_{plaster1} = L_{p1}/K_p * A_{p1(1-\dim)} = 0{,}32/0{,}22 * 0{,}015 * 1 = 96{,}97\ °C/W$

$R_{plaster2} = L_{p2}/K_p * A_{p2(1-\dim)} = 0{,}32/0{,}22 * 0{,}015 * 1 = 96{,}97\ °C/W$

$R_{bric} = L_{brick}/K_{brick} * A_{brick(1-\dim)} = 0{,}32/0{,}72 * 0{,}22 * 1 = 2{,}02\ °C/W$

$$1/R_{total-parallel} = 1/R_{plaster1} + 1/R_{brick} + 1/R_{plaster2} = 1/96{,}97 + 1/2{,}02 + 1/96{,}97 = 0{,}516\ W/°C$$

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

$R_{plaster\ left} = R_{plaster\ right} =$
$L_p/k_p * A_{p(1-\dim)} = 0{,}02/0{,}022 * (0{,}015 + 0{,}22 + 0{,}015) * 1 = 0{,}363\ °C/W$

$R_{2,conv} = 1/h_2 * A_{1-dim} = 1/40 * (0{,}015 + 0{,}22 + 0{,}015) * 1 = 0{,}1\ °C/W$

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

$$\dot{Q} = T_1 - T_\infty / R_{wall\ total} = 20 - (-10)/7{,}781 = 3{,}86\ W$$

We have already calculated the $R_{wall\ total}$ with the thickness of the wall like a 16 mm

$R_{wall\ total}$ = 6,81 °C/W

$$\dot{Q} = T_1 - T_\infty / R_{wall\ total} = 20 - (-10)/6{,}81 = 4{,}41\ W$$

Comment

We can see by the two results that there isn't so much difference, in fact there isn't a significantly increase of the thermal resistance of the whole wall between the 16 cm thickness of brick and 32 thickness of brick, so the rate of heat transfer doesn't have a significantly decrease in the wall with a thickness of 32 cm.

Question 2 – *Find the two R_{unit} values*

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 glass fiber insulation. The inside is finished with 13-mm gypsum wallboard and the outside with 13-mm wood fiberboard 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 percent. The headers constitute 4 percent of the area, and they can be treated as studs.

	Wood	Insulation
Outside air	0,03	0,03
Wood bevel (13*200mm)	0,14	0,14
Plywood (13mm)	0,11	0,11
Urethane Rigif Foam (90mm)	X	0,98*90/25=3,528
Wood Studs (90mm)	0,63	X
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)= 1,109 m^2°C/W

$R_{with\ insulation}$ = (0,03+0,14+0,11+3,528+0,079+0,12)= 4,007 m^2°C/W