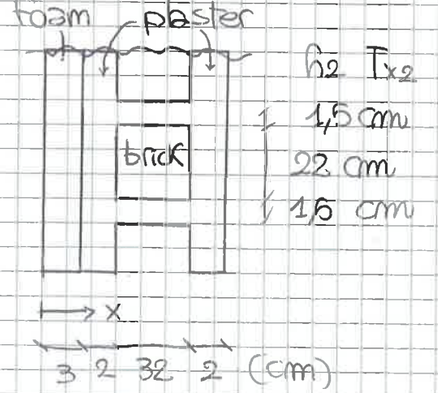
WEEK 3 POTER

Question 1:

Heat loss through a composite wall

A 3 m high and 5 m wide wall consists of long 32 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 26°C and -10°C, and the convection heat transfer coefficients on the inner and the outer sides are $h_1 = 10$ W/m²°C and $h_2 = 40$ W/m²°C, respectively.
Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.



$$R_{1\,conv} = \frac{1}{h_1 \cdot A_{1\text{-dimen}}} = \frac{1}{10\frac{W}{m^2°C}\cdot(0{,}015+0{,}22+0{,}015)m\cdot 1m} =$$

$$= 0{,}4\ \frac{°C}{W}$$

$$R_{Foam} = \frac{L_{Foam}}{K_{Foam}\cdot A_{1\text{-dimen}}} = \frac{0{,}03}{0{,}026\frac{W}{m°C}\cdot(0{,}015\cdot 2+0{,}22)m\cdot 1m} \simeq$$

$$\simeq 4{,}615\ °C/W$$

$$R_{plaster\ up} = R_{plaster\ down} = \frac{L_{up\ or\ dn}}{K_p \cdot A_{up\ or\ dn\ (1\text{-dimen})}} =$$

$$= \frac{0{,}32\ m}{0{,}22\frac{W}{m°C}\cdot 0{,}015\,m\cdot 1m} \simeq 96{,}97\ \frac{°C}{W}$$

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

$$\simeq 2{,}02\ \frac{°C}{W}$$

$$\frac{1}{R_{TOT\text{-}parallel}} = \frac{1}{R_{plaster\ up}} + \frac{1}{R_{brick}} + \frac{1}{R_{plaster\ down}} \simeq$$

$$\simeq \frac{1}{96{,}97\frac{°C}{W}} + \frac{1}{2{,}02\frac{°C}{W}} + \frac{1}{96{,}97\frac{°C}{W}} \simeq 0{,}516\ \frac{W}{°C}$$

$$R_{TOT\text{-}parallel} = \frac{1}{0{,}516\frac{W}{°C}} = 1{,}94\ \frac{°C}{W}$$

$$R_{plaster\ left} = R_{plaster\ right} = \frac{L_{plt\ or\ rt}}{K_p \cdot A_{p\ lt\ or\ rt\ (1\text{-dimen})}} =$$

$$= \frac{0{,}02\ m}{0{,}022\frac{W}{m°C}\cdot(0{,}015\cdot 2+0{,}22)m\cdot 1m} = 0{,}363\ \frac{°C}{W}$$

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

$$R_{wall\text{-}tot\ (1\text{-}dimen)} = R_{1\,conv} + R_{FOAM} + R_{plaster\,left} + R_{TOT\text{-}parallel} + R_{2\,conv} =$$

$$\simeq 0{,}4\ \frac{°C}{W} + 4{,}615\ \frac{°C}{W} + 0{,}363\ \frac{°C}{W} + 1{,}94\ \frac{°C}{W} + 0{,}363\ \frac{°C}{W} +$$

$$+ 0{,}1\ \frac{°C}{W} = 7{,}781\ \frac{°C}{W}$$

The heat transfer rate is:

$$\dot{Q} = \frac{T_1 - T_\infty}{R_{wall,tot}} \simeq \frac{20°C - (-10°C)}{7{,}781\ \frac{°C}{W}} \simeq 3{,}86\ W$$

Considering thickness of brick = 16 cm, it results that:

$$R^*_{TOT\,wall} \simeq 6{,}81\ \frac{°C}{W}$$

$$\dot{Q}' = \frac{T_1 - T_\infty}{R^*_{TOT\,wall}} \simeq \frac{20°C - (-10°C)}{6{,}81\ \frac{°C}{W}} \simeq 4{,}41\ W$$

Increasing the thickness of a brick into a composite wall doesn't increas the thermal resistance of the wall, and the rate of heat transfer doesn't particularly decrease.

QUESTION 2:

A wood frame wall that is build around 38 mm 90 mm wood studs with a center-to-center disance 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 poly wood and 13 mm 200 mm wood Bevel lapped siding. The insulated cavity constitues 75 percent 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 two Runit values

	Wood	Insulation
Outside air	0,03	0,03
Wood Bevel (13 mm · 200 mm)	0,14	0,14
Poly wood (13 mm)	0,11	0,11
Urethane Rig. Foam. In. (90 mm)	No	0,98 · 90/25 = 3,528
Wood Studs (90 mm)	0,63	No
Gypsum Board (13 mm)	0,079	0,079
Inside Surface	0,12	0,12

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

$$= 1{,}109\ \frac{m^2\,°C}{W}$$

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

$$= 4{,}007\ \frac{m^2\,°C}{W}$$