WEEK 3

domenica 15 dicembre 2019 10:31

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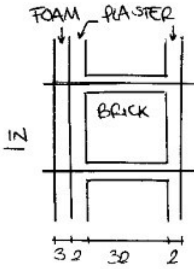
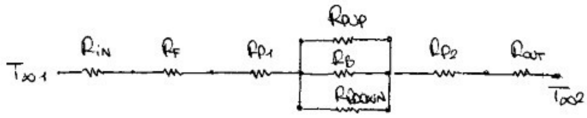
A 3 m high and 5 m wide wall consists of long 32 cm 22 cm cross section horizontal bricks (k = 0.72 W/m°C) separated by 3 cm thick plaster layers (k = 0.22 W/m°C). There are also 2 cm thick plaster layers on each side of the brick and a 3 cm thick rigid foam (k = 0.026 W/m°C) on the inner side of the wall. The indoor and the outdoor temperatures are 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°C and h_2 = 40 W/m^2°C, respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.



$A_{WALL} = 3 \cdot 5 = 15\,m$

WE CONSIDER $A = (0{,}015 + 0{,}22 + 0{,}015) \cdot 1\,m = 0{,}25\,m^2$



$$R_{IN} = \frac{1}{h_1 \cdot A} = \frac{1}{10\,\frac{W}{m^2\,°C} \cdot 0{,}25\,m^2} = 0{,}4\,\frac{°C}{W}$$

$$R_F = \frac{L_F}{K_F \cdot A} = \frac{0{,}03\,m}{0{,}026\,\frac{W}{m\,°C} \cdot 0{,}25\,m^2} = 4{,}62\,\frac{°C}{W}$$

$$R_{P1} = R_{P2} = \frac{L_{P1}}{k_P \cdot A} = \frac{0{,}02\,m}{0{,}22\,\frac{W}{m\,°C} \cdot 0{,}25\,m^2} = 0{,}36\,\frac{°C}{W}$$

$$R_{PUP} = R_{PDOWN} = \frac{L_{PUP}}{k_P \cdot A_{UP}} = \frac{0{,}32\,m}{0{,}22\,\frac{W}{m\,°C} \cdot (0{,}015 \cdot 1)\,m^2} = 96{,}96\,\frac{°C}{W}$$

$$R_{BRICK} = \frac{L_B}{k_B \cdot A_B} = \frac{0{,}32\,m}{0{,}72\,\frac{W}{m\,°C} \cdot (0{,}22 \cdot 1)\,m^2} = 2{,}02\,\frac{°C}{W}$$

IF $L_{BRICK} = 16\,cm$

$R_{PUP/DOWN} = 48{,}48\,\frac{°C}{W}$

$R_{BRICK} = 1{,}01\,\frac{°C}{W}$

$$\frac{1}{R_{TOT\ PARALLEL}} = \frac{1}{R_{PUP}} + \frac{1}{R_B} + \frac{1}{R_{PDOWN}} = \frac{1}{2{,}02} + 2\left(\frac{1}{96{,}96}\right) = 0{,}52\,\frac{W}{°C}$$

$$R_{TOT\ PARALLEL} = \frac{1}{0{,}52\,\frac{W}{°C}} = 1{,}92\,\frac{°C}{W}$$

IF $L_{BRICK} = 16\,cm$

$R_{TOT\ PARALLEL} = 0{,}97\,\frac{°C}{W}$

$$R_{OUT} = \frac{1}{h_2 \cdot A} = \frac{1}{40\,\frac{W}{m^2\,°C} \cdot 0{,}25\,m^2} = 0{,}1\,\frac{°C}{W}$$

$$R_{WALL\ TOTAL} = 0{,}4 + 4{,}62 + 2(0{,}36) + 1{,}92 + 0{,}1 = 7{,}76\,\frac{°C}{W}$$

IF $L_{BRICK} = 16\,cm$

$R_{WALL\ TOTAL} = 6{,}81\,\frac{°C}{W}$

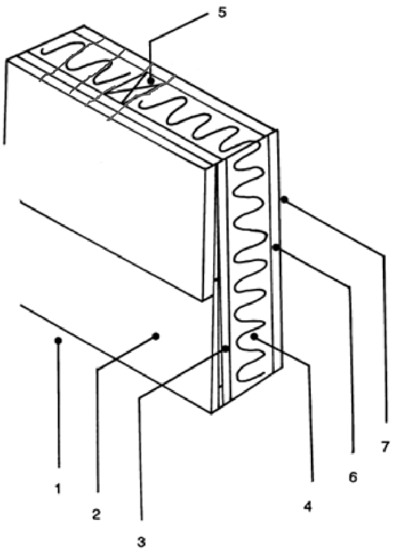
HEAT TRANSFER RATE $\dot{Q}$ (IF $L_{BRICK} = 32\,cm$)

$$\dot{Q} = \frac{T_{IN} - T_{OUT}}{R_{WALL\ TOTAL}} = \frac{[20 - (-10)]\,°C}{7{,}76\,\frac{°C}{W}} = 3{,}87\,W$$

HEAT TRANSFER RATE $\dot{Q}$ (IF $L_{BRICK} = 16\,cm$)

$$\dot{Q} = \frac{[20 - (-10)]\,°C}{6{,}81\,\frac{°C}{W}} = 4{,}4\,W$$

2



	WOOD	INSULATION
Outside	0.03	0.03
Wood Bevel	14	14
Plywood	0.11	0.11
Urethane Rigid Foam	no	0.98*0.90/25 = 3.53
Wood Studs	0.63	no
Gypsum Board	0.079	0.079
Inside	0.12	0.12

Determine the overall unit thermal resistance (the *R*-value) of 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 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 (this means 75% of area is insulation and 25% can be considered wood).

$\mathbf{R_{wood} = (0.03 + 14 + 0.11 + 0.63 + 0.079 + 0.12) = 1.11\ W/m^2{}^\circ C}$

$\mathbf{R_{insulation} = (0.03 + 14 + 0.11 + 3.53 + 0.079 + 0.12) = 4\ W/m^2{}^\circ C}$