COMPOSITE WALL

Tuesday, October 22, 2019 4:23 PM

Politecnico di Milano
MSc. Sustainable Architecture and Landscape Design
22/october/2019
Fabiola Anahí Mogrovejo León

1. Finalize 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.

A 3 m high and 5 m wide wall consists of long 16 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 h1=10 W/m2 · °C and h2 =40 W/m2 · °C, respectively.Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.

The heat transfer rate while the thickness of the brick is **16 cm is:**

$$\dot{Q} = \frac{\Delta T}{R_{Total}} = \frac{20-(-10)°C}{6.81\,°\frac{C}{W}} = \mathbf{4.41\,W}$$

Same question while the thickness of the brick is increased to 32 cm:

$$R_i = \frac{1}{h_i \times A} = \frac{1}{10 * 0.25} = 0.4\,°C/W$$

$$R_f = \frac{L_f}{k_f \times A} = \frac{0.03}{0.026 * 0.25} = 4.615\,°C/W$$

$$R_{p_{c_1}} = R_{p_{c_2}} = \frac{L_{p_{c_1}}}{k_p \times A_{p_{c_1}}} = \frac{0.32}{0.22 * 0.015} = 96.97\,°C/W$$

$$R_b = \frac{L_b}{k_b \times A_b} = \frac{0.32}{0.72 * 0.22} = 2.02\,°C/W$$

$$\frac{1}{R_{tot_{parallel}}} = \frac{1}{R_b} + \frac{1}{R_{p_{c_1}}} + \frac{1}{R_{p_{c_2}}} = \frac{1}{2.02} + 2 * \left(\frac{1}{96.97}\right) = 0.516\,°C/W$$

$$\rightarrow \frac{1}{R_{tot_{parallel}}} = 0.516\frac{W}{°C} \dashrightarrow R_{tot_{parallel}} = \frac{1}{0.516} = 1.94°\frac{C}{W}$$

$$R_{P_1} = R_{P_2} = \frac{L_{p_1}}{k_p \times A_{p_1}} = \frac{0.02}{(0.22*0.25)} = 0.363\,°C/W$$

$$R_{\_o} = \frac{1}{h_0 \times A} = \frac{1}{40 * 0.25} = 0.1\,°C/W$$

$$R_{total} = R_i + R_o + 2 * R_{P_1} + R_{tot_{parallel}} + R_{foam}$$

$$R_{total} = 7.781\,°\frac{C}{W}$$

The heat transfer rate is:

$$\dot{Q} = \frac{\Delta T}{R_{Total}} = \frac{20-(-10)°C}{7.781\ °C/W} = \mathbf{3.86\ W}$$

Comparing both results, we can notice that doubling the thickness of the brick does not increase significantly the thermal resistance of a wall, is better to spend on the thickness of the foam.

2. 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 Runit values.

Determine the overall unit thermal resistance (the *R*-value) and the overall heat transfer coefficient (the *U*-factor) 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.

Runit values:

	Wood	Insulation
Outside Air	0.03	0.03
Wood bevel l.	0.14	0.14
plywood(13mm)	0.11	0.11
Urethane rigid foam insulation	no	0.98*90/25=3.53
Wood studs	0.63	No
Gypsum board	0.079	0.079
Inside surface	0.12	0.12

$$R'_{withWood} = 0.03 + 0.14 + 0.11 + 0.63 + 0.079 + 0.12 = 1.109\ m^2.°\frac{C}{W}$$
$$R'_{withIns} = 0.03 + 0.14 + 0.11 + 3.53 + 0.079 + 0.12 = 4.009\ m^2.°C/W$$