*weekly_submission_**03***

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> Complete the composite wall question by finding the heat transfer rate.

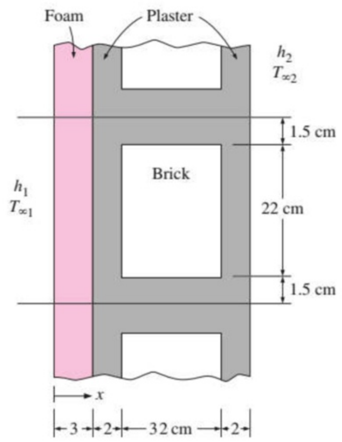
According to the results we found during the lesson, we have:

$$R_{tot} = 6{,}81 \frac{°C}{W}$$

Assuming one-dimensional heat transfer and disregarding radiation, the rate of heat transfer through the wall:

$$\dot{Q} = \frac{\Delta T}{R_{tot}} = \frac{20 - (-10)}{6{,}81} = 4{,}40\ W$$

> 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 32 cm 22 cm cross section horizontal bricks ($k = 0{,}72 \frac{W}{m°C}$) separated by 3 cm thick plaster layers ($k = 0{,}22 \frac{W}{m°C}$).
There are also 2 cm thick plaster layers on each side of the brick and a 3 cm thick rigid foam ($k = 0{,}026 \frac{W}{m°C}$) 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 ($h_1 = 10 \frac{W}{m^2°C}$) and ($h_2 = 25 \frac{W}{m^2°C}$), respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.

The thermal resistance of the <u>convection</u> between inner surface and the air:

$$R_i = \frac{1}{h_1 A} = \frac{1}{10 * 0{,}25} = 0{,}4 \frac{°C}{W}$$

The thermal resistance of the <u>conduction</u> of a 3 cm thick of foam:

$$R_f = \frac{L_f}{k_f A} = \frac{0{,}03}{0{,}026 * 0{,}25} = 4{,}615 \frac{°C}{W}$$

The thermal resistance of the <u>conduction</u> of a 2 cm thick of plaster:

$$R_{p,1} = R_{p,2} = \frac{L_{p,1}}{k_{p,1} A} = \frac{0{,}02}{0{,}22 * 0{,}25} = 0{,}363 \frac{°C}{W}$$

The thermal resistance in parallel:

$$R_{p_{c,1}} = \frac{L_{p_{c,1}}}{k_{p_{c,1}} A_{p_{c,1}}} = \frac{0{,}32}{0{,}22 * 0{,}015} = 96{,}970 \frac{°C}{W}$$

$$R_b = \frac{L_b}{k_b A_b} = \frac{0{,}32}{0{,}72 * 0{,}22} = 2{,}020 \frac{°C}{W}$$

$$\frac{1}{R_{paral}} = \frac{1}{R_{p_{c,1}}} + \frac{1}{R_b} + \frac{1}{R_{p_{c,2}}} = \frac{1}{96,970} + \frac{1}{2,020} + \frac{1}{96,970} = 0,516\ \frac{°C}{W}$$

$$R_{paral} = \frac{1}{0,516} = 1,938\ \frac{°C}{W}$$

The thermal resistance of the convection between outer surface and the air:

$$R_o = \frac{1}{h_2 A} = \frac{1}{40 * 0,25} = 0,1\ \frac{°C}{W}$$

The total thermal resistance:

$$R_{tot} = R_i + R_f + R_{p,1} + R_{paral} + R_{p,2} + R_o = 0,4 + 4,615 + 0,363 + 1,938 + 0,363 + 0,1 = 7,779\frac{°C}{W}$$

The rate of heat transfer through the wall:

$$\dot{Q} = \frac{\Delta T}{R_{tot}} = \frac{20 - (-10)}{7,779} = 3,85\ W$$

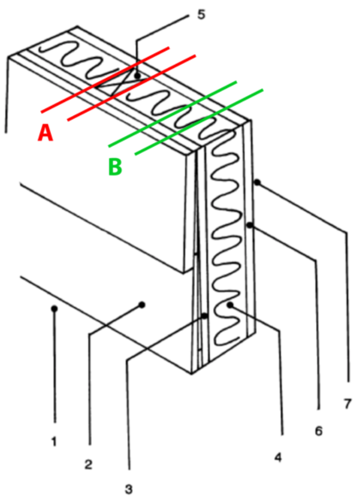
Comparing the two obtained results of the value of R_{tot} and $\dot{Q}$ in two different walls (with different thickness of brick), we can observe that:

In a composite wall, duplicating the thickness of the brick did not significantly change the total thermal resistance of the whole wall. The only way to significantly change the performance of the wall is to change the thickness of the insulation placed in series and not the one in parallel.

> 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 $13mm\ \ 200mm$ wood bevel lapped siding.

Unit thermal resistance (the R-value) of common components used in buildings

Component	R-Value $m^2 \cdot °C/W$	R-Value $ft^2 \cdot h \cdot °F/Btu$	Component	R-Value $m^2 \cdot °C/W$	R-Value $ft^2 \cdot h \cdot °F/Btu$
Outside surface (winter)	0.030	0.17	Wood stud, nominal 2 in × 6 in (5.5 in or 140 mm wide)	0.98	5.56
Outside surface (summer)	0.044	0.25	Clay tile, 100 mm (4 in)	0.18	1.01
Inside surface, still air	0.12	0.68	Acoustic tile	0.32	1.79
Plane air space, vertical, ordinary surfaces (ε_{eff} = 0.82):			Asphalt shingle roofing	0.077	0.44
			Building paper	0.011	0.06
13 mm ($\frac{1}{2}$ in)	0.16	0.90	Concrete block, 100 mm (4 in):		
20 mm ($\frac{3}{4}$ in)	0.17	0.94	Lightweight	0.27	1.51
40 mm (1.5 in)	0.16	0.90	Heavyweight	0.13	0.71
90 mm (3.5 in)	0.16	0.91	Plaster or gypsum board,		
Insulation, 25 mm (1 in)			13 mm ($\frac{1}{2}$ in)	0.079	0.45
Glass fiber	0.70	4.00	Wood fiberboard, 13 mm ($\frac{1}{2}$ in)	0.23	1.31
Mineral fiber batt	0.66	3.73	Plywood, 13 mm ($\frac{1}{2}$ in)	0.11	0.62
Urethane rigid foam	0.98	5.56	Concrete, 200 mm (8 in)		
Stucco, 25 mm (1 in)	0.037	0.21	Lightweight	1.17	6.67
Face brick, 100 mm (4 in)	0.075	0.43	Heavyweight	0.12	0.67
Common brick, 100 mm (4 in)	0.12	0.79	Cement mortar, 13 mm (1/2 in)	0.018	0.10
Steel siding	0.00	0.00	Wood bevel lapped siding,		
Slag, 13 mm ($\frac{1}{2}$ in)	0.067	0.38	13 mm × 200 mm		
Wood, 25 mm (1 in)	0.22	1.25	(1/2 in × 8 in)	0.14	0.81
Wood stud, nominal 2 in × 4 in (3.5 in or 90 mm wide)	0.63	3.58			



	Section A	Section B
1. Outside surface	0,03	0,03
2. Wood Bevel Lapped Siding $(13mm * 200mm)$	0,14	0,14
3. Plywood $(13mm)$	0,11	0,11
4. Urethane Rigid Foam Insulation $(90mm)$	---	$\frac{0,98 * 90}{25} = 3,528$
5. Wood Stud $(90mm)$	0,63	---
6. Gypsum Wallaboard $(13mm)$	0,079	0,079
7. Inside Surface	0,12	0,12

Section A = section with wood
Section B = section with insulation

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

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