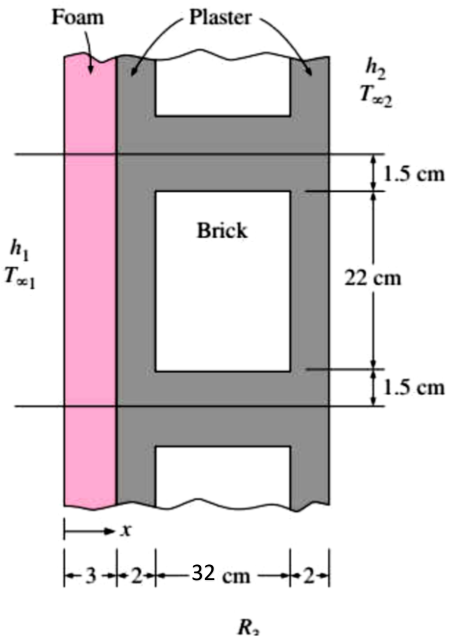
The rate of heat transfer through the composite wall analyzed in class is:

$$\dot{Q} = \frac{T\infty 1 - T\infty 2}{\text{Rtot}} = \frac{20-(-10)\ °C}{6{,}81\ °C/W} = 4{,}417\ \text{W}$$

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 h1=10 W/m2 · °C and h2 =25 W/m2 · °C, respectively.
Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.



Solving:

$$R_i = \frac{1}{\text{hi A}} = \frac{1}{10*0{,}25} = 0{,}4\ \frac{°C}{W} \qquad \text{Inner resistance}$$

$$R_f = \frac{Lf}{\text{kf A}} = \frac{0.3}{0.026*0{,}25} = 4.615\ \frac{°C}{W} \qquad \text{Foam resistance}$$

$$R_{pc1} = R_{pc2} = \frac{Lpc1}{\text{kp Apc1}} = \frac{0.02}{0.22*0{,}25} = 0.36\ \frac{°C}{W} \qquad \text{Plaster resistance}$$

$$R_{pc1} = R_{pc2} = \frac{Lpc1}{\text{kp Apc1}} = \frac{0.32}{0.22*0{,}015} = 96.97\ \frac{°C}{W} \qquad \text{Plaster resistance in parallel}$$

$$R_b = \frac{Lb}{\text{kb A}} = \frac{0.32}{0.72*0{,}22} = 2.02\ \frac{°C}{W} \qquad \text{Brick resistance in parallel}$$

$$\frac{1}{\text{R tot}} = \frac{1}{\text{R pc1}} + \frac{1}{\text{R b}} + \frac{1}{\text{R pc2}} = \frac{1}{96.97} + \frac{1}{2.02} + \frac{1}{96.97} = 0.516\ \frac{W}{°C}$$

$$R_{\text{tot parall}} = \frac{1}{0.516} = 1.938\ \frac{°C}{W} \qquad \text{Total resistance in parallel}$$

$R_o = \frac{1}{\mathrm{h2\ A}} = \frac{1}{50*0,25} = 0,1\,\frac{°C}{W}$ Outer resistance

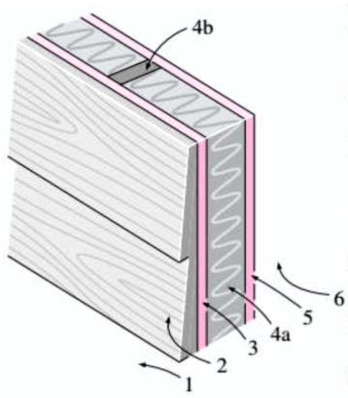
$R_{tot} = 0.4 + 4.615 + 0.36 + 0.36 + 1.938 + 0.1 = 7,773\,\frac{°C}{W}$ Total resistance

$\dot{Q} = \frac{T\infty 1 - T\infty 2}{Rtot} = \frac{20-(-10)\ °C}{7,773\ °C/W} = 3,86$ W Heat transfer through the composite wall

Conclusion:

Duplicating the thickness of the brick (from 16 cm to 32 cm), the total parallel resistance increases only to $1\,\frac{°C}{W}$ (from 6.81 $\frac{°C}{W}$ to 7.77 $\frac{°C}{W}$) and, consequently, the heat transfer through the wall decreases of 0,8 W (from 4.417 W to 3.86 W).
As a consequence, to reduce the heat transfer, the better solution is increasing the thickness of the foam (because it has the biggest resistance); increasing the thickness of the brick doesn't produce a significant effect in order to reduce the heat transfer.

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 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.



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

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

	$\frac{m^2\ °C}{W}$	$\frac{m^2\ °C}{W}$
	Insulation	Wood Studs
1. Outside air surface	0.03	0.3
2. Wood bevel (13*200) mm	0.14	0.14
3. Plywood (13 mm)	0.11	0.11
4.a Urethane rigid foam	$0.98 * \frac{90}{25} = 3.528$	/
4.b Wood Studs (90 mm)	/	0.63
5. Gypsum Wallboard (13 mm)	0.079	0.079
6. Inside air surface	0.12	0.12

The R_unit values are respectively:

R' with insulation =	4,007 $\frac{m^2\ °C}{W}$	
R' with wood studs =		1,379 $\frac{m^2\ °C}{W}$