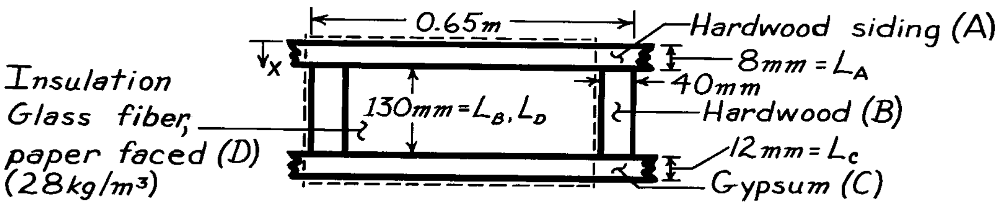
PROBLEM 3.15

KNOWN: Dimensions and materials associated with a composite wall (2.5m × 6.5m, 10 studs each 2.5m high).

FIND: Wall thermal resistance.

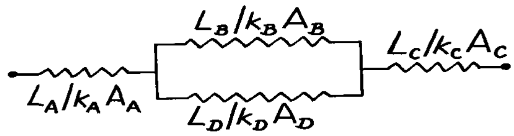
SCHEMATIC:



ASSUMPTIONS: (1) Steady-state conditions, (2) Temperature of composite depends only on x (surfaces normal to x are isothermal), (3) Constant properties, (4) Negligible contact resistance.

PROPERTIES: *Table A-3* (T ≈ 300K): Hardwood siding, k_A = 0.094 W/m·K; Hardwood, k_B = 0.16 W/m·K; Gypsum, k_C = 0.17 W/m·K; Insulation (glass fiber paper faced, 28 kg/m^3), k_D = 0.038 W/m·K.

ANALYSIS: Using the isothermal surface assumption, the thermal circuit associated with a single unit (enclosed by dashed lines) of the wall is



$$\left(L_A / k_A A_A\right) = \frac{0.008\text{m}}{0.094\ \text{W/m}\cdot\text{K}\ \left(0.65\text{m}\times 2.5\text{m}\right)} = 0.0524\ \text{K/W}$$

$$\left(L_B / k_B A_B\right) = \frac{0.13\text{m}}{0.16\ \text{W/m}\cdot\text{K}\ \left(0.04\text{m}\times 2.5\text{m}\right)} = 8.125\ \text{K/W}$$

$$\left(L_D / k_D A_D\right) = \frac{0.13\text{m}}{0.038\ \text{W/m}\cdot\text{K}\left(0.61\text{m}\times 2.5\text{m}\right)} = 2.243\ \text{K/W}$$

$$\left(L_C / k_C A_C\right) = \frac{0.012\text{m}}{0.17\ \text{W/m}\cdot\text{K}\left(0.65\text{m}\times 2.5\text{m}\right)} = 0.0434\ \text{K/W.}$$

The equivalent resistance of the core is

$$R_{eq} = \left(1/R_B + 1/R_D\right)^{-1} = \left(1/8.125 + 1/2.243\right)^{-1} = 1.758\ \text{K/W}$$

and the total unit resistance is

$$R_{tot,1} = R_A + R_{eq} + R_C = 1.854\ \text{K/W.}$$

With 10 such units in parallel, the total wall resistance is

$$R_{tot} = \left(10\times 1/R_{tot,1}\right)^{-1} = 0.1854\ \text{K/W.}$$ <

COMMENTS: If surfaces parallel to the heat flow direction are assumed adiabatic, the thermal circuit and the value of R_{tot} will differ.