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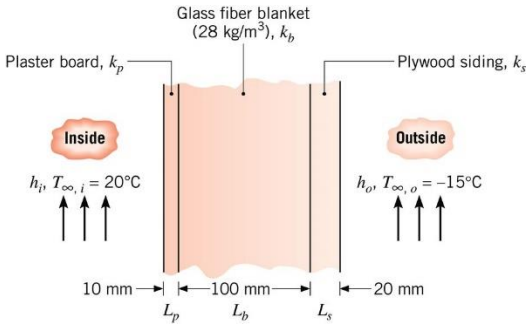
Quiz 3

CHG 2314 **January 28, 2019**

A house has a composite wall of wood, fiberglass insulation, and plaster board, as indicated in the sketch. On a cold winter day, the convection heat transfer coefficients are h_o = 60 W/m^2 · K and h_i = 30 W/m^2 · K. The total wall surface area is 350 m^2. Thermal conductivities of glass fiber blanket, plaster board and plywood siding are k_b = 0.038 W/m·K, k_o = 0.17 W/m·K and k_s = 0.12 W/m·K, respectively.

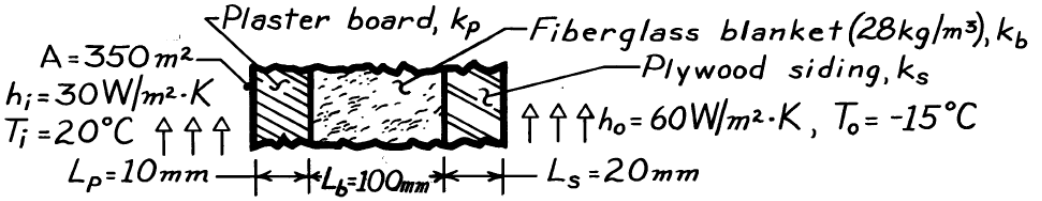


a) Determine a symbolic expression for the total thermal resistance of the wall, including inside and outside convection effects for the prescribed conditions. (**3 points**)
b) Evaluate the total thermal resistance using the provided data (**5 points**) and calculate the total rate of heat loss through the wall. (**2 points**)

Solution

NB: Since the schematic diagram is provided in the problem statement, the following diagram is not necessary.

SCHEMATIC:



ASSUMPTIONS: (1) One-dimensional conduction, (2) Steady-state conditions, (3) Negligible contact resistance.

ANALYSIS: (a) The expression for the total thermal resistance of the house wall follows from Eq. 3.18.

$$R_{tot} = \frac{1}{h_i A} + \frac{L_p}{k_p A} + \frac{L_b}{k_b A} + \frac{L_s}{k_s A} + \frac{1}{h_o A}.$$ <

(b) The total heat loss through the house wall is

$$q = \Delta T / R_{tot} = (T_i - T_o) / R_{tot}.$$

Substituting numerical values, find

$$R_{tot} = \frac{1}{30\,W/m^2\cdot K \times 350\,m^2} + \frac{0.01m}{0.17\,W/m\cdot K \times 350\,m^2} + \frac{0.10m}{0.038\,W/m\cdot K \times 350\,m^2} + \frac{0.02m}{0.12\,W/m\cdot K \times 350\,m^2} + \frac{1}{60\,W/m^2\cdot K \times 350\,m^2}$$

$$R_{tot} = \left[9.52 + 16.8 + 752 + 47.6 + 4.76\right] \times 10^{-5}\ ^\circ C/W = 831 \times 10^{-5}\ ^\circ C/W$$

The heat loss is then,

$$q = \left[20 - (-15)\right]^\circ C / 831 \times 10^{-5}\ ^\circ C/W = 4.21\ kW.$$ <