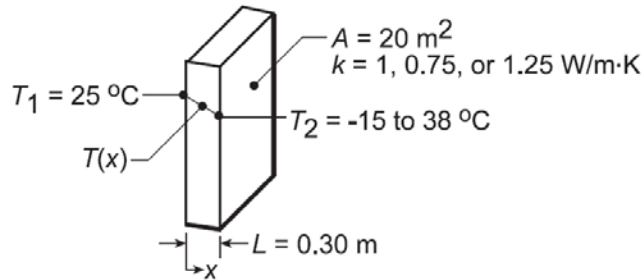


PROBLEM 1.4

KNOWN: Inner surface temperature and thermal conductivity of a concrete wall.

FIND: Heat loss by conduction through the wall as a function of outer surface temperatures ranging from -15 to 38°C .

SCHEMATIC:



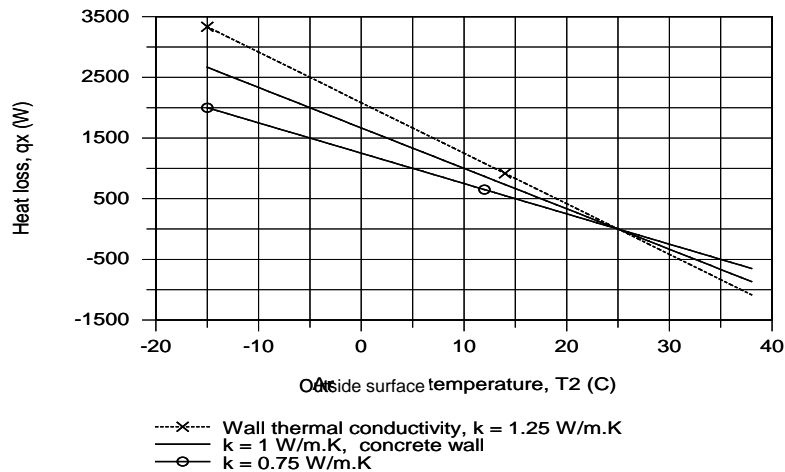
ASSUMPTIONS: (1) One-dimensional conduction in the x-direction, (2) Steady-state conditions, (3) Constant properties.

ANALYSIS: From Fourier's law, if q_x'' and k are each constant it is evident that the gradient, $dT/dx = -q_x''/k$, is a constant, and hence the temperature distribution is linear. The heat flux must be constant under one-dimensional, steady-state conditions; and k is approximately constant if it depends only weakly on temperature. The heat flux and heat rate when the outside wall temperature is $T_2 = -15^\circ\text{C}$ are

$$q_x'' = -k \frac{dT}{dx} = k \frac{T_1 - T_2}{L} = 1 \text{ W/m}\cdot\text{K} \frac{25^\circ\text{C} - (-15^\circ\text{C})}{0.30 \text{ m}} = 133.3 \text{ W/m}^2. \quad (1)$$

$$q_x = q_x'' \times A = 133.3 \text{ W/m}^2 \times 20 \text{ m}^2 = 2667 \text{ W}. \quad (2) \quad \text{<}$$

Combining Eqs. (1) and (2), the heat rate q_x can be determined for the range of outer surface temperature, $-15 \leq T_2 \leq 38^\circ\text{C}$, with different wall thermal conductivities, k .



For the concrete wall, $k = 1 \text{ W/m}\cdot\text{K}$, the heat loss varies linearly from $+2667 \text{ W}$ to -867 W and is zero when the inside and outer surface temperatures are the same. The magnitude of the heat rate increases with increasing thermal conductivity.

COMMENTS: Without steady-state conditions and constant k , the temperature distribution in a plane wall would not be linear.