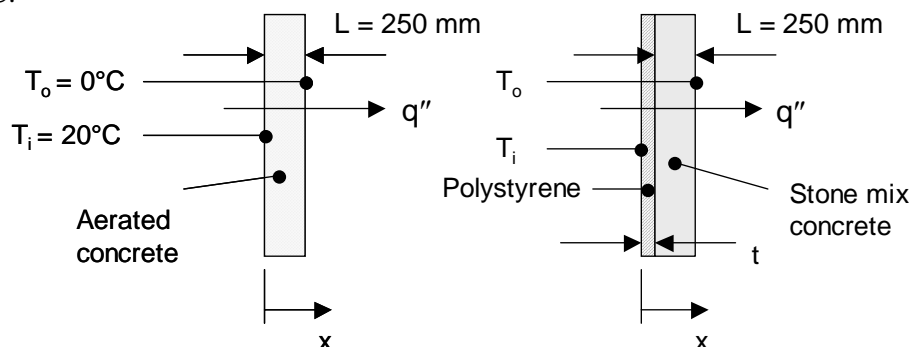# PROBLEM 3.2

KNOWN: Thickness of basement wall. Inner and outer wall temperatures. Thermal conductivity of aerated concrete.

FIND: Thickness of polystyrene insulation needed to reduce heat flux through the stone mix concrete wall to that of the aerated concrete wall. Lost annual rental income associated with specification of the stone mix concrete wall.

SCHEMATIC:

ASSUMPTIONS: (1) Steady-state, one-dimensional conduction, (2) Constant properties, (3) Negligible contact resistance.

PROPERTIES: *Table A.3*, Stone mix concrete (300 K): k_{sm} = 1.4 W/m·K; Rigid extruded polystyrene sheet (285 K, ρ = 35 kg/m^3): k_{ps} = 0.027 W/m·K. Aerated concrete: k_{ac} = 0.15 W/m·K (given).

ANALYSIS: The heat flux through the aerated concrete is

$$q'' = k_{ac}(T_i - T_o)/L = 0.15 \text{ W/m} \cdot \text{K} \times (20°\text{C} - 0°\text{C})/0.25 \text{ m} = 12 \text{ W/m}^2 \tag{1}$$

The heat flux through the stone mix concrete and polystyrene sheet composite wall is

$$q'' = 12 \text{ W/m}^2 = \frac{T_i - T_o}{(t/k_{ps}) + (L/k_{sm})} = \frac{(20°\text{C} - 0°\text{C})}{(t/0.027 \text{ W/m} \cdot \text{K}) + (0.250 \text{ m}/1.4 \text{ W/m} \cdot \text{K})} \tag{2}$$

Hence, t = 0.040 m = 40 mm.   <

The floor space occupied by the polystyrene insulation is A = 0.040 m × (25 m + 40 m) × 2 = 5.22 m^2. The lost annual revenue associated with specification of the stone mix concrete is ΔR = \$50/m^2/month × 12 months/year × 5.22 m^2 = \$3132 per year.   <

COMMENTS: (1) Inclusion of the thermal contact resistance will reduce the value of the required insulation thickness. (2) A careful economic analysis would account for the difference in cost of the two materials. However, additional costs associated with specification of the stone mix concrete are labor costs for installation of the insulation, and the cost of the insulation itself. Additional costs for the aerated concrete wall are labor costs for constructing the wall of aerated concrete blocks. (3) Lightweight aerated concrete blocks are fabricated of recycled fly ash, a byproduct of coal combustion. The low thermal conductivity is due to small air bubbles that are entrapped within the solid matrix.