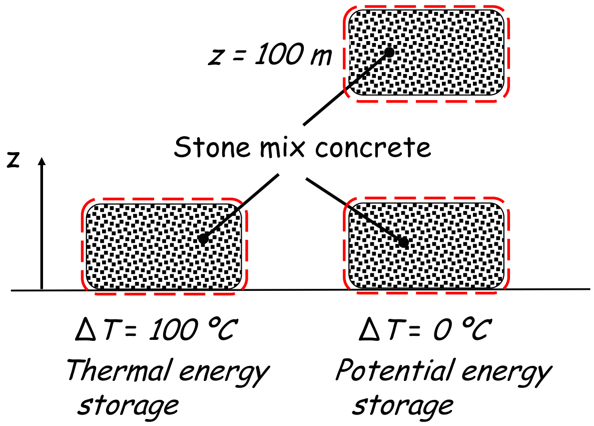
PROBLEM 1.28

KNOWN: Storage medium, minimum and maximum temperatures for thermal energy storage, vertical elevation change for potential energy storage.

FIND: Ratio of sensible energy storage capacity to potential energy storage capacity.

SCHEMATIC:



ASSUMPTIONS: (1) Constant properties, (2) Uniform minimum and maximum temperatures.

PROPERTIES: Table A.3, stone mix concrete (300 K): $c_p = c = 880$ J/kg·K.

ANALYSIS: The change in sensible thermal energy storage is due to the temperature change, thus

$$\dot{E}_{\text{st},t} = \frac{dU_t}{dt} = mc\frac{dT}{dt} \tag{1}$$

Integrating Equation 1 over the time period between the minimum and maximum temperatures associated with the thermal energy storage yields

$$\Delta E_{\text{st},t} = mc\left(T_{\max} - T_{\min}\right) = mc\Delta T \tag{2}$$

The potential energy storage capacity is

$$\Delta E_{\text{st,PE}} = mgz \tag{3}$$

Combining Equations 2 and 3 yields

$$R = \frac{c\Delta T}{gz}$$ <

Continued …

PROBLEM 1.28 (Cont.)

For stone mix concrete with ΔT = 100°C and z = 100 m,

$$R = \frac{880 \text{ J/kg}\cdot\text{K} \times 100 \text{ K}}{9.8 \text{ m/s}^2 \times 100 \text{ m}} = 89.8$$

Since R >> 1, thermal energy storage is more effective for the parameters of this problem. <

COMMENTS: (1) Note that ΔT = 100°C = 100 K. (2) The ratio, R, is dimensionless. We shall utilize dimensionless parameters frequently in later chapters. (3) Thermal energy storage can be used in conjunction with solar thermal energy generation. In general, storage of energy in a mechanical form is not as effective as in thermal or chemical forms.