A 1.8-m concrete post ($E_c = 25$ GPa, $\alpha_c = 9.9 \times 10^{-6}/°C$) is reinforced with six steel bars ($E_s = 200$ GPa, $\alpha_s = 11.7 \times 10^{-6}/°C$). If the diameter of each steel bar is 22 mm and temperature **drops** 35°C, determine (*a*) the normal stresses σ_s and σ_c induced in the steel and in the concrete, respectively, (*b*) the change in length δ_{post} of the post.

1.8 m

0.24 m   0.24 m
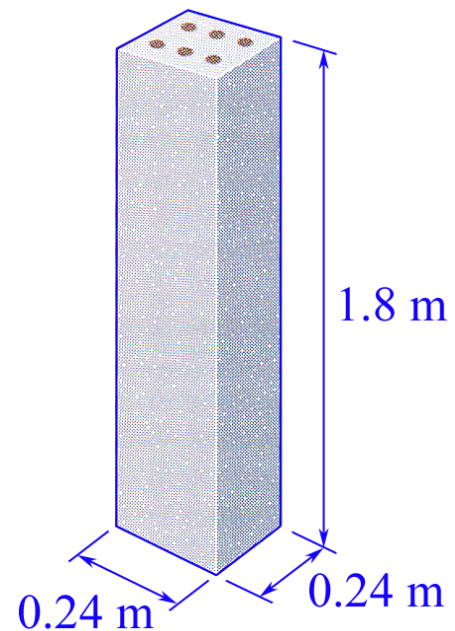
Sketch ①

$$\delta_{cT} + \delta_{cP} = \delta_{sT} - \delta_{sP} \quad ①$$

$$\delta_T = \alpha(\Delta T)L \qquad \delta_P = \frac{PL}{AE} \qquad P_s = P_c = P$$

$$9.9 \times 10^{-6}(35)(1.8) + \frac{P(1.8)}{\left[(0.24)^2 - 6\pi(0.011)^2\right](25 \times 10^9)}$$

$$= 11.7 \times 10^{-6}(35)(1.8) - \frac{P(1.8)}{6\pi(0.011)^2(200 \times 10^9)}$$

$$P = 21610 \text{ N} \quad ② \qquad \sigma_s = +9474839 \text{ Pa} \qquad \sigma_c = -390645 \text{ Pa}$$

$$\sigma_s = +9.47 \text{ MPa} \quad ② \qquad \sigma_c = -0.391 \text{ MPa} \quad ②$$

$$\delta_{\text{post}} = -(\delta_{sT} - \delta_{sP}) = -6.518 \times 10^{-4} \text{ m} \qquad \delta_{\text{post}} = -0.652 \text{ mm} \quad ②$$