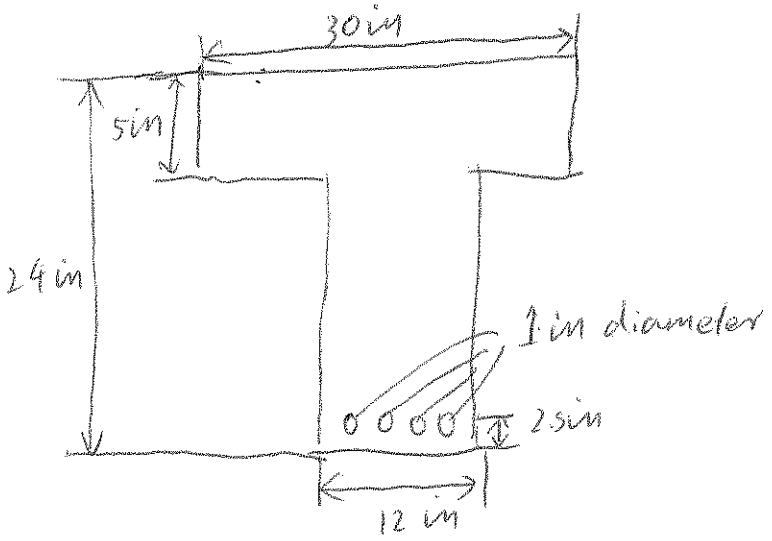
11.45 Solution



Review of Problem:

The concret beam (right) is reinforced by four steel bars.

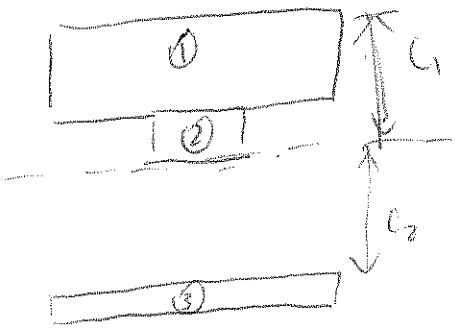
$E_C = 3.75 \times 10^6$ Psi Concrete

$E_S = 30 \times 10^6$ Psi steel

The bending moment $M = 150$ Kip·ft

Transform steel to Concrete

$$n = \frac{E_S}{E_C} = \frac{30 \times 10^6 \text{Psi}}{3.75 \times 10^6 \text{Psi}} = 8$$



$$nA_S = 8\,(\pi/4\,(1\text{in})^2)\,4 = 25.13\ \text{in}^2$$

Neutral Axis

$$\underbrace{150(x-2.5)}_{①} + \underbrace{(x-5)/2 \cdot 12(x-5)}_{②} - \underbrace{25.13 \cdot (21.5-x)}_{③} = 0$$

So $X = 5.225$ in

Moment of area

$$I = \frac{1}{12}\,30 \times 5^3 + (x-2.5)^2 150 + \frac{1}{12}\left((5.225-5)^2 \cdot 12 + (5.225-5)12 \cdot \left(\frac{(5.225-5)}{2}\right)^2\right)$$

$$+ 25.13 \cdot (21.5 - 5.22)$$

$$= 8082.7\ \text{in}^4$$

Max stress in steel

$$\sigma_s = n\frac{Mc_2}{I} = 8 \cdot \frac{150\times10^3 \cdot 12}{8082.7}\cdot(29.5 - 5.225) \approx 29 \text{ ksi}$$

Max stress in concrete

$$\sigma_c = \frac{Mc_1}{I} = \frac{150\times10^3\times12}{8082.7} \cdot 5.225 = 1.163 \text{ ksi}$$