

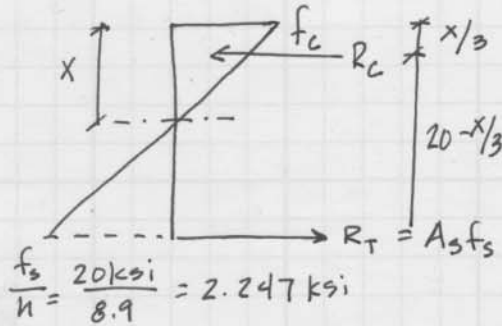
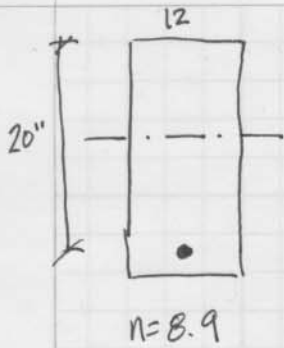
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13-2 (IV)



The beam is underreinforced.
So f_c is the Actual stress and not the Allowable.

$$M_{\text{Bend}} = 50 \text{ k}$$

$$f_s = 20 \text{ ksi}$$

$$R_c = \frac{f_c B x}{2} = R_T = A_s f_s$$

$$M_{\text{Resisting}} = M_{\text{Bend}} = 50 \text{ k} = 600 \text{ in-k} = R_c (20 - x/3) = R_T (20 - x/3)$$

By similar triangles from stress Diagram:

$$\frac{f_c}{x} = \frac{2.247 \text{ ksi}}{20 - x} \rightarrow f_c = \frac{2.247 x}{20 - x}$$

$$\text{by substitution } R_c = \frac{f_c B x}{2} = \frac{\left(\frac{2.247 x}{20 - x}\right) (12 \text{ in}) (x)}{2} = \frac{13.482 x^2}{20 - x}$$

$$600 \text{ in-k} = R_c (20 - x/3) = \left(\frac{13.482 x^2}{20 - x}\right) (20 - x/3)$$

$$12000 - 600x = 269.64 x^2 - 4.494 x^3$$

$$\text{Solve by trial and error } \boxed{x \approx 6 \text{ in}}$$

$$600 \text{ in-k} = R_T (20 - x/3) = A_s f_s (20 - x/3)$$

$$600 \text{ in-k} = (A_s) (20 \text{ ksi}) (20 - 6/3)$$

$$\boxed{A_s = 1.66 \text{ in}^2}$$