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ARCH 324 - Structures 2, Winter 2009

von Buelow, Peter

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The beam is under-reinforced, so $f_c$ is the actual stress and not the allowable.

$$n = \frac{20 \text{ kpsi}}{2.247 \text{ kpsi}} = 8.9$$

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

$$R_c = \frac{f_c B x}{2}$$

$$R_T = A_s f_s$$

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

By similar triangles from stress diagram:

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

by substitution

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

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

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

Solve by trial and error: $x \approx 6''$

$$600^k = R_T (20 - x/3) = A_s f_s (20 - x/3)$$

$$600^k = (A_s)(20 \text{ kpsi})(20 - x/3)$$

$$A_s = \frac{1.64 \text{ in}^2}{6}$$