ARCH 324 - Structures 2, Winter 2009

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13-1 (A)

\[ F_c = 36,250 \text{ ksi} \quad \rightarrow \quad n = 8 \quad \text{(From Data Sheet D-23)} \]
\[ F_s = 29,000 \text{ ksi} \]

First transform section:
(1) Determine Neutral Axis of the Effective Section:
\[ A_c \bar{x}_c = A_t \bar{x}_t \]
\[ (12'' \times x) \left( \frac{x}{2} \right) = 24 \text{in}^2 \quad (18'' - x) \]

\[ 6x^2 - 432 - 24x \]

\[ x^2 + 4x - 72 = 0 \]

Use quadratic equation to solve:
\[ x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \]

\[ x = \frac{-4 \pm \sqrt{(4)^2 - (4)(1)(72)}}{2(1)} = \frac{6.7''}{1} \]

(Note: ignore negative answer, because we are only interested in a positive value)

(2) Transformed Moment of Inertia
\[ I = \frac{bd^3}{3} = \frac{(12'')(6.7'')^3}{3} = 1203 \text{ in}^4 \]

\[ I = A_x x^2 = (24\text{in}^2)(11.3'')^2 = 3064.56 \text{ in}^4 \]

\[ I_{tr} = \frac{4267.6 \text{ in}^4}{1} \]

(3) Resisting Capacity of Concrete & Steel
Concrete: \( f = 1.8 \text{ ksi} \)
\[ M = \frac{fI_{tr}}{c} = \frac{(1.8 \text{ ksi})(4268 \text{ in}^4)}{6.7''} = 1146.4'' \text{k} = 95.5' \text{k} \]

Steel: \( f = 20 \text{ ksi} \)
\[ M = \frac{fI_{tr}}{cn} = \frac{(20 \text{ ksi})(4268 \text{ in}^4)}{(11.3'')(8)} = 944.2'' \text{k} = 78.68' \text{k} \text{ steel governs.} \]

(4) Actual stress in concrete:
\[ f = \frac{Mc}{I_{tr}} = \frac{(944.2'' \text{k})(6.7'')}{4268 \text{ in}^4} = 1.48 \text{ ksi} \]