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ARCH 324 - Structures 2, Winter 2009

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EXAMPLE: CONCRETE BEAM DESIGN
WORKING STRESS METHOD

GIVEN:

\[ M = 200 \text{ kN} \cdot \text{m} \]
\[ E_s = 29,000 \text{ ksi} \]
\[ f_s = 24 \text{ ksi} \]
\[ E_c = 36,250 \text{ ksi} \]
\[ f_c = 1.8 \text{ ksi} \]

DESIGN THE SECTION SO THAT IT IS EXACTLY BALANCED.

1. MODULUS RATIO:
\[ n = \frac{E_s}{E_c} = \frac{29,000}{36,250} = 0.8 \]

2. FIND DEPTH, D, SO THAT BOTH MATERIALS ARE STRESSED TO ALLOWABLE:

\[ f_c = 1.8 \text{ ksi} \]

\[ f_s/n = 3 \text{ ksi} \]

\[ \frac{1.8}{x} = \frac{3}{D-x} \]

\[ 1.8D - 1.8x = 3x \]

\[ D = 2.67x \]

CONSIDERING THE INTERNAL COUPLE:
\[ M = R_c(D - \frac{x}{2}) \]
\[ R_c = \frac{f_c (B)(x)}{2} = \frac{(1.8 \text{ ksi})(14\text{''})(x)}{2} = 12.6x \]

\[ M = R_c (D - \frac{x}{2}) \]
\[ 200 \text{ kN} \cdot \text{m} \times 12\text{''} = 12.6x (2.67x - \frac{x}{2}) \]
\[ 2400 \text{ kN} \cdot \text{m} = 33.64x^2 - 4.20x^2 \]
\[ = 29.44x^2 \]

\[ \rightarrow x = 9.0\text{''} \]

\[ D = 2.67x = 2.67(9\text{''}) = 24.1\text{''} \]
3. FIND AREA OF STEEL:

\[ R_c = \frac{f_c (8)(x)}{2} = 12.6 \times \]

\[ = 12.6 (9.0'') \]

\[ = 113.4 \text{k} \]

\[ R_t = R_c \]

\[ R_t = A_s f_s \]

\[ 113.4 \text{k} = A_s (24 \text{ksi}) \quad \rightarrow \quad A_s = 4.73 \text{ in}^2 \]