ARCH 324 - Structures 2, Winter 2009

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EXAMPLE: CONCRETE BEAM DESIGN
WORKING STRESS METHOD

GIVEN:

\[ M = 200 \text{ k"f} \]
\[ E_s = 29,000 \text{ ksi}, \quad f_s = 24 \text{ ksi} \]
\[ E_c = 3,062.5 \text{ ksi}, \quad f_c = 1.8 \text{ ksi} \]

DESIGN THE SECTION SO THAT IT IS EXACTLY BALANCED.

1. MODULUS RATIO: \[ n = \frac{E_s}{E_c} = \frac{29,000}{3,062.5} = 8 \]

2. FIND DEPTH \( D \) SO THAT BOTH MATERIALS ARE STRESSED TO ALLOWABLE:

\[ f_s/n = 3 \text{ ksi} \]
\[ f_c = 1.8 \text{ ksi} \]

\[ \frac{1.8}{x} = \frac{3}{D-x} \]
\[ \rightarrow 1.8D - 1.8x = 3x \]
\[ D = 2.67x \]

CONSIDERING THE INTERNAL COUPLE: \[ M = R_c(D - \frac{x}{3}) \]

\[ R_c = \frac{f_c(B)(x)}{2} = \frac{(1.8 \text{ ksi})(14 \text{ in})(x)}{2} = 12.6x \]

\[ M = R_c(D - \frac{x}{3}) \]
\[ 200 \text{ k"f} \times 12 \text{ in} = 12.6x \left(2.67x - \frac{x}{3}\right) \]
\[ 2400 \text{ k"f} = 33.64x^2 - 4.20x^2 \]
\[ = 29.44x^2 \]
\[ \rightarrow x = 9.0 \text{ in} \]

\[ D = 2.67x = 2.67(9 \text{ in}) = 24.1 \text{ in} \]
3. Find area of steel:

\[ R_c = \frac{p_c(b)(x)}{2} = 12.6 \times \]
\[ = 12.6 \times (9.0^\circ) \]
\[ = 113.4^k \]

\[ R_t = R_c \]

\[ R_t = A_s f_s \]

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