ARCH 324 - Structures 2, Winter 2009

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http://hdl.handle.net/2027.42/64938
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**EXAMPLE: CONCRETE BEAM DESIGN**

**WORKING STRESS METHOD**

**GIVEN:**

\[ M = 200 \text{in-kf} \]

\[ E_s = 29,000 \text{ksi}, \quad f_s = 24 \text{ksi} \]

\[ E_c = 3,025 \text{ksi}, \quad f_c = 1.8 \text{ksi} \]

Design the section so that it is exactly balanced.

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1. **Modulus Ratio:**

\[ n = \frac{E_s}{E_c} = \frac{29,000}{3,025} = 8 \]

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2. Find depth, \( D \), so that both materials are stressed to allowable:

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

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

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

\[ D = 2.67x \]

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Considering the internal couple:

\[ M = R_c(D - \frac{x}{3}) \]

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

\[ M = R_c(D - \frac{x}{3}) \]

\[ 200 \text{in-kf \times 12 in} = 12.6x (2.67x - \frac{x}{3}) \]

\[ 2400 \text{in-kf} = 33.64x^2 - 4.20x^2 \]

\[ = 29.44x^2 \]

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

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

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

\[ = 12.6 (9.0^2) \]

\[ = 113.4 k \]

\[ R_t = R_c \]

\[ R_t = A_s f_s \]

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