ARCH 324 - Structures 2, Winter 2009

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EXAMPLE: CONCRETE BEAM ANALYSIS
WORKING STRESS METHOD

CALCULATE THE BENDING CAPACITY OF THE FOLLOWING BEAM:

3 - #9 BARS
(A_s = 3.00 in^2)

E_s = 29,000 ksi, f_s = 20 ksi
E_c = 3,220 ksi, f_c = 1.8 ksi

1. TRANSFORM SECTION:

n = \frac{E_s}{E_c} = \frac{29,000}{3,220} = 9

A_{TR} = (21 in^2)(9) = 27 in^2

2. DETERMINE NEUTRAL AXIS OF EFFECTIVE SECTION:

A_e \bar{x_e} = A_s \bar{x_s}

(12'' \times x) \left( \frac{x}{2} \right) = (27 in^2)(17-x)

6x^2 = 459 - 27x
0 = 6x^2 + 27x - 459
0 = x^2 + 4.5x - 76.5

SOLVE WITH QUADRATIC EQUATION:

x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}
2. NEUTRAL AXIS, CONT'D...

\[ x = -4.5 \pm \sqrt{(4.5)^2 - 4(1)(-70.5)} \]
\[ 2(1) \]
\[ = 6.78" \quad \text{or} \quad -11.25" \]
\[ \text{(Ignore Negative Answer)} \]

3. FIND TRANSFORMED MOMENT OF INERTIA:

\[ I_c = \frac{bd^3}{3} = \frac{(12)(6.78)^3}{3} = 1247 \text{ in}^4 \]

\[ I_s = A \frac{a^2}{12} = (27 \text{ in}^2)(10.22)^2 = 2820 \text{ in}^4 \]
\[ \text{(Assume Minute Thickness of Steel \rightarrow No lb} \frac{\text{in}^2}{12} \text{)} \]
\[ I_{tr} = 4067 \text{ in}^4 \]

4. RESISTING CAPACITY OF CONCRETE AND STEEL:

**CONCRETE:** \( f_c = 1.8 \text{ksi} \)

\[ M = \frac{f_c I_{tr}}{C} = \frac{(1.8 \text{ ksi})(4067 \text{ in}^4)}{6.78"} = 1080 \text{ in.k} = 90 \text{k} \]

**STEEL:** \( f_s = 20 \text{ksi} \)

\[ M = \frac{f_s I_{tr}}{C} = \frac{(20 \text{ ksi})(4067 \text{ in}^4)}{(10.22")^2(9)} = 884 \text{ in.k} = 74 \text{k} \]

\[ 90774 \rightarrow \text{STEEL GOVERNS} \]

**BEAM CAPACITY = 74 k**

5. FIND ACTUAL STRESSES IN STEEL & CONCRETE:

**STEEL:** Moment-Resisting Capacity Governs

Stress in Steel = Allowable = 20 ksi

**CONCRETE:** \[ f = \frac{M_c}{I_{tr}} = \frac{(74 \text{ k} \times 12\text{ in}^2)(6.78")}{4067 \text{ in}^4} = 1.48 \text{ ksi} \]