ARCH 324 - Structures 2, Winter 2009

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EXAMPLE: CONCRETE BEAM ANALYSIS
WORKING STRESSES METHOD

CALCULATE THE BENDING CAPACITY OF THE FOLLOWING BEAM:

\[ E_S = 29,000 \text{ ksi}, \ f_s = 20 \text{ ksi} \]
\[ E_c = 3,220 \text{ ksi}, \ f_c = 1.8 \text{ ksi} \]

1. TRANSFORM SECTION:
\[ n = \frac{E_s}{E_c} = \frac{29,000}{3,220} = 9 \]
\[ A_{tr} = (3 \text{ in}^2)(9) = 27 \text{ in}^2 \]

2. DETERMINE NEUTRAL AXIS OF EFFECTIVE SECTION:
\[ A_c \bar{x}_c = A_s \bar{x}_s \]
\[ (12\text{"} \times x) \left( \frac{x}{2} \right) = (27 \text{ in}^2)(17 - x) \]
\[ 6x^2 = 459 - 27x \]
\[ 6x^2 + 27x - 459 = 0 \]
\[ x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \]

SOLVE WITH QUADRATIC EQUATION: \( x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \)
2. NEUTRAL AXIS, CONT'D...

\[ x = \frac{-4.5 \pm \sqrt{(4.5)^2 - 4(1)(-76.5)}}{2(1)} = 6.78'' \text{ or } -4.28'' \]

 IGNORING NEGATIVE ANSWER

3. FIND TRANSFORMED MOMENT OF INERTIA:

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

\[ I_s = A_x^2 = (27 \text{ in}^2)(10.22'')^2 = 2820 \text{ in}^4 \]

 ASSUMING MINUTE THICKNESS OF STEEL \rightarrow NO \ \text{KIN}^2 \text{ of 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:**

\[ f_s = 20 \text{ ksi} \]

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

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:**

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