CLASS # 18 - COMPOSITE BEAMS

OBJECTIVES:
1. Behavior of Composite Beams
2. Composite Beam Example - R/C

READ: CH 8.6 PHILPOT

0. COMPOSITE BEAMS

Composite Beam - Beam Constructed Of Two Or More Materials

E.g. Concrete Beam With Steel Reinforcement

Concrete
- Weak In Tension
- Strong In Compression
Steel
- Strong In Tension

Flexure Formula Was Developed For Homogeneous Beams
Not Applicable Directly For Composite Beams

Transformed Section Method

When Bending, Plane Sections Remain Plane
. . . Strain Varies Linearly

Integrate Stress Distribution To Find N.S.
EASIER TO TRANSFORM SECTION TO ONE EQUIVALENT MATERIAL AND USE FLEXURE FORMULA

\[ \text{SAY STIFFER \rightarrow THEN CARRIES GREATER LOAD} \]

\[ \text{WIDEN BEAM TO TAKE EQUIVALENT LOAD} \]

\[ dF_1 = 0 \, dA = (E_1 \varepsilon) \, dz \, dy \]

\[ \text{SAY, WE WIDEN E}_2 \text{ TO TAKE SAME LOAD} \]

\[ dF_1 = 0 \, dA = (E_2 \varepsilon) \, dz \, (n) \, dy \]

\[ \therefore \, E_1 \, \varepsilon \, \frac{dF_1}{dy} = E_2 \, \varepsilon \, n \, \frac{dF_1}{dy} \]

\[ n = \frac{E_1}{E_2} \]

APPLY FLEXURE FORMULA AS \text{ONE MATERIAL} IF
Concretes

1. Can take almost no tension

2. Outstanding in compression

3. Embed steel for tension
The reinforced concrete beam is used to support the loading shown. Determine the absolute maximum normal stress in each of the A-36 steel reinforcing rods and the absolute maximum compressive stress in the concrete. Assume the concrete has a high strength in compression and yet neglect its strength in supporting tension.
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\[ M_{\text{max}} = (10 \text{ kip})(4 \text{ ft}) = 40 \text{ kip-ft} \]

\[ A_r = 3(\pi)(0.5)^2 = 2.3562 \text{ in}^2 \]

\[ E_{st} = 29.0(10^3) \text{ ksi} \]

\[ E_{con} = 4.20(10^3) \text{ ksi} \]

\[ A' = \alpha A_r = \frac{29.0(10^3)}{4.20(10^3)}(2.3562) = 16.2690 \text{ in}^2 \]

\[ \Sigma \bar{y} = 0; \quad 8(k^2)\left(\frac{k}{2}\right) - 16.2690(13 - h') = 0 \]

\[ h'^2 + 4.06724h - 52.8741 = 0 \]

Solving for the positive root:

\[ h' = 5.517 \text{ in.} \]

\[ I = \frac{1}{12} (8)(5.517)^3 + 8(5.517)(5.517/2)^3 = 1358.781 \text{ in}^4 \]

\[ (\sigma_{st})_{\text{max}} = \frac{M_y}{I} = \frac{40(12)(5.517)}{1358.781} = 1.95 \text{ ksi} \quad \text{Ans} \]

\[ (\sigma_{con})_{\text{max}} = \frac{M_y}{4.20(10^3)I} = \left( \frac{29.0(10^3)}{4.20(10^3)} \right)\left( \frac{40(12)(13 - 5.517)}{1358.781} \right) = 18.3 \text{ ksi} \quad \text{Ans} \]