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ARCH 324 - Structures 2, Winter 2009

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Problem:

For the flitched beam show find the maximum allowable W load.

Transformed section:

\[ W = \frac{E_I}{h^3} = \frac{19 \times (10)^3}{12} = 1583.33 \text{ in}^4 \]

\[ I_T = \frac{b h^3}{12} = \frac{19 \times (10)^3}{12} = 1583.33 \text{ in}^4 \]

\[ n = \frac{E_{\text{steel}}}{E_{\text{wood}}} = \frac{30}{2} = 15 \]

Assume wood controls:

\[ M_{\text{max}} = \frac{W l^2}{8} \quad \text{also} \quad M_{\text{max}} = \frac{F I_T}{c} \]

\[ \frac{W l^2}{8} = \frac{F I_T}{c} \quad \Rightarrow \quad W = \frac{E_{\text{steel}} I_T \delta}{c l^2 (n)} = \frac{1.5 (1583.33) 8}{(5)(24 \times 12)^2} = 0.04581 \text{ kip/ft} \]

Assume steel controls:

\[ W = \frac{f_s I_T \delta}{c l^2 (n)} = \frac{20 (1583.33) 8}{5(24 \times 12)^2 (15)} = 0.407 \text{ kip/ft} \]

So, steel controls:

\[ W = 0.488 \text{ kip/ft} \quad \text{and} \quad \delta = 11.7 \text{ in} \]
$$W_{\text{total}} = \frac{M_{\text{max}} L}{8}$$
$$M_{\text{max}} = \frac{W_{\text{total}} L}{8}$$

**Transformed Section:**

$$M = \frac{E e}{E w} \cdot \frac{30}{2} = 15$$

$$I_{\text{tr}} = \frac{b h^3}{12} = \frac{19 (10)^3}{12} = 1583.33 \text{ in}^4$$

**Strain Compatibility:** (Alternate Method)

Assume wood controls strain

$$f_{\text{wood}} = \frac{E f}{E} = 15 \cdot \frac{0.00075}{0.00075} = 1.5 \text{ ksi}$$

**Stress - Steel**

$$f = Ee = 30,000 (0.00075) = 22.5 > 20$$

Steel controls strain!

**Strain - Steel**

$$E = \frac{f}{E} = \frac{20}{E} = \frac{0.000667}{E}$$

$$f_{\text{steel}} = 20 \text{ ksi}$$

**Stress - Wood**

$$f = E e = 2000 (0.000667) = 1.33 \text{ ksi}$$
Find Max Allowable Moment:

\[
f = \frac{M_c}{I}; \quad M = f \frac{I}{c} = \frac{1.33 \times (1583.33)}{5} = 422.22 \text{ in-k}
\]

For Steel:

\[
M = f \frac{I}{c(n)} = \frac{20 \times (1583.33)}{5 \times 15} = 422.22 \text{ ft-k}
\]

Moments agree; OK.

Find load \( W \):

\[
WJ = \frac{M \cdot b}{f} = \frac{35185}{24} = 11.73 \text{ k total}
\]