ARCH 324 - Structures 2, Winter 2009

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Given:

\[ b_0 = 80'' \quad \text{5'' subs} \]
\[ w_{124'' 	imes 68''} \]
\[ F_b' = 24 \text{ kips} \]
\[ F_c' = 1800 \text{ psi} \]
\[ n = \frac{1}{8} \]

Find:

1) Check the safety

\[ F_b' \geq F_b \]

Allowable, Actual.

**Step 1: Find \( M_{max} \)**

- Since asymmetrical loading, must use Diagrams.

Reactions:

\[ \Sigma M = 0 \]

\[ \Sigma F_y = 0 \]

\[ R_L = 48 \text{ kips} \]
\[ R_R = 50 \text{ kips} \]

Shear:

- Find \( x \) where \( V = 0 \)

\[ AV = \text{Area loading} \]
\[ Z = 1.2 \text{ kips} \text{/in} (x) \]
\[ x = 20'' \]

From Diag:

\[ M_{max} = 455 \text{ kips} \text{ft} \]
**STEP 2:** TRANSFORM TO "HOMOGENEOUS" SECTION.

\[ b_c = 80'' \]

\[ n = \frac{1}{8} \]

**GEOMETRY:**

STEEL - LOOK UP IN TABLES. (p. 347)

For W 24 x 68

- \( b = 8.965'' \)
- \( d = 23.73'' \)
- \( A = 20.1 \text{ in}^2 \)
- \( I = 1830 \text{ in}^4 \)
- \( S = 154 \text{ in}^3 \)

CONCRETE - TRANSFORM TO STEEL

Transformed \( b_c = b_c \times n \)

\[ = 80'' \left( \frac{1}{8} \right) = 10'' \]

**STEP 3:** FIND N.A.

\[ \Sigma A x = A x \text{ (p. 40)} \]

\[ \bar{x} = \frac{\Sigma A x}{A} = \frac{464 \text{ in}^3}{70.1 \text{ in}^2} = 6.62 \text{ in} \]

**REFERENCE:**

- \( x_{constr} = 10'' \)
- \( x_{concr} = 23.73'' \)

**STEP 4:** FIND ITR.

\[ I_{tr} = I + A \bar{x}^2, \quad I = \frac{b d^3}{12} \text{ for beam.} \]

- USE ONLY THE PORTION OF CONCRETE IN COMPRESSION, IGNORE CONCRETE BELOW N.A. (THIS CASE USE ALL THE CONCRETE)

<table>
<thead>
<tr>
<th>I (in^4)</th>
<th>A (in^2)</th>
<th>x (in)</th>
<th>A x^2</th>
<th>I + A x^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONC. ( 10(5)^3/12 )</td>
<td>10 x 5 = 50</td>
<td>4.12</td>
<td>848.7</td>
<td>952.9</td>
</tr>
<tr>
<td>STL. 1830</td>
<td>20.1</td>
<td>22.17 x 22.17 ( = 10.28 )</td>
<td>2122.1</td>
<td>3952.1</td>
</tr>
</tbody>
</table>

\[ I_{tr} = 4905 \text{ in}^4 \]
STEP 5: FIND $F_0$

$$F_0 = \frac{M_c E_0}{I_{co}} \leq \text{GENERAL EQUATION}$$

Since "link-in" $M_c$ must convey concrete stress, $F_{conk} = \frac{M_c E_0}{I_{co}} = \frac{455 \text{ kft} \times (0.62'')(1/8) \times 12''}{4905 \text{ in}^4} = 9.21 \text{ psi}$

$$F_{stl} = \frac{M_c I}{I_{tr}} = \frac{455 \text{ kft} \times (22.17'') \times 12''/1}{4905 \text{ in}^4} = 24.7 \text{ ksi}$$

STEP 6: CHECK SAFETY

$$F'_{stl} \geq \frac{F_{stl}}{\gamma} \Rightarrow 24 \text{ ksi} \neq 24.7 \text{ ksi}$$

N.G. - STEEL FAILS!!!

$$F'_{conc} \geq \frac{F_{conc}}{\gamma} \Rightarrow 1800 \text{ psi} \neq 921 \text{ psi} \text{ V.A.K.}$$

IN CONCLUSION, THE BEAM IS NOT ADEQUATELY DESIGNED SINCE STEEL FAILS.