ARCH 324 - Structures 2, Winter 2009

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Given:
$bc = 80''$
$\frac{5''}{6''}$
$124'' \times 68''$
$F_{v1} = 24'' kfl$
$F_{v2} = 1800 psi$
$n = 1/8$

Find:
0. Crash the Safety
$F_{b1} \geq F_{b2}$
Allow: Actual

Step 1: Find $M_{max}$
- Since Unsymmetrical Loading, Must Use Diag. $d$

Reactions:
$\Sigma M_{O} = 0 = 16''(5'') + 48''(20') + 32''(30')$
$- R_{R}(90'')$

$R_{L} = 50''$

Shear:
Find $x$ where $V = 0$
$AV = Area Loading$
$24''x = 1.2 kfl (x)$
$x = 20''$

From Diag:
$M_{max} = 455''$
STEP 2: TRANSFORM TO "HOMOGENEOUS" SECTION.

\[ b_c = 80'' \]

\[ \frac{10''}{n} \]

\[ 11'' \times 68 \]

\[ \frac{23.75''}{23.75''} \]

\[ \frac{5''}{S} \]

\[ \text{ALL "STEEL"} \]

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

\[ \text{transformed } b_c = b_c \times n \]

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

STEP 3: FIND N.A.

\[ \sum A_x = A \bar{x} \quad (p. 40) \quad \Rightarrow \quad \bar{x} = \frac{\sum A_x}{A} = \frac{464}{701.1} = 0.662 \text{ in} \quad \text{from the top} \]

<table>
<thead>
<tr>
<th>CONC.</th>
<th>10'' x 5'' = 50</th>
<th>X (in)</th>
<th>A x (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8</td>
<td>2.5</td>
<td></td>
<td>125</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STL</th>
<th>20.1</th>
<th>[ \frac{23.93 + 5}{2} = 16.9 ]</th>
<th>339.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>70.1</td>
<td>4104</td>
<td></td>
</tr>
</tbody>
</table>

STEP 4: FIND ITR.

\[ I_{TR} = I + A \bar{x}^2 \]

\[ I = \frac{b_d^3}{12} \quad \text{for beam.} \]

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

\[ C_c \]

\[ C_t \]

<table>
<thead>
<tr>
<th>I (in(^4))</th>
<th>A (in(^2))</th>
<th>X (in)</th>
<th>[ A \bar{x}^2 ]</th>
<th>[ I + A \bar{x}^2 ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONC.</td>
<td>10(5)(^3)/12</td>
<td>10 x 5 = 50</td>
<td>6.62 - [ \frac{5}{2} ]</td>
<td>848.7</td>
</tr>
<tr>
<td>STL.</td>
<td>1830</td>
<td>20.1</td>
<td>22.57 - [ \frac{22.57}{2} ]</td>
<td>2122.1</td>
</tr>
</tbody>
</table>

\[ I_{TR} = 4905 \text{ in}^4 \]

\[ \Rightarrow \quad I_{TR} = 4905 \text{ in}^4 \]
**STEP 5:** Find \( F_0 \)

\[
F_0 = \frac{Mc}{I_{cr}} \quad \text{GENERAL EQUATION}
\]

\[
F_{cmk} = \frac{Mc_{cmk}}{I_{cr}} = \frac{455 \text{ kft} \times (0.62 \text{ in}) \times (18) \times 12^\prime}{4905 \text{ in}^4} = 921 \text{ psi}
\]

\[
F_{cm} = \frac{Mc}{I_{cr}} = \frac{455 \text{ kft} \times (22.17 \text{ in}) \times 12^\prime}{4905 \text{ in}^4} = 24.7 \text{ KSI}
\]

**STEP 6:** Check Safety

\[
F_{cmk} \geq F_{cm} \quad \Rightarrow \quad 921 \text{ psi} \neq 24.7 \text{ KSI}
\]

N.C. - STEEL FAILS!!

\[
F_{conc} = F_{conc} = 1800 \text{ psi} \geq 921 \text{ psi} \quad \text{V.A.K.}
\]

**IN CONCLUSION,** the beam **is not adequately designed** since steel fails.