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ARCH 324 - Structures 2, Winter 2009

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Given:

Framing Plan

D.L + L.L = 200 psf

Effective Width = 90"

Section

\[ n = \frac{1}{9} \left[ \frac{\text{Ec}}{\text{Es}} \right] \]

\[ f_{\text{steel}} = 24 \text{ ksi} \]

\[ f_{\text{concrete}} = 1.35 \text{ ksi} \]

1. Loading Diagram.

\[ W = 156k \]

\[ W = \omega l = 2600 \text{ psf} \times 60' \]

\[ W = 156k \]
2. Determine most economical section (W shape) to carry load without composite action.

For a simply supported uniformly loaded beam,

Max. Bending Moment,
\[ M = \frac{WL}{8} = \frac{156 \times 60}{8} \]

\[ \therefore M = 1170 \text{ kips} \]

Thus,
\[ S = \frac{M}{f} = \frac{1170 \times 12}{24 \times 2500} \]

\[ \therefore S = 585 \text{ in}^3 \]

From Table D-35, for \( S_x = 585 \text{ in}^3 \), sections appropriate are,

- W 30 x 191 \( 598 \text{ in}^3 \)
- W 33 x 201 \( 684 \text{ in}^3 \)

\( \rightarrow \) W 36 x 182 \( 623 \text{ in}^3 \)

Thus 'W 36 x 182' is used.

3. Transformed Section

\[ h = \frac{1}{q} = \frac{E_c}{E_s} \]

\( \therefore \) transforming the concrete to an equivalent area of steel by reducing the width we get,
4. LOCATION OF NEUTRAL AXIS
   (USING D-28)

\[ \bar{x} = \frac{\int_A x \, A \, dx}{\int_A A \, dx} \]

\[
\begin{array}{c|c|c}
A & \bar{x} & A \\
50 \text{ in}^2 & 2.5'' & 125 \text{ in}^3 \\
\end{array}
\]

\[ I = 391.7 \text{ in}^4 \]

\[ 22.75'' = 904.1675 \text{ in}^3 \]

\[ \bar{x} = \frac{\int A \, x \, dx}{\int A \, dx} = \frac{1029.175}{89.7} \]

\[ \bar{x} = 11.47'' \text{ (from top)} \]

5. TRANSFORMED MOMENT OF INERTIA
   (By Parallel Axis Theorem)

\[
\begin{array}{c|c|c}
I_{TR} & I_A & Ad^2 \\
10 & \frac{bd^3}{12} = \frac{10.15^3}{12} & 50(11.47 - 2.5)^2 \\
 & = 104.17 & = 4023 \\
I & 7800 & 39.7(11.3)^2 \\
 & = 5073.78 \\
\end{array}
\]

\[ I_A = I_R + Ad^2 \]

\[ I_A = 104.17 + 4023 = 4127.17 \]

\[ + I = 7800 + 5073.78 = 12873.78 \]

\[ \therefore I_{TR} = 17000.99 \text{ in}^4 \]
STRESSES

Now, \[ M_c = \frac{f_c}{C} \frac{I_{TR}}{n} \]

\[ M_c = \frac{1.35 (7001)}{11.47 (1/9)} = 18008.9 \, \text{k}-\text{in} \]

\[ M_s = \frac{f_s I_{TR}}{C} \]

\[ M_s = \frac{24 (7001)}{29.08} = 14031.08 \, \text{k}-\text{in} \leftarrow \text{CONTROLS} \]

\[ f_s = 24 \, \text{ksi} \]

\[ f_c = \frac{M_c C_n}{I_{TR}} = \frac{14031.08 (11.47)^{1/9}}{7001} \]

\[ f_c = 1.052 \, \text{ksi} \]