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APPENDIX A

EXAMPLE OF AISC FLEXURAL THEORY CALCULATIONS

The flexural strength for Beam Test 1 is calculated using the AISC flexural theory outlined in Sec. 8.3.2.

Test Parameters:

- **Beam span:** 30.0 ft
- **Slab:**
  - Slab depth = 5.0 in.
  - Slab width = 81.0 in.
- **Concrete:**
  - $f'_c = 5000$ psi
  - $w = 141.3$ pcf
  - $E_c = 57000(5000)^{0.5} = 4 \times 10^6$ psi
- **Steel beam:**
  - Section = W16x31
  - $A_s = 9.12$ in$^2$
  - $d = 15.88$ in.
  - $b_f = 5.525$ in.
  - $t_f = 0.44$ in.
  - $t_w = 0.275$ in.
  - $A_{sf} = b_f \times t_f = (5.525)(0.44) = 2.431$ in$^2$
  - $A_{sw} = A_s - 2A_{sf} = 9.12 - 2(2.431) = 4.258$ in$^2$
  - $F_{yw} = 58.2$ ksi
  - $F_{yk} = 54.3$ ksi
- **Studs:**
  - diameter = 0.75 in. ($A_{sc} = 0.4418$ in$^2$)
  - $H_s = length = 3.5$ in.
  - $F_u = 66.81$ ksi
  - no. of studs = 12
- **Deck:**
  - $h_r = height = 2$ in.
  - $w_r = ave. \ rib \ width = 6$ in.
20 gauge

Calculations:

1. Sum the strengths of the studs, $Q_{c}$ or $Q_{AISC}$, located between zero and maximum moment.

   \[
   Q_{AISC} = SRF \times 0.5A_{sc} \sqrt{f'_c E_c} \leq A_{sc} F_u
   \]

   \[
   SRF = \frac{0.85}{\sqrt{N_r}} \left( \frac{w_r}{h_r} \right) \left( \frac{H_s}{h_r} \right) - 1.0 \leq 1.0
   \]

   \[
   SRF = \frac{0.85}{1} \left( \frac{6}{2} \right) \left( \frac{3.5}{2} \right) - 1.0 = 1.91 > 1.0, \quad \text{use } SRF = 1.0
   \]

   \[
   SRF \times 0.5A_{sc} \sqrt{f'_c E_c} = 1.0(0.5)(0.4418) \sqrt{\left( \frac{5000}{1000} \right)} = 31.4 \text{ k}
   \]

   \[
   A_{sc} F_u = (0.4418)(66.81) = 29.5 \text{ k}
   \]

   \[
   Q_{AISC} = 29.5 \text{ k}
   \]

   \[
   \sum Q_{AISC} = 12(29.5) = 354 \text{ k}
   \]

2. Calculate the effective width, $b_e$, of the concrete slab.

   \[
   b_e = \text{minimum of } \frac{1}{4} \text{ (beam span)} = \frac{1}{4} \text{ (30 ft)} = 7.5 \text{ ft} = 90 \text{ in.}
   \]

   \[
   1/2 \text{ (distance to c.l. of adjacent beams)} = \text{Not Applicable}
   \]

   \[
   \text{distance to edge of slab} = 81 \text{ in.}
   \]

   \[
   b_e = 81 \text{ in.}
   \]

3. Calculate the force, $C$, in the concrete slab at ultimate load. This value is taken as the minimum of $C_1$, $C_2$, and $C_3$, where

   \[
   C_1 = A_s F_y = A_{sf} F_{sf} + A_{sw} F_{yw} = (2)(2.431)(54.3) + (4.258)(58.2) = 512 \text{ k}
   \]

   \[
   C_2 = 0.85 f'_c A_c = 0.85 f'_c b_e (t_{slab} - h_r) = 0.85(5)(81)(5 - 2) = 1033 \text{ k}
   \]

   \[
   C_3 = \sum Q_{AISC} = 354 \text{ k}
   \]
4. Calculate the depth, \( a \), of the equivalent rectangular stress block in the slab.

\[
a = \frac{C}{0.85 f_c' b_e} = \frac{354}{0.85(5)(81)} = 1.03 \text{ in.}
\]

5. Determine the location of the plastic neutral axis (p.n.a.).

Because \( \sum Q_{\text{disc}} < A_s F_y \), the p.n.a. is located in the steel section.

Determine location of p.n.a. First assume p.n.a. is in web.

- \( C_f = \) compression force in flange = \( A_{sf} F_{yf} = (2.431)(54.3) = 132 \text{ k} \)
- \( T = C_f - C_f = \) remainder of force in steel section = \( 512 - 132 = 380 \text{ k} \)
- \( C_f + C = \) total compression force = \( 132 + 354 = 486 \text{ k} \)

\( C_f + C > T \), therefore p.n.a. is in flange

Determine location of p.n.a. knowing it is in flange.

\[
T_y = \text{tension force in steel section} = \frac{(A_s F_y + C)}{2} = 433 \text{ k}
\]

\[
T_w = \text{tension force in web} = A_{sw} F_{yw} = (4.258)(58.2) = 248 \text{ k}
\]

\[
T_{fb} = \text{tension force in bottom flange} = A_{sf} F_{yf} = (2.431)(54.3) = 132 \text{ k}
\]

\[
T_{ft} = \text{tension force in top flange} = T_y - T_w - T_{fb} = 433 - 248 - 132 = 53 \text{ k}
\]

\[
s = \text{portion of top flange in tension} = \frac{T_{ft}}{b_f F_{yf}} = \frac{53}{(5.525)(54.3)} = 0.18 \text{ in.}
\]

\[
\rho = \text{portion of top flange in compression} = t_f - s = 0.26 \text{ in.}
\]

\[
C_f = \text{compression force in top flange} = \rho b_f F_{yf} = (0.26)(5.525)(54.3) = 78 \text{ k}
\]

Therefore, the p.n.a. is located in the flange 0.26 in. from the top of the beam.
6. Calculate the flexural strength of the beam. Summing the couples caused by the compression force in the slab and the compression and tension forces in the beam about the top flange of the steel section yields the following equation:

\[
M_{AISC} = C \left( \text{slab depth} - \frac{a}{2} \right) - C_f \left( \frac{p}{2} \right) + T_{f_{b}} \left( p + \frac{s}{2} \right) + T_{w} \left( \frac{d}{2} \right) + T_{f_{b}} \left( d - \frac{t_{f}}{2} \right)
\]

\[
= 354 \left( 5 - \frac{1.03}{2} \right) - 78 \left( \frac{0.26}{2} \right) + 53 \left( 0.26 + \frac{0.18}{2} \right) + 248 \left( \frac{15.88}{2} \right) + 132 \left( 15.88 - \frac{0.44}{2} \right)
\]

\[
= 5632 \text{ k-in.} = 469 \text{ k-ft}
\]
VITA

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