Description:

Provide a continuous torsional brace per AISC Appendix 6. Provide shear studs connection the beam to the concrete slab
Find the required strength and stiffness of the slab to bracing the beam

Material properties:

Concrete at 28 days: $f'_c := 3000 \cdot psi$ $E := E_c(f'_c, 0)$ $E = 3155.92\ ksi$

Reinforcing Steel Yield Stress: $f_y := 60 \cdot ksi$

ASTM A992 Steel rolled shapes: $F_y := 50 \cdot ksi$

Code Parameters:

Safety Factor per 6.2.a: $\Omega := 3$

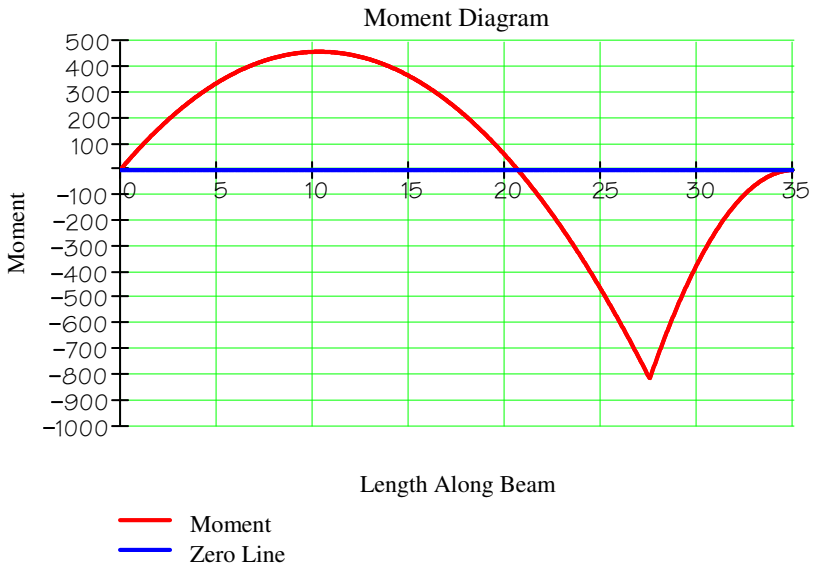
Geometry:

Assumed Beam Spacing: $Spacing := 30ft$

For an interior beam, the slab stiffness and strength comes from two adjacent spans, one each side of the beam.: $N := 2$

By trial and error, find the unbraced length that gives the design moment: $L_q := 10.25 \cdot ft$

Loading: Assumed moment diagram:



$M_A := M\left(\frac{A}{4 \cdot ft}\right)$ $M_A = 410\ k'$ $M_B := M\left(\frac{A}{2 \cdot ft}\right)$ $M_B = 411\ k'$ $M_C := M\left(\frac{3 \cdot A}{4 \cdot ft}\right)$ $M_C = 2\ k'$

Bending Moment: $M_{max} := \left| M\left(\frac{A}{ft}\right) \right|$ $M_{max} = 816\ k'$

Use Beam Size: Depth = 30 in Wt = 116 plf

Distance between the flanges: $h_o := d - 2t_f$ $h_o = 28.31\,in$ $t_w = 0.57\,in$

By trial and error, find the unbraced length that gives the design moment: $L_q = 10.25\,ft$

Torsional Bracing between the supports :

The distortional stiffness for an unstiffened web (A-6-13): $\beta_{sec} := \frac{3.3 \cdot E_s \cdot t_w^{\,3}}{12 \cdot h_o}$ $\beta_{sec} = 50.8 \frac{kip \cdot in}{in}$

$C_b := \min\left(\frac{12.5 \cdot M_{max}}{2.5M_{max} + 3 \cdot M_A + 4 \cdot M_B + 3M_C}, 3\right)$ $C_b = 2.07$

The required bracing moment: $M_{br} := \frac{.024 \cdot M_r}{C_b \cdot L_q}$ $M_{br} = 1.02 \frac{k'}{ft}$

Required brace stiffness excluding web distortion: $\beta_T := \Omega \cdot \frac{2.4 \cdot M_{max}^{\,2}}{E_s \cdot I_y \cdot C_b^{\,2}}$ $\beta_T = 33.8 \frac{k'}{ft}$

$if(\beta_T \le \beta_{sec}, OK, NG) = "O.K."$

The required slab torsional bracing stiffness $\beta_{Tb} := \frac{\beta_T}{1 - (\beta_T \div \beta_{sec})}$ $\beta_{Tb} = 100.6 \frac{kip \cdot in}{in}$

Solve for slab thickness. assuming single curvature of the slab: Given $N \cdot \frac{2 \cdot E \cdot (t^3 \div 12)}{Spacing} = \beta_{Tb}$ $t_{req} := Find(t)$

Uncracked slab thickness required: $t_{req} = 3.25\,in$

Solve for the cracked slab moment of inertia: $I_{cr} := \frac{\beta_{Tb} \cdot Spacing}{N \cdot 2 \cdot E}$ $I_{cr} = 34.4 \frac{in^4}{ft}$