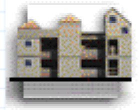


CHAPTER 5: Structural Steel Columns - ASD Design

5.1 Wide Flange Columns

Description

The selection of steel columns, subject to axial load and bending, can sometimes involve a tedious, iterative process. The first step requires guessing at a suitable trial section or using an elaborate set of formulas to select a first trial selection for the steel columns. The second step requires checking the first trial section to ensure that it satisfies the AISC Specification (specifically, the AISC interaction equations). If the first trial selection is not satisfactory, then the process must be repeated with a second trial section. In some cases additional iterations are required to ensure that the lowest weight section is obtained.

This application allows the user to rapidly check trial sections and to determine that the standards of the AISC Specification, Eqs. (H1-1) and (H1-2), are met. For input, the user only needs to enter the flange width, the section depth and the section weight. The necessary section properties and parameters are then computed by this application. Once the trial section is found satisfactory, the user may enter the actual values of the flange width, the section depth, the flange thickness and the web thickness to check that AISC Specification, Eqs. (H1-1) and (H1-2) are satisfied.

This application computes the section properties, compact section criteria, lateral bracing lengths, and slenderness ratios of I or H shaped column sections. In addition, it computes the actual and allowable axial and bending stresses, the amplification factors and moment modifiers, and the beam-column interaction equations following the AISC Specification for a column with axial load and end moments about one or both axes. (Formulas from Sections B, E, F and H of the AISC Specification are computed within this application.)

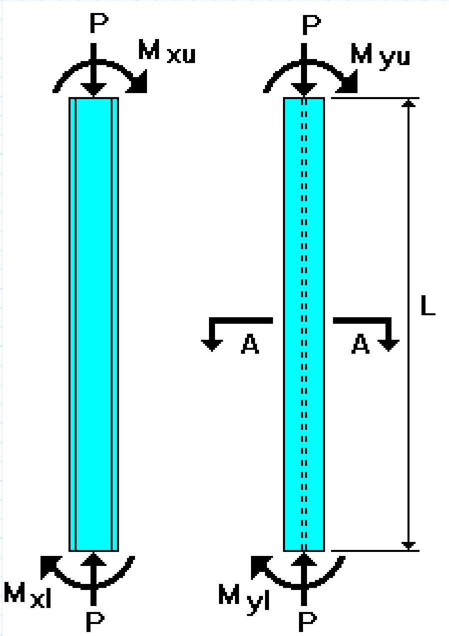
The required input includes the axial load and end moments about one or both axes, unbraced column length, effective length factors, yield strength, indication as to whether the column is free to sway about one or both axis directions, assumed depth, width and weight of section for initial trials, plus the flange and web thicknesses for check of the final section.

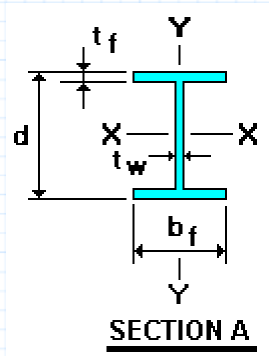
A summary listing input values, the solution of the interaction equations, and the computed values are shown on pages 17-19.

Reference: AISC "Specification for Structural Steel Buildings -- Allowable Stress Design and Plastic Design with Commentary." June 1, 1989

Input

Notation





Input Variables

Yield strength of steel: $F_y := 36\ ksi$

Column axial load: $P := 200\ kip$

Unbraced column length: $L := 11.5\ ft$

End moment about the X axis, at the upper end of the column: $M_{xu} := 120\ kip \cdot ft$

End moment about the X axis, at the lower end of the column: $M_{xl} := -120\ kip \cdot ft$

End moment about the Y axis, at the upper end of the column:

$M_{yu} := 40\ kip \cdot ft$

End moment about the Y axis, at the lower end of the column:

$M_{yl} := -40\ kip \cdot ft$

Note : Positive values of M indicate clockwise moments and negative values indicate counter-clockwise moments.

Effective length factor relative to the X axis:

$K_x := 1.0$

Effective length factor relative to the Y axis:

$K_y := 1.0$

Variable "X_Sway" defined as 0 if sidesway is prevented, and 1 if sidesway is permitted:

$X\_Sway := 0$

Variable "Y_Sway" defined as 0 if sidesway is prevented, and 1 if sidesway is permitted:

$Y\_Sway := 0$

Section Dimensions and Weight

Enter estimated values for the section depth, flange width and section weight. Define the flange and web thickness equal to 0 inches for preliminary trial section selections, or enter the actual section depth, flange width, web thickness, flange thickness and section weight if checking a specific section.

Section depth: $d := 14.32\ in$

Flange width: $b_f := 14.605\ in$

Web thickness: $t_w := 0.525\ in$

Flange thickness: $t_f := 0.860\ in$

Section weight per unit length: $W := 109\ \frac{lb}{ft}$

Computed Section Properties

A cross section area of member

I_x moment of inertia about the X axis

r_x radius of gyration about the X axis

S_x section modulus about the X axis

I_y moment of inertia about the Y axis

r_y radius of gyration about the Y axis

S_y section modulus about the Y axis

r_T radius of gyration of the compression flange + 1/3 of compression web area about an axis in the plane of the web

Computed Variables

f_a axial compressive stress

f_{b_xu} bending stress about the X axis at the upper end of the column

f_{b_xl} bending stress about the X axis at the lower end of the column

f_{b_yu} bending stress about the Y axis at the upper end of the column

f_{b_yl} bending stress about the Y axis at the lower end of the column

F_a allowable compressive axial stress
(AISC Specification, Eqs. (E2-1) and (E2-2))

F_{bx} allowable bending stress about the X axis
(AISC Specification, Eqs. (F1-1), (F1-2), (F1-3) and (F1-5))

F_{by} allowable bending stress about the Y axis
(AISC Specification, Identity (F2-2) and Eq. (F2-3)

F'_{ex} Euler's stress about the X axis divided by a factor of safety
(AISC Specification, Sect. H-1)

F'_{ey} Euler's stress about the Y axis divided by a factor of safety
(AISC Specification, Sect. H-1)

C_c slenderness ratio separating elastic and inelastic behavior
(AISC Specification, Eq. (E2-1))

C_{mx} moment modifier coefficient about the X axis
(AISC Specification, Sect. H-1)

C_{my} moment modifier coefficient about the Y axis
(AISC Specification, Sect. H-1)

C_b moment modifier factor (AISC Specification, Sect. F1-3)

L_c maximum unbraced length of a compact section at which allowable strong axis (X axis) bending may be $0.66F_y$
(AISC Specification, Eq. (F1-2))

L_u maximum unbraced length of a section at which allowable strong axis (X axis) bending may be $0.60F_y$
(AISC Specification, Eq. (F1-2))

CF a variable defined within this application to reflect compact section criteria of AISC Specification, Table B5.1. (CF = 2 if both flange and web are compact, 1 if flange is compact, and 0 if neither the flanges nor the web are compact.)

FR maximum ratio of half the flange to the flange thickness, for a compact shape (AISC Specification, Table B5.1)

FR_{max} maximum ratio of half the flange to the flange thickness, for a non-compact shape (AISC Specification, Table B5.1)

WR(fa) maximum ratio of the section depth to the web thickness for webs in compression or combined flexural and axial compression, as a function of axial stress

Calculations

This application is limited to steel with a yield strength less than or equal to 65 ksi:

$$F_y := \text{if}\left(F_y > 65 \cdot ksi, 65 \cdot ksi, F_y\right) \qquad F_y = 36\ ksi$$

Dimensions and Properties

The approximate area and moment of inertia of fillets between the web and flanges of rolled sections are computed assuming circular fillets with a radius of 0.4 inches for W8 shapes, 0.5 inches for W10 shapes, and 0.6 inches for for W12 and W14 sections. Some computed properties may vary slightly from values tabulated in the AISC Manual due to varying assumptions of fillet sizes. The distance between the inner face of the flanges is used to distinguish between shapes.

Clear distance between flanges:

$$T := d - 2 \cdot t_f \qquad T = 12.6\ in$$

Estimated radius of circular radius fillets between flange and web:

$$r := \text{if}\left(T \le 7.13\ in, 0.4\ in, \text{if}\left(T \le 8.86\ in, 0.5\ in, 0.6\ in\right)\right) = 0.6\ in$$

Area of four circular radius fillets:

$$A_o := 4 \cdot r^2 \cdot \left(1 - \frac{\pi}{4}\right) = 0.309\ in^2$$

Moment of inertia of four circular radius fillets:

$$I_o := r^4 \cdot \left(\frac{1}{3} - \frac{\pi}{16} - \frac{1}{36 \cdot \left(1 - \frac{\pi}{4}\right)}\right) \qquad I_o = 0.00098\ in^4$$

Distance from the centroid of a fillet to the face of the web or flange:

$$z := r \cdot \left(1 - \frac{1}{6 \cdot \left(1 - \frac{\pi}{4}\right)}\right) \qquad z = 0.134\ in$$

Cross section area of member:

$$A := \text{if}\left(t_f = 0 \cdot in, \frac{W}{3.4} \cdot \frac{in^2 \cdot ft}{lb}, 2 \cdot b_f \cdot t_f + t_w \cdot \left(d - 2 \cdot t_f\right) + A_o\right) = 32.045\ in^2$$

Estimated flange thickness:

$$t_f := \text{if}\left(t_f = 0 \cdot in, \frac{\left(\frac{8 \cdot b_f}{5} + \frac{d}{2}\right) - \sqrt{\left(\frac{8 \cdot b_f}{5} + \frac{d}{2}\right)^2 - \frac{16}{5} \cdot (A - A_o)}}{2}, t_f\right) = 0.86\ in$$

Estimated web thickness:

$$t_w := \text{if}\left(t_w = 0\ in, \frac{5}{8} \cdot t_f, t_w\right) \qquad t_w = 0.525\ in$$

Estimated section weight if the entered flange thickness is 0 inches, or the actual section weight entered:

$$W := \text{if}\left(W = 0 \cdot \frac{lb}{ft}, A \cdot 3.4 \cdot \frac{lb}{ft \cdot in^2}, W\right) \qquad W = 109\ \frac{lb}{ft}$$

Moment of inertia about the X axis:

$$I_x := \frac{b_f \cdot t_f \cdot (d - t_f)^2}{2} + \frac{t_w \cdot (d - 2 \cdot t_f)^3}{12} + \frac{b_f \cdot t_f^3}{6} + I_o + A_o \cdot \left(\frac{d}{2} - t_f - z\right)^2 \qquad I_x = 1238.6\ in^4$$

Section modulus about the X axis:

$$S_x := \frac{2 \cdot I_x}{d} \qquad S_x = 173\ in^3$$

Radius of gyration about the X axis:

$$r_x := \sqrt{\frac{I_x}{A}} \qquad r_x = 6.22\ in$$

Moment of inertia about the Y axis:

$$I_y := \frac{t_f \cdot b_f^3}{6} + \frac{(d - 2 \cdot t_f) \cdot t_w^3}{12} + I_o + A_o \cdot \left(\frac{t_w}{2} + z\right)^2 = 446.733\ in^4$$

Section modulus about the Y axis:

$$S_y := \frac{2 \cdot I_y}{b_f} \qquad S_y = 61.18\ in^3$$

Radius of gyration about the Y axis:

$$r_y := \sqrt{\frac{I_y}{A}} \qquad r_y = 3.73\ in$$

Area of one flange and the ratio of section depth to the area of the compression flange:

$$A_f := b_f \cdot t_f \qquad A_f = 12.56\ in^2 \qquad \frac{d}{A_f} = 1.14\ in^{-1}$$

Radius of gyration of a T-section comprised of the compression flange plus 1/3 of the compression web area:

$$r_T := \sqrt{\frac{\frac{1}{12} \cdot t_f \cdot b_f^{\,3} + \frac{1}{12} \cdot \frac{d - 2 \cdot t_f}{6} \cdot t_w^{\,3} + \frac{1}{2} \cdot \left(I_o + A_o \cdot \left(\frac{t_w}{2} + z\right)^2\right)}{b_f \cdot t_f + \frac{d - 2 \cdot t_f}{6} \cdot t_w + \frac{A_o}{2}}}$$

$$r_T = 4.02\ in$$

Axial and Bending Stresses

Axial stress:

$$f_a := \frac{P}{A} \qquad f_a = 6.2\ ksi$$

Bending stress due to moment about the X axis at the upper end of the column:

$$f_{b\_xu} := \frac{M_{xu}}{S_x} \qquad f_{b\_xu} = 8.3\ ksi$$

Bending stress due to moment about the X axis at the lower end of the column:

$$f_{b\_xl} := \frac{M_{xl}}{S_x} \qquad f_{b\_xl} = -8.3\ ksi$$

Bending stress due to moment about the Y axis at the upper end of the column:

$$f_{b\_yu} := \frac{M_{yu}}{S_y} \qquad f_{b\_yu} = 7.8\ ksi$$

Bending stress due to moment about the Y axis at the lower end of the column:

$$f_{b\_yl} := \frac{M_{yl}}{S_y} \qquad f_{b\_yl} = -7.8\ ksi$$

Slenderness ratios about the X and Y axes:

$$\frac{K_x \cdot L}{r_x} = 22.2 \qquad \frac{K_y \cdot L}{r_y} = 37$$

Larger slenderness ratio:

$$SR := \text{if}\left(\frac{K_x \cdot L}{r_x} > \frac{K_y \cdot L}{r_y}, \frac{K_x \cdot L}{r_x}, \frac{K_y \cdot L}{r_y}\right) \qquad SR = 37$$

If SR is >200 a larger section or bracing is required.

Modulus of elasticity of steel:

$$E := 29000\ ksi$$

Column slenderness ratio separating elastic and inelastic buckling
(AISC Specification, Eq. (E2-1)):

$$C_c := \sqrt{\frac{2 \cdot \pi^2 \cdot E}{F_y}} = 126.099$$

Allowable axial stress (AISC Specification, Eqs. (E2-1) and (E2-2)) combined with SR substituted for Kl/r:

$$F_a := \text{if}\left(\left((SR > C_c) \cdot (SR \le 200)\right), \frac{12\ \pi^2 \cdot E}{23\ SR^2}, \text{if}\left(SR > 200, 0\ ksi, \frac{\left(1 - \frac{SR^2}{2 \cdot C_c^{\ 2}}\right) \cdot F_y}{\frac{5}{3} + \frac{3\ SR}{8\ C_c} - \frac{SR^3}{8 \cdot C_c^{\ 3}}}\right)\right)$$

$$F_a = 19.4\ ksi$$

Ratio of the smaller end moment Mxa, to the larger end moment Mxb about the X axis:

$$M_{xa} := \text{if}\left(\left|M_{xu}\right| < \left|M_{xl}\right|, M_{xu}, M_{xl}\right)$$

$$M_{xb} := \text{if}\left(M_{xa} = M_{xu}, M_{xl}, M_{xu}\right)$$

$$\frac{M_{xa}}{M_{xb}} = -1$$

Ratio of the smaller end moment M_{ya}, to the larger end moment M_{yb} about the Y axis:

$$M_{ya} := \textbf{if}\left(\left|M_{yu}\right| < \left|M_{yl}\right|, M_{yu}, M_{yl}\right)$$

$$M_{yb} := \textbf{if}\left(M_{ya} = M_{yu}, M_{yl}, M_{yu}\right)$$

$$\frac{M_{ya}}{M_{yb}} = -1$$

Moment modifier factor C_b (AISC Specification, Sect. F1-3):

$$C_b := 1.75 + 1.05 \cdot \frac{M_{xa}}{M_{xb}} + 0.3 \cdot \left(\frac{M_{xa}}{M_{xb}}\right)^2$$

$$C_b := \textbf{if}\left(\left(X\_Sway = 0\right) \cdot \left(f_a > 0 \cdot ksi\right), 1.0, \textbf{if}\left(C_b < 2.3, C_b, 2.3\right)\right)$$

$$C_b = 1$$

When the ends of the member are braced to prevent sidesway in the X direction and the axial stress is greater than 0 ksi, then C_b equals 1.0.

Compact Section Criteria

Limiting ratio of one-half the flange width to the flange thickness for compact shapes (AISC Specification, Table B5.1):

$$FR := \frac{65}{\sqrt{\frac{F_y}{ksi}}} \qquad FR = 10.833$$

Limiting ratio of one-half the flange width to the flange thickness for non-compact shapes (AISC Specification, Table B5.1):

$$FR_{max} := \frac{95}{\sqrt{\frac{F_y}{ksi}}} \qquad FR_{max} = 15.833$$

Section depth to web thickness ratio for webs in compression or combined flexural and axial compression for compact sections (AISC Specification, Table B5.1) modified by expressing the limiting ratio as a function of f_a:

$$WR\left(f_a\right) := \textbf{if}\left(\frac{f_a}{F_y} \le 0.16, \frac{640}{\sqrt{\frac{F_y}{ksi}}} \cdot \left(1 - 3.74 \cdot \frac{f_a}{F_y}\right), \frac{257}{\sqrt{\frac{F_y}{ksi}}}\right)$$

Actual ratios of one-half the flange width to flange thickness and section depth to web thickness, and the limiting ratios for a compact flange FR, a compact web WR(f_a), and the maximum permissible flange ratio for a non-compact section FR_{max}:

$$\frac{b_f}{2 \cdot t_f} = 8.5 \qquad FR = 10.8 \qquad FR_{max} = 15.8$$

$$\frac{d}{t_w} = 27.3 \qquad WR\left(f_a\right) = 42.8$$

Variable CF defined to test for compact section criteria. If both the web and flange are compact, CF = 2; if the flange is non-compact and the web is compact, CF = 1; and if the web is non-compact and the flange is either compact or non-compact, CF = 0.:

$$CF := \textbf{if}\left(\left(\frac{b_f}{2 \cdot t_f} \le FR\right) \cdot \left(\frac{d}{t_w} \le WR\left(f_a\right)\right), 2, \textbf{if}\left(\left(\frac{b_f}{2 \cdot t_f} \ge FR\right) \cdot \left(\frac{d}{t_w} \le WR\left(f_a\right)\right), 1, 0\right)\right)$$

$$CF = 2$$

Lateral bracing lengths, L_u and L_c (AISC Specifications, Eq. (F1-2)):

$$L_u := \frac{20000}{\frac{d}{b_f \cdot t_f} \cdot \frac{F_y}{ksi}} = 40.607\ ft$$

$$L_{c1} := \frac{76 \cdot b_f}{\sqrt{\frac{F_y}{ksi}}} = 15.416\ ft$$

$$L_c := \textbf{if}\left(L_{c1} < L_u, L_{c1}, L_u\right) = 15.416\ ft$$

Allowable bending stress for adequately braced, compact and non-compact sections (AISC Specifications, Eqs. (F1-1), (F1-2), (F1-3) and (F1-5), combined):

$$F1' := F_y \cdot \left(0.79 - 0.002 \cdot \textbf{if}\left(\frac{b_f}{2 \cdot t_f} < FR, FR, \frac{b_f}{2 \cdot t_f}\right) \cdot \sqrt{\frac{F_y}{ksi}}\right)$$

$F1' = 23.8\ ksi$

$F1 := \mathbf{if}\left(\left(L \le L_c\right) \cdot (CF = 2), 0.66 \cdot F_y, \mathbf{if}\left(\left(L \le L_c\right) \cdot (CF = 1), F1', \mathbf{if}\left(\left(L \le L_c\right) \cdot (CF = 0), 0.60 \cdot F_y, 0 \cdot ksi\right)\right)\right)$

$F1 = 23.8\ ksi$

If F1 = 0 ksi, the allowable bending stress is controlled by AISC Specification Eqs. (F1-6), (F1-7) or (F1-8).

Allowable bending stress for compact and non-compact sections with unbraced lengths greater than Lc (AISC Specification, Eqs. (F1-6) and (F1-7) combined):

$$\frac{L}{r_T} = 34.3$$

$$R_1 := \sqrt{\frac{102 \cdot 10^3 \cdot C_b \cdot ksi}{F_y}} \qquad R_1 = 53.2$$

$$R_2 := \sqrt{\frac{510 \cdot 10^3 \cdot C_b \cdot ksi}{F_y}} \qquad R_2 = 119$$

$$F2' := \begin{cases} \left(\dfrac{2}{3} - \dfrac{F_y \cdot \left(\dfrac{L}{r_T}\right)^2}{1530 \cdot 10^3 \cdot C_b \cdot ksi}\right) \cdot F_y & \text{if } \left(\dfrac{L}{r_T} \ge R_1\right) \wedge \left(\dfrac{L}{r_T} \le R_2\right) \\ \dfrac{170 \cdot 10^3 \cdot C_b \cdot ksi}{\left(\dfrac{L}{r_T}\right)^2} & \text{else if } \dfrac{L}{r_T} \ge R_2 \\ 0\ ksi & \text{else} \end{cases} = 0\ ksi$$

$F2 := \mathbf{if}\left(F2' > 0.60 \cdot F_y, 0.60 \cdot F_y, F2'\right) \qquad F2 = 0\ ksi$

AISC Specification, Eq. (F1-8):

$$F3 := \mathbf{if}\left(\frac{12\cdot 10^3\cdot C_b\cdot \boldsymbol{ksi}}{\frac{L\cdot d}{A_f}} > 0.60\cdot F_y, 0.60\cdot F_y, \frac{12\cdot 10^3\cdot C_b\cdot \boldsymbol{ksi}}{\frac{L\cdot d}{A_f}}\right)$$

$$F3 = 21.6\ ksi$$

Allowable bending stress equal to the largest value of F1, F2 or F3:

$$F_{bx} := \mathbf{if}(F1 > 0\cdot \boldsymbol{ksi}, F1, \mathbf{if}(F2 > F3, F2, F3)) \qquad F_{bx} = 23.8\ ksi$$

Allowable bending stress for bending about the Y axis for compact or non-compact sections (AISC Specification, Identity (F2-2) and Eq. (F2-3) combined) and with maximum flange ratio for a compact section substituted for the actual ratio if it is larger:

$$F_{by} := F_y\cdot\left(1.075 - 0.005\cdot\left(\mathbf{if}\left(\frac{b_f}{2\cdot t_f} > FR, \frac{b_f}{2\cdot t_f}, FR\right)\cdot\sqrt{\frac{F_y}{\boldsymbol{ksi}}}\right)\right)$$

$$F_{by} = 27\ ksi$$

F_{by} ranges from a lower limit of 0.60Fy to an upper limit of $0.75F_y$.

Euler's stress for the X and Y directions, divided by a factor or safety and using the actual unbraced length and corresponding radius of gyration in the plain of bending
(AISC Specification, Sect. H-1):

$$F'_{ex} := \frac{12\cdot \pi^2\cdot E}{23\cdot\left(\frac{K_x\cdot L}{r_x}\right)^2} \qquad F'_{ex} = 303.1\ ksi$$

$$F'_{ey} := \frac{12\cdot \pi^2\cdot E}{23\cdot\left(\frac{K_y\cdot L}{r_y}\right)^2} \qquad F'_{ey} = 109.3\ ksi$$

Moment modifier coefficients C_{mx} and C_{my} (AISC Specification, Sect. H-1):

$$C_{mx} := \mathbf{if}\left(X\_Sway = 0, 0.6 - 0.4 \cdot \left(\frac{M_{xa}}{M_{xb}}\right), 0.85\right) = 1$$

$$C_{my} := \mathbf{if}\left(Y\_Sway = 0, 0.6 - 0.4 \cdot \left(\frac{M_{ya}}{M_{yb}}\right), 0.85\right) = 1$$

AISC Specification, Eqs. (H1-1) and (H1- 2) for combined axial compression and bending, expressed as functions of bending stresses about the X and Y axes:

$$H1\_1\left(f_{bx}, f_{by}\right) := \frac{f_a}{F_a} + \frac{C_{mx} \cdot f_{bx}}{\left(1 - \frac{f_a}{F'_{ex}}\right) \cdot F_{bx}} + \frac{C_{my} \cdot f_{by}}{\left(1 - \frac{f_a}{F'_{ey}}\right) \cdot F_{by}}$$

$$H1\_2\left(f_{bx}, f_{by}\right) := \frac{f_a}{0.60 \cdot F_y} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}}$$

At upper end of column:

$$H1\_1\left(\left|f_{b\_xu}\right|, \left|f_{b\_yu}\right|\right) = 0.987$$

$$H1\_2\left(\left|f_{b\_xu}\right|, \left|f_{b\_yu}\right|\right) = 0.93$$

At lower end of column:

$$H1\_1\left(\left|f_{b\_xl}\right|, \left|f_{b\_yl}\right|\right) = 0.987$$

$$H1\_2\left(\left|f_{b\_xl}\right|, \left|f_{b\_yl}\right|\right) = 0.93$$

Maximum value of H1_1 or H1_2:

$$HEQ := \begin{bmatrix} H1\_1\left(f_{b\_xu}, f_{b\_yu}\right) & H1\_1\left(f_{b\_xl}, f_{b\_yl}\right) \\ H1\_2\left(f_{b\_xu}, f_{b\_yu}\right) & H1\_2\left(f_{b\_xl}, f_{b\_yl}\right) \end{bmatrix}$$

$$\max(HEQ) = 0.987$$

If the maximum value of interaction equations H1_1 or H1_2 is less than or equal 1.0 the section is adequate If the section is too small or too large, a new trial section may be entered.

Summary

Enter section designation: W14x109

Input

Yield strength of steel:	$F_y = 36\ ksi$
Column axial load:	$P = 200\ kip$
Unbraced column length:	$L = 11.5\ ft$
End moment about the X axis, at the upper end of the column:	$M_{xu} = 120\ kip \cdot ft$
End moment about the X axis, at the lower end of the column:	$M_{xl} = -120\ kip \cdot ft$
End moment about the Y axis, at the upper end of the column:	$M_{yu} = 40\ kip \cdot ft$
End moment about the Y axis, at the lower end of the column:	$M_{yl} = -40\ kip \cdot ft$
Effective length factor relative to the X axis:	$K_x = 1$
Effective length factor relative to the Y axis:	$K_y = 1$
Variable "X_Sway" defined as 0 if sidesway is prevented, and 1 if sidesway is permitted:	$X\_Sway = 0$
Variable "Y_Sway" defined as 0 if sidesway is prevented, and 1 if sidesway is permitted:	$Y\_Sway = 0$

Section dimensions and weight entered:

Section depth:	$d=14.32\ in$
Flange width:	$b_f=14.605\ in$
Web thickness:	$t_w=0.525\ in$
Flange thickness:	$t_f=0.86\ in$
Section weight per unit length:	$W=109\ \frac{lb}{ft}$
Maximum value of H1_1 or H1_2:	$\max(HEQ)=0.987$

Note: If the maximum value of H1_1 or H1_2 is significantly larger than 1.0 a stronger section must be used.

Estimated trial weight for follow-up estimates, assuming no change in bf or d:

$$\max(HEQ)\cdot W=107.602\ \frac{lb}{ft}$$

$$W=109\ \frac{lb}{ft}$$

Intermediate Computed Values:

(Refer to document for definitions.)

$A=32.045\ in^2$	$f_a=6.241\ ksi$	$F_a=19.428\ ksi$
$I_x=\left(1.239\cdot10^3\right)\ in^4$	$f_{b\_xu}=8.324\ ksi$	$F_{bx}=23.76\ ksi$
$r_x=6.217\ in$	$f_{b\_xl}=-8.324\ ksi$	$F'_{ex}=303.088\ ksi$
$S_x=172.989\ in^3$	$f_{b\_yu}=7.846\ ksi$	$F_{by}=27\ ksi$
$I_y=446.733\ in^4$	$f_{b\_yl}=-7.846\ ksi$	$F'_{ey}=109.316\ ksi$
$r_y=3.734\ in$	$\frac{K_x\cdot L}{r_x}=22.197$	$C_c=126.099$
$S_y=61.175\ in^3$		$C_b=1$
$r_T=4.02\ in$	$\frac{K_y\cdot L}{r_y}=36.96$	$C_{mx}=1$
$\frac{d}{A_f}=1.14\ in^{-1}$		$C_{my}=1$

A_f

$L_c = 15.416\ ft$

$\frac{b_f}{2 \cdot t_f} = 8.491$

$FR = 10.833$

$L_u = 40.607\ ft$

$\frac{d}{t_w} = 27.276$

$FR_{max} = 15.833$

$WR\left(f_a\right) = 42.833$

$CF = 2$