Steel HW 1,3,9,13-15

GIVEN

7-1. Using the alignment chart from the AISC Specification, determine the effective length factors for columns *IJ*, *FG*, and *GH* of the frame shown in the accompanying figure, assuming that the frame is subject to sidesway and that all of the assumptions on which the alignment charts were developed are met. (*Ans.* 1.27, 1.20, and 1.17)

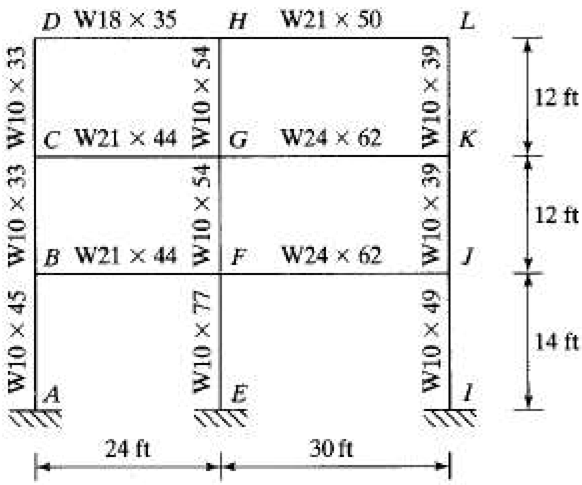

FIGURE P7-1

GIVEN $Lij := 14$ ft
$Lfg := 12$ ft
$Lgh := 12$ ft

FIND
1. K for column IJ
2. K for column FG
3. K for column GH

METHOD
1. Find G at each of the ends of the column
1.1 For fixed end $Gi := 1$
1.2 For other cases, determine G at each joint by:

$$Gc1 := \left(\frac{Ec1 \cdot Ic1}{Lc1}\right) \qquad Gc2 := \left(\frac{Ec2 \cdot Ic2}{Lc2}\right)$$

$$Gg1 := K1 \cdot \left(\frac{Eg1 \cdot Ig1}{Lg1}\right) \qquad Gg2 := K2 \cdot \left(\frac{Eg2 \cdot Ig2}{Lg2}\right)$$

$$Gjoint := \left(\frac{Gc1 + Gc2}{Gg1 + Gg2}\right)$$

AISC C-A-7-2

Where K1 and K2 are multipliers due to girder end joint restraint, in this case: $K1 := 1$ $K2 := K1 = 1$

2. With the values of G for each of the joints, determine K using alingment charts

SOLUTION

1) $Ec1 := 1$ $Eg1 := Ec1$ $Ec2 := Ec1$

Value will be canceled out, thus assumption of 1 is used.

W10x39 $Ic1 := 209$ $Lc1 := 12$ ft W24x62 $Ig1 := 1550$ $Lg1 := 30$ ft
W10x49 $Ic2 := 250$ $Lc2 := 14$ ft

$$Gc1 := \left(\frac{Ec1 \cdot Ic1}{Lc1}\right) = 17.417 \qquad Gg1 := K1 \cdot \left(\frac{Eg1 \cdot Ig1}{Lg1}\right) = 51.667$$

$$Gc2 := \left(\frac{Ec2 \cdot Ic2}{Lc2}\right) = 17.857 \qquad Gg2 := 0 \qquad Gj := \left(\frac{Gc1 + Gc2}{Gg1 + Gg2}\right) = 0.683 \qquad K := 1.26$$

2) $Ec1 := 1$ $\quad Eg1 := Ec1$ $\quad Ec2 := Ec1$ $\quad Eg2 := Ec1$

Value will be canceled out, thus assumption of 1 is used.

W10x77 $\quad Ic1 := 455$ $\quad Lc1 := 14 \text{ ft}$ $\quad$ W24x62 $\quad Ig1 := 1550$ $\quad Lg1 := 30 \text{ ft}$
W10x54 $\quad Ic2 := 303$ $\quad Lc2 := 12 \text{ ft}$ $\quad$ W21x44 $\quad Ig2 := 843$ $\quad Lg2 := 24 \text{ ft}$

$$Gc1 := \left(\frac{Ec1 \cdot Ic1}{Lc1}\right) = 32.5 \qquad Gg1 := K1 \cdot \left(\frac{Eg1 \cdot Ig1}{Lg1}\right) = 51.667$$

$$Gc2 := \left(\frac{Ec2 \cdot Ic2}{Lc2}\right) = 25.25 \qquad Gg2 := K2 \cdot \left(\frac{Eg2 \cdot Ig2}{Lg2}\right) = 35.125 \qquad Gf := \left(\frac{Gc1 + Gc2}{Gg1 + Gg2}\right) = 0.665$$

W10x54 $\quad Ic1 := 303$ $\quad Lc1 := 12 \text{ ft}$ $\quad$ W24x62 $\quad Ig1 := 1550$ $\quad Lg1 := 30 \text{ ft}$
W10x54 $\quad Ic2 := 303$ $\quad Lc2 := 12 \text{ ft}$ $\quad$ W21x44 $\quad Ig2 := 843$ $\quad Lg2 := 24 \text{ ft}$

$$Gc1 := \left(\frac{Ec1 \cdot Ic1}{Lc1}\right) = 25.25 \qquad Gg1 := K1 \cdot \left(\frac{Eg1 \cdot Ig1}{Lg1}\right) = 51.667$$

$$Gc2 := \left(\frac{Ec2 \cdot Ic2}{Lc2}\right) = 25.25 \qquad Gg2 := K2 \cdot \left(\frac{Eg2 \cdot Ig2}{Lg2}\right) = 35.125 \qquad Gg := \left(\frac{Gc1 + Gc2}{Gg1 + Gg2}\right) = 0.582$$

$K := 1.20$

3) $Gg = 0.582$

W10x54 $\quad Ic1 := 303$ $\quad Lc1 := 12 \text{ ft}$ $\quad$ W21x50 $\quad Ig1 := 984$ $\quad Lg1 := 30 \text{ ft}$
$Ic2 := 1$ $\quad Lc2 := 1 \text{ ft}$ $\quad$ W18x35 $\quad Ig2 := 510$ $\quad Lg2 := 24 \text{ ft}$

$$Gc1 := \left(\frac{Ec1 \cdot Ic1}{Lc1}\right) = 25.25 \qquad Gg1 := K1 \cdot \left(\frac{Eg1 \cdot Ig1}{Lg1}\right) = 32.8$$

$$Gc2 := \left(\frac{Ec2 \cdot Ic2}{Lc2}\right) = 1 \qquad Gg2 := K2 \cdot \left(\frac{Eg2 \cdot Ig2}{Lg2}\right) = 21.25 \qquad Gh := \left(\frac{Gc1 + Gc2}{Gg1 + Gg2}\right) = 0.486$$

$K := 1.17$

Use both LRFD and ASD methods.

7-3. a. Determine the available column strength for column AB in the frame shown if F_y = 50 ksi, and only in-plane behavior is considered. Furthermore, assume that the column immediately above or below AB are the same size as AB, and also that all the other assumptions on which the alignment charts were developed are met. (*Ans.* 825 k, LRFD; 549 k, ASD)

b. Repeat part (a) if inelastic behavior is considered and P_D = 200 k and P_L = 340 k. (*Ans.* 838 k, LRFD; 563 k, ASD)

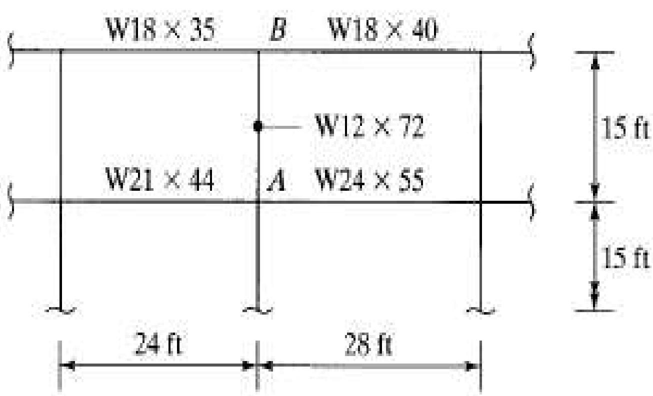

FIGURE P7-3

$Fy := 50 \quad ksi$

METHOD 1. Find G at each of the ends of the column

$$Gc1 := \left(\frac{Ec1 \cdot Ic1}{Lc1}\right) \qquad Gc2 := \left(\frac{Ec2 \cdot Ic2}{Lc2}\right)$$

$$Gg1 := K1 \cdot \left(\frac{Eg1 \cdot Ig1}{Lg1}\right) \qquad Gg2 := K2 \cdot \left(\frac{Eg2 \cdot Ig2}{Lg2}\right)$$

$$Gjoint := \left(\frac{Gc1 + Gc2}{Gg1 + Gg2}\right)$$

AISC C-A-7-2

Where K1 and K2 are multipliers due to girder end joint restraint, in this case: $K1 := 1 \qquad K2 := K1 = 1$

2. With the values of G for each of the joints, determine K using alingment charts
3. Find KLy-eq
4. Determine ϕPc and Pc/Ω using Table 4-1

$rxry := 1.75$ Table 1-1 or 4-1

SOLUTION

A) $Ec1 := 1 \quad Eg1 := Ec1 \quad Ec2 := Ec1 \quad Eg2 := Ec1$ Value will be canceled out, thus assumption of 1 is used.

W12x72 $Ic1 := 597$ $Lc1 := 15$ ft W21x44 $Ig1 := 843$ $Lg1 := 24$ ft
W12x72 $Ic2 := Ic1$ $Lc2 := Lc1$ ft W24x55 $Ig2 := 1350$ $Lg2 := 28$ ft

$$Gc1 := \left(\frac{Ec1 \cdot Ic1}{Lc1}\right) = 39.8 \qquad Gg1 := K1 \cdot \left(\frac{Eg1 \cdot Ig1}{Lg1}\right) = 35.125$$

$$Gc2 := \left(\frac{Ec2 \cdot Ic2}{Lc2}\right) = 39.8 \qquad Gg2 := K2 \cdot \left(\frac{Eg2 \cdot Ig2}{Lg2}\right) = 48.214 \qquad Ga := \left(\frac{Gc1 + Gc2}{Gg1 + Gg2}\right) = 0.955$$

$Gc1 = 39.8$ $\quad Gc2 := 0$ $\quad$ W18x35 $\; Ig1 := 510$ $\quad Lg1 := 24\ ft$

W18x40 $\; Ig2 := 612$ $\quad Lg2 := 28\ ft$

$Gg1 := K1 \cdot \left(\frac{Eg1 \cdot Ig1}{Lg1}\right) = 21.25$ $\quad Gg2 := K2 \cdot \left(\frac{Eg2 \cdot Ig2}{Lg2}\right) = 21.857$ $\quad Gb := \left(\frac{Gc1 + Gc2}{Gg1 + Gg2}\right) = 0.923$ $\quad K := 1.3$

$KLyeq := K \cdot \frac{Lc1}{rxry} = 11.143$ $\quad$ By interpolation: $\quad \phi Pc := 838\ k$ $\quad \frac{Pc}{\Omega} := 563\ k$

B $\quad$ For W12x72 $\quad A := 21.1\ \ in^2$ $\quad Py := Fy \cdot A = 1.055 \times 10^3$

$PD := 200 \quad PL := 340$ $\quad Pu := 1.2 \cdot PD + 1.6 \cdot PL = 784$ $\quad Pa := PD + PL = 540$

LRFD $\quad \alpha := 1$ $\quad Fac := \alpha \cdot \frac{Pu}{Py} = 0.743$ $\quad \tau b := 4 \cdot \left(\alpha \cdot \frac{Pu}{Py}\right) \cdot \left[1 - \left(\alpha \cdot \frac{Pu}{Py}\right)\right] = 0.764$

$Ga2 := \tau b \cdot Ga = 0.729$ $\quad Gb2 := \tau b \cdot Gb = 0.705$ $\quad K := 1.23$ $\quad KLyeq := K \cdot \frac{Lc1}{rxry} = 10.543$

ASD $\quad \alpha := 1.6$ $\quad Fac := \alpha \cdot \frac{Pa}{Py} = 0.819$ $\quad \tau b := 4 \cdot \left(\alpha \cdot \frac{Pa}{Py}\right) \cdot \left[1 - \left(\alpha \cdot \frac{Pa}{Py}\right)\right] = 0.593$

$Ga2 := \tau b \cdot Ga = 0.566$ $\quad Gb2 := \tau b \cdot Gb = 0.548$ $\quad K := 1.18$ $\quad KLyeq := K \cdot \frac{Lc1}{rxry} = 10.114$

Using Table 4-2: $\quad \phi Pc := 838\ k$ $\quad \frac{Pc}{\Omega} := 563\ k$

Use the Effective Length Method, assume elastic behavior, and use both the LRFD and ASD methods. The columns are assumed to have no bending moments.

7-9. Design W14 columns for the bent shown in the accompanying figure, with 50 ksi steel. The columns are braced top and bottom against sidesway out of the plane of the frame so that $K_y = 1.0$ in that direction. Sidesway is possible in the plane of the frame, the x-x axis. Design the interior column as a leaning column, $K_x = K_y = 1.0$ and the exterior columns as a moment frame columns, K_x determined from the alignment chart. (*Ans.* (Interior) W14 × 176, LRFD; W14 × 193, ASD – (Exterior) W14 × 211, LRFD and ASD)

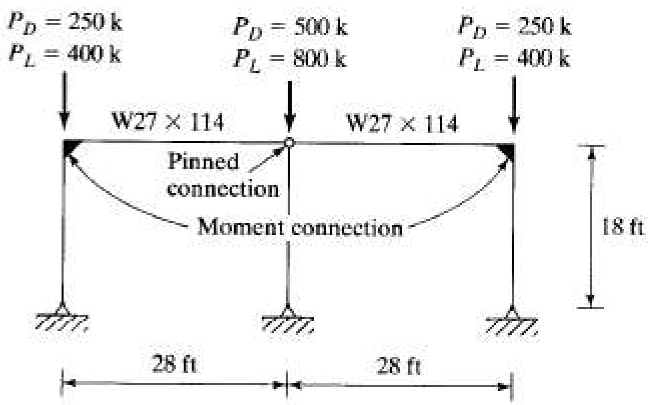

FIGURE P7-9

$Kx := 1 \quad Ky := Kx \qquad Lx := 18 \quad Ly := 18$ ft

$PD := 500$ k $\qquad PL := 800$ k

Method
PART 1 - INTERIOR
1. Determine KLy
2. Determine Pu and Pa
3. Using Table 4-2 determine available strength for section tried out

PART 2 - EXTERIOR
1. Determine KLy
2. Determine Pu and Pa
3. Using Table 4-2 determine available strength for section tried out

SOLUTION $\quad KLy := Ky \cdot Ly = 18 \qquad Pu := 1.2 \cdot PD + 1.6 \cdot PL = 1.88 \times 10^3 \qquad Pa := PD + PL = 1.3 \times 10^3$

Trying a W14x176 $\quad \phi Pc := 1890$ k $\qquad$ Trying a W14x176 $\quad \frac{Pc}{\Omega} := 1380$ k

PART 2 $\quad Pu := 1.2 \cdot PD + 1.6 \cdot PL = 1.88 \times 10^3 \qquad Pa := PD + PL = 1.3 \times 10^3$

Select the lightest W12 shape for column AB of the pinned-base unbraced-moment frame shown in the figure. All steel is ASTM A992. The horizontal girder is a W18 × 76. The girder and columns are oriented so that bending is about the x-x axis. In the plane perpendicular to the frame, $K_y = 1.0$ and bracing is provided to the y-y axis of

the column at the top and mid-height using pinned end connections. The loads on each are $P_D = 150$ k and $P_L = 200$ k. (*Ans.* W12 × 53, LRFD; W12 × 58, ASD)

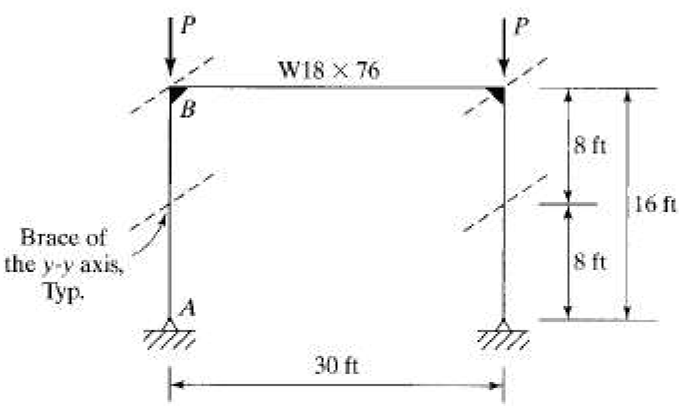

FIGURE P7-13

7-14. Design a square base plate with A36 steel for a W10 × 60 column with a service dead load of 175 k and a service live load of 275 k. The concrete 28-day strength, f'_c, is 3000 psi. The base plate rests on a 12 ft 0 in × 12 ft 0 in concrete footing. Use the LRFD and ASD design methods.

7-15. Repeat Prob. 7-14 if the column is supported by a 24 in × 24 in concrete pedestal.
(*Ans.* B PL – 1¾ × 18 × 1 ft 6 in A36 LRFD and ASD)