DTY Tutoring, inc.
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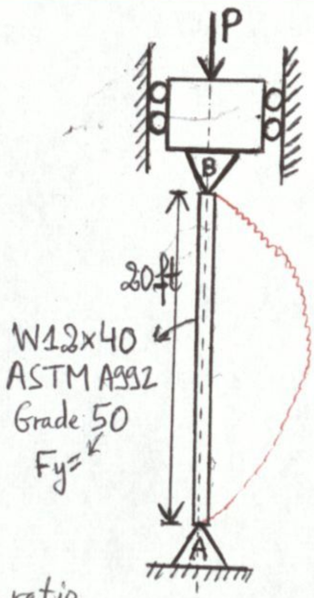
Date: 20th March 2019




Pinned - Pinned

$K = 1$

$L = 20 ft$

$KL = (1)(20ft) = 20ft\left(\frac{12 in}{1 ft}\right) = 240 in$

W12x40

$A = 11.7 in^2 = A_g$

$r_x = 5.13 in$

$r_y = 1.94 in$

Effective slenderness ratio

$$\frac{KL}{r_x} = \frac{(1)(240 in)}{5.13 in} = 46.784$$

$$\frac{KL}{r_y} = \frac{(1)(240 in)}{1.94 in} = 123.71$$ larger value governs

$$4.71\sqrt{\frac{E}{F_y}} = 4.71\sqrt{\frac{29{,}000 ksi}{50 ksi}} = 113.43 < \frac{KL}{r_y} = 123.71$$

Elastic buckling stress, Fe

$$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} = \frac{(\pi)^2(29{,}000 ksi)}{(123.71)^2} = 18.702 ksi$$

(a)

$$F_{CR} = 0.877 F_e = 0.877(18.702 ksi)$$

$$F_{CR} = 16.401654 ksi = 16.4 ksi$$

$$P_{CR} = (F_{CR})(A_g) = \left(16.401654 \frac{kips}{in^2}\right)(11.7 in^2)$$

$$P_{CR} = 191.89 kips = 192 kips$$

(b) $\phi P_n = 0.9 P_{CR} = 0.9(191.89 kips) = 172.701 kips$

(c) $\phi_c F_{CR} = 0.9(16.401654 ksi) = 14.761 ksi$

# Table 4-1 (continued)
# Available Strength in Axial Compression, kips

## W12 W-Shapes

$F_y$ = 50 ksi

| Shape | W12× | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| lb/ft | 58 | | 53 | | 50 | | 45 | | 40 | |
| Design | $P_n/\Omega_c$ ASD | $\phi_c P_n$ LRFD | $P_n/\Omega_c$ ASD | $\phi_c P_n$ LRFD | $P_n/\Omega_c$ ASD | $\phi_c P_n$ LRFD | $P_n/\Omega_c$ ASD | $\phi_c P_n$ LRFD | $P_n/\Omega_c$ ASD | $\phi_c P_n$ LRFD |
| Effective length, $KL$ (ft), with respect to least radius of gyration, $r_y$: 0 | 509 | 765 | 467 | 702 | 437 | 657 | 392 | 589 | 350 | 526 |
| 6 | 479 | 720 | 439 | 660 | 396 | 595 | 355 | 534 | 317 | 476 |
| 7 | 469 | 705 | 429 | 646 | 382 | 574 | 342 | 515 | 305 | 459 |
| 8 | 457 | 687 | 419 | 629 | 367 | 551 | 329 | 494 | 293 | 440 |
| 9 | 445 | 668 | 407 | 611 | 350 | 526 | 313 | 471 | 279 | 420 |
| 10 | 431 | 647 | 394 | 592 | 332 | 500 | 297 | 447 | 265 | 398 |
| 11 | 416 | 625 | 380 | 571 | 314 | 472 | 281 | 422 | 250 | 375 |
| 12 | 400 | 601 | 365 | 549 | 295 | 443 | 263 | 396 | 234 | 352 |
| 13 | 384 | 577 | 350 | 526 | 275 | 413 | 246 | 369 | 218 | 328 |
| 14 | 367 | 551 | 334 | 502 | 255 | 384 | 228 | 343 | 202 | 304 |
| 15 | 349 | 525 | 318 | 478 | 236 | 355 | 210 | 316 | 187 | 281 |
| 16 | 332 | 499 | 301 | 453 | 217 | 326 | 193 | 290 | 171 | 257 |
| 17 | 314 | 472 | 285 | 428 | 198 | 298 | 176 | 265 | 156 | 235 |
| 18 | 296 | 445 | 268 | 403 | 180 | 270 | 160 | 240 | 142 | 213 |
| 19 | 278 | 418 | 252 | 378 | 162 | 244 | 144 | 216 | 127 | 191 |
| 20 | 261 | 392 | 235 | 354 | 146 | 220 | 130 | 195 | 115 | 173 |
| 22 | 227 | 341 | 204 | 307 | 121 | 182 | 107 | 161 | 95.0 | 143 |
| 24 | 194 | 292 | 174 | 261 | 102 | 153 | 90.3 | 136 | 79.8 | 120 |
| 26 | 165 | 249 | 148 | 223 | 86.6 | 130 | 76.9 | 116 | 68.0 | 102 |
| 28 | 143 | 214 | 128 | 192 | 74.7 | 112 | 66.3 | 99.7 | 58.6 | 88.1 |
| 30 | 124 | 187 | 111 | 167 | 65.0 | 97.8 | 57.8 | 86.8 | 51.1 | 76.8 |
| 32 | 109 | 164 | 97.8 | 147 | 57.2 | 85.9 | 50.8 | 76.3 | 44.9 | 67.5 |
| 34 | 96.7 | 145 | 86.6 | 130 | | | | | | |
| 36 | 86.3 | 130 | 77.3 | 116 | | | | | | |
| 38 | 77.4 | 116 | 69.4 | 104 | | | | | | |
| 40 | 69.9 | 105 | 62.6 | 94.1 | | | | | | |
| **Properties** | | | | | | | | | | |
| $P_{wo}$, kips | 74.4 | 112 | 67.9 | 102 | 70.3 | 105 | 60.3 | 90.5 | 50.2 | 75.2 |
| $P_{wi}$, kips/in. | 12.0 | 18.0 | 11.5 | 17.3 | 12.3 | 18.5 | 11.2 | 16.8 | 9.83 | 14.8 |
| $P_{wb}$, kips | 83.1 | 125 | 73.3 | 110 | 88.4 | 133 | 65.6 | 98.6 | 44.8 | 67.4 |
| $P_{fb}$, kips | 76.6 | 115 | 61.9 | 93.0 | 76.6 | 115 | 61.9 | 93.0 | 49.6 | 74.6 |
| $L_p$, ft | 8.87 | | 8.76 | | 6.92 | | 6.89 | | 6.85 | |
| $L_r$, ft | 29.8 | | 28.2 | | 23.8 | | 22.4 | | 21.1 | |
| $A_g$, in.$^2$ | 17.0 | | 15.6 | | 14.6 | | 13.1 | | 11.7 | |
| $I_x$, in.$^4$ | 475 | | 425 | | 391 | | 348 | | 307 | |
| $I_y$, in.$^4$ | 107 | | 95.8 | | 56.3 | | 50.0 | | 44.1 | |
| $r_y$, in. | 2.51 | | 2.48 | | 1.96 | | 1.95 | | 1.94 | |
| $r_x/r_y$ | 2.10 | | 2.11 | | 2.64 | | 2.64 | | 2.64 | |
| $P_{ex}(KL)^2/10^4$, k-in.$^2$ | 13600 | | 12200 | | 11200 | | 9960 | | 8790 | |
| $P_{ey}(KL)^2/10^4$, k-in.$^2$ | 3060 | | 2740 | | 1610 | | 1430 | | 1260 | |

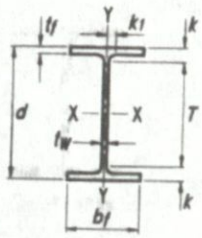
| ASD | LRFD |
|---|---|
| $\Omega_c$ = 1.67 | $\phi_c$ = 0.90 |

Note: Heavy line indicates $KL/r_y$ equal to or greater than 200.

## Table 1-1 (continued)
# W-Shapes
## Properties

**W12-W10**

| Nom-inal Wt. | Compact Section Criteria | | Axis X-X | | | | Axis Y-Y | | | | $r_{ts}$ | $h_o$ | Torsional Properties | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\frac{b_f}{2t_f}$ | $\frac{h}{t_w}$ | $I$ | $S$ | $r$ | $Z$ | $I$ | $S$ | $r$ | $Z$ | | | $J$ | $C_w$ |
| lb/ft | | | in.$^4$ | in.$^3$ | in. | in.$^3$ | in.$^4$ | in.$^3$ | in. | in.$^3$ | in. | in. | in.$^4$ | in.$^6$ |
| 58 | 7.82 | 27.0 | 475 | 78.0 | 5.28 | 86.4 | 107 | 21.4 | 2.51 | 32.5 | 2.81 | 11.6 | 2.10 | 3570 |
| 53 | 8.69 | 28.1 | 425 | 70.6 | 5.23 | 77.9 | 95.8 | 19.2 | 2.48 | 29.1 | 2.79 | 11.5 | 1.58 | 3160 |
| 50 | 6.31 | 26.8 | 391 | 64.2 | 5.18 | 71.9 | 56.3 | 13.9 | 1.96 | 21.3 | 2.25 | 11.6 | 1.71 | 1880 |
| 45 | 7.00 | 29.6 | 348 | 57.7 | 5.15 | 64.2 | 50.0 | 12.4 | 1.95 | 19.0 | 2.23 | 11.5 | 1.26 | 1650 |
| W12X 40 | 7.77 | 33.6 | 307 | 51.5 | 5.13 | 57.0 | 44.1 | 11.0 | 1.94 | 16.8 | 2.21 | 11.4 | 0.906 | 1440 |
| 35 | 6.31 | 36.2 | 285 | 45.6 | 5.25 | 51.2 | 24.5 | 7.47 | 1.54 | 11.5 | 1.79 | 12.0 | 0.741 | 879 |
| 30 | 7.41 | 41.8 | 238 | 38.6 | 5.21 | 43.1 | 20.3 | 6.24 | 1.52 | 9.56 | 1.77 | 11.9 | 0.457 | 720 |
| 26 | 8.54 | 47.2 | 204 | 33.4 | 5.17 | 37.2 | 17.3 | 5.34 | 1.51 | 8.17 | 1.75 | 11.8 | 0.300 | 607 |
| 22 | 4.74 | 41.8 | 156 | 25.4 | 4.91 | 29.3 | 4.66 | 2.31 | 0.848 | 3.66 | 1.04 | 11.9 | 0.293 | 164 |
| 19 | 5.72 | 46.2 | 130 | 21.3 | 4.82 | 24.7 | 3.76 | 1.88 | 0.822 | 2.98 | 1.02 | 11.9 | 0.180 | 131 |
| 16 | 7.53 | 49.4 | 103 | 17.1 | 4.67 | 20.1 | 2.82 | 1.41 | 0.773 | 2.26 | 0.983 | 11.7 | 0.103 | 96.9 |
| 14 | 8.82 | 54.3 | 88.6 | 14.9 | 4.62 | 17.4 | 2.36 | 1.19 | 0.753 | 1.90 | 0.961 | 11.7 | 0.0704 | 80.4 |
| 112 | 4.17 | 10.4 | 716 | 126 | 4.66 | 147 | 236 | 45.3 | 2.68 | 69.2 | 3.08 | 10.2 | 15.1 | 6020 |
| 100 | 4.62 | 11.6 | 623 | 112 | 4.60 | 130 | 207 | 40.0 | 2.65 | 61.0 | 3.04 | 10.0 | 10.9 | 5150 |
| 88 | 5.18 | 13.0 | 534 | 98.5 | 4.54 | 113 | 179 | 34.8 | 2.63 | 53.1 | 2.99 | 9.81 | 7.53 | 4330 |
| 77 | 5.86 | 14.8 | 455 | 85.9 | 4.49 | 97.6 | 154 | 30.1 | 2.60 | 45.9 | 2.95 | 9.73 | 5.11 | 3630 |
| 68 | 6.58 | 16.7 | 394 | 75.7 | 4.44 | 85.3 | 134 | 26.4 | 2.59 | 40.1 | 2.92 | 9.63 | 3.56 | 3100 |
| 60 | 7.41 | 18.7 | 341 | 66.7 | 4.39 | 74.6 | 116 | 23.0 | 2.57 | 35.0 | 2.88 | 9.52 | 2.48 | 2640 |
| 54 | 8.15 | 21.2 | 303 | 60.0 | 4.37 | 66.6 | 103 | 20.6 | 2.56 | 31.3 | 2.85 | 9.49 | 1.82 | 2320 |
| 49 | 8.93 | 23.1 | 272 | 54.6 | 4.35 | 60.4 | 93.4 | 18.7 | 2.54 | 28.3 | 2.84 | 9.44 | 1.39 | 2070 |
| 45 | 6.47 | 22.5 | 248 | 49.1 | 4.32 | 54.9 | 53.4 | 13.3 | 2.01 | 20.3 | 2.27 | 9.48 | 1.51 | 1200 |
| 39 | 7.53 | 25.0 | 209 | 42.1 | 4.27 | 46.8 | 45.0 | 11.3 | 1.98 | 17.2 | 2.24 | 9.39 | 0.976 | 992 |
| 33 | 9.15 | 27.1 | 171 | 35.0 | 4.19 | 38.8 | 36.6 | 9.20 | 1.94 | 14.0 | 2.20 | 9.30 | 0.583 | 791 |
| 30 | 5.70 | 29.5 | 170 | 32.4 | 4.38 | 36.6 | 16.7 | 5.75 | 1.37 | 8.84 | 1.60 | 10.0 | 0.622 | 414 |
| 26 | 6.56 | 34.0 | 144 | 27.9 | 4.35 | 31.3 | 14.1 | 4.89 | 1.36 | 7.50 | 1.58 | 9.86 | 0.402 | 345 |
| 22 | 7.99 | 36.9 | 118 | 23.2 | 4.27 | 26.0 | 11.4 | 3.97 | 1.33 | 6.10 | 1.55 | 9.84 | 0.239 | 275 |
| 19 | 5.09 | 35.4 | 96.3 | 18.8 | 4.14 | 21.6 | 4.29 | 2.14 | 0.874 | 3.35 | 1.06 | 9.81 | 0.233 | 104 |
| 17 | 6.08 | 36.9 | 81.9 | 16.2 | 4.05 | 18.7 | 3.56 | 1.78 | 0.845 | 2.80 | 1.04 | 9.77 | 0.156 | 85.1 |
| 15 | 7.41 | 38.5 | 68.9 | 13.8 | 3.95 | 16.0 | 2.89 | 1.45 | 0.810 | 2.30 | 1.01 | 9.72 | 0.104 | 68.3 |
| 12 | 9.43 | 46.6 | 53.8 | 10.9 | 3.90 | 12.6 | 2.18 | 1.10 | 0.785 | 1.74 | 0.983 | 9.66 | 0.0547 | 50.9 |



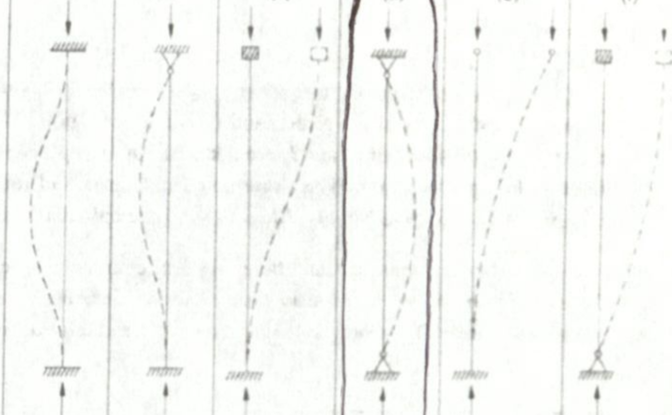

# Table 1-1 (continued)
# W-Shapes
## Dimensions

| Shape | Area, $A$ | Depth, $d$ | | Web Thickness, $t_w$ | | Web $\frac{t_w}{2}$ | Flange Width, $b_f$ | | Flange Thickness, $t_f$ | | Distance $k$, $k_{des}$ | Distance $k$, $k_{det}$ | Distance $k_1$ | Distance $T$ | Distance Workable Gage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | in.² | in. | | in. | | in. | in. | | in. | | in. | in. | in. | in. | in. |
| W12×58 | 17.0 | 12.2 | 12 1/4 | 0.360 | 3/8 | 3/16 | 10.0 | 10 | 0.640 | 5/8 | 1.24 | 1 1/2 | 15/16 | 9 1/4 | 5 1/2 |
| ×53 | 15.6 | 12.1 | 12 | 0.345 | 3/8 | 3/16 | 10.0 | 10 | 0.575 | 9/16 | 1.18 | 1 3/8 | 15/16 | 9 1/4 | 5 1/2 |
| W12×50 | 14.6 | 12.2 | 12 1/4 | 0.370 | 3/8 | 3/16 | 8.08 | 8 1/8 | 0.640 | 5/8 | 1.14 | 1 1/2 | 15/16 | 9 1/4 | 5 1/2 |
| ×45 | 13.1 | 12.1 | 12 | 0.335 | 5/16 | 3/16 | 8.05 | 8 | 0.575 | 9/16 | 1.08 | 1 3/8 | 15/16 | ↓ | ↓ |
| ×40 | 11.7 | 11.9 | 12 | 0.295 | 5/16 | 3/16 | 8.01 | 8 | 0.515 | 1/2 | 1.02 | 1 3/8 | 7/8 | ↓ | ↓ |
| W12×35[c] | 10.3 | 12.5 | 12 1/2 | 0.300 | 5/16 | 3/16 | 6.56 | 6 1/2 | 0.520 | 1/2 | 0.820 | 1 3/16 | 3/4 | 10 1/8 | 3 1/2 |
| ×30[c] | 8.79 | 12.3 | 12 3/8 | 0.260 | 1/4 | 1/8 | 6.52 | 6 1/2 | 0.440 | 7/16 | 0.740 | 1 1/8 | 3/4 | ↓ | ↓ |
| ×26[c] | 7.65 | 12.2 | 12 1/4 | 0.230 | 1/4 | 1/8 | 6.49 | 6 1/2 | 0.380 | 3/8 | 0.680 | 1 1/16 | 3/4 | ↓ | ↓ |
| W12×22[c] | 6.48 | 12.3 | 12 1/4 | 0.260 | 1/4 | 1/8 | 4.03 | 4 | 0.425 | 7/16 | 0.725 | 15/16 | 5/8 | 10 3/8 | 2 1/4[g] |
| ×19[c] | 5.57 | 12.2 | 12 1/8 | 0.235 | 1/4 | 1/8 | 4.01 | 4 | 0.350 | 3/8 | 0.650 | 7/8 | 9/16 | ↓ | ↓ |
| ×16[c] | 4.71 | 12.0 | 12 | 0.220 | 1/4 | 1/8 | 3.99 | 4 | 0.265 | 1/4 | 0.565 | 13/16 | 9/16 | ↓ | ↓ |
| ×14[c,v] | 4.16 | 11.9 | 11 7/8 | 0.200 | 3/16 | 1/8 | 3.97 | 4 | 0.225 | 1/4 | 0.525 | 3/4 | 9/16 | ↓ | ↓ |
| W10×112 | 32.9 | 11.4 | 11 3/8 | 0.755 | 3/4 | 3/8 | 10.4 | 10 3/8 | 1.25 | 1 1/4 | 1.75 | 1 15/16 | 1 | 7 1/2 | 5 1/2 |
| ×100 | 29.3 | 11.1 | 11 1/8 | 0.680 | 11/16 | 3/8 | 10.3 | 10 3/8 | 1.12 | 1 1/8 | 1.62 | 1 13/16 | 1 | ↓ | ↓ |
| ×88 | 26.0 | 10.8 | 10 7/8 | 0.605 | 5/8 | 5/16 | 10.3 | 10 1/4 | 0.990 | 1 | 1.49 | 1 11/16 | 15/16 | ↓ | ↓ |
| ×77 | 22.7 | 10.6 | 10 5/8 | 0.530 | 1/2 | 1/4 | 10.2 | 10 1/4 | 0.870 | 7/8 | 1.37 | 1 9/16 | 7/8 | ↓ | ↓ |
| ×68 | 19.9 | 10.4 | 10 3/8 | 0.470 | 1/2 | 1/4 | 10.1 | 10 1/8 | 0.770 | 3/4 | 1.27 | 1 7/16 | 7/8 | ↓ | ↓ |
| ×60 | 17.7 | 10.2 | 10 1/4 | 0.420 | 7/16 | 1/4 | 10.1 | 10 1/8 | 0.680 | 11/16 | 1.18 | 1 3/8 | 13/16 | ↓ | ↓ |
| ×54 | 15.8 | 10.1 | 10 1/8 | 0.370 | 3/8 | 3/16 | 10.0 | 10 | 0.615 | 5/8 | 1.12 | 1 5/16 | 13/16 | ↓ | ↓ |
| ×49 | 14.4 | 10.0 | 10 | 0.340 | 5/16 | 3/16 | 10.0 | 10 | 0.560 | 9/16 | 1.06 | 1 1/4 | 13/16 | ↓ | ↓ |
| W10×45 | 13.3 | 10.1 | 10 1/8 | 0.350 | 3/8 | 3/16 | 8.02 | 8 | 0.620 | 5/8 | 1.12 | 1 5/16 | 13/16 | 7 1/2 | 5 1/2 |
| ×39 | 11.5 | 9.92 | 9 7/8 | 0.315 | 5/16 | 3/16 | 7.99 | 8 | 0.530 | 1/2 | 1.03 | 1 3/16 | 13/16 | ↓ | ↓ |
| ×33 | 9.71 | 9.73 | 9 3/4 | 0.290 | 5/16 | 3/16 | 7.96 | 8 | 0.435 | 7/16 | 0.935 | 1 1/8 | 3/4 | ↓ | ↓ |
| W10×30 | 8.84 | 10.5 | 10 1/2 | 0.300 | 5/16 | 3/16 | 5.81 | 5 3/4 | 0.510 | 1/2 | 0.810 | 1 1/8 | 11/16 | 8 1/4 | 2 3/4[g] |
| ×26 | 7.61 | 10.3 | 10 3/8 | 0.260 | 1/4 | 1/8 | 5.77 | 5 3/4 | 0.440 | 7/16 | 0.740 | 1 1/16 | 11/16 | ↓ | ↓ |
| ×22[c] | 6.49 | 10.2 | 10 1/8 | 0.240 | 1/4 | 1/8 | 5.75 | 5 3/4 | 0.360 | 3/8 | 0.660 | 15/16 | 5/8 | ↓ | ↓ |
| W10×19 | 5.62 | 10.2 | 10 1/4 | 0.250 | 1/4 | 1/8 | 4.02 | 4 | 0.395 | 3/8 | 0.695 | 15/16 | 5/8 | 8 3/8 | 2 1/4[g] |
| ×17[c] | 4.99 | 10.1 | 10 1/8 | 0.240 | 1/4 | 1/8 | 4.01 | 4 | 0.330 | 5/16 | 0.630 | 7/8 | 9/16 | ↓ | ↓ |
| ×15[c] | 4.41 | 9.99 | 10 | 0.230 | 1/4 | 1/8 | 4.00 | 4 | 0.270 | 1/4 | 0.570 | 13/16 | 9/16 | ↓ | ↓ |
| ×12[c,f] | 3.54 | 9.87 | 9 7/8 | 0.190 | 3/16 | 1/8 | 3.96 | 4 | 0.210 | 3/16 | 0.510 | 3/4 | 9/16 | ↓ | ↓ |

[c] Shape is slender for compression with $F_y$ = 50 ksi.
[f] Shape exceeds compact limit for flexure with $F_y$ = 50 ksi.
[g] The actual size, combination and orientation of fastener components should be compared with the geometry of the cross section to ensure compatibility.
[v] Shape does not meet the $h/t_w$ limit for shear in AISC *Specification* Section G2.1(a) with $F_y$ = 50 ksi.

## TABLE C-A-7.1
## Approximate Values of Effective Length Factor, *K*

Pinned-Pinned

| | (a) | (b) | (c) | (d) | (e) | (f) |
|---|---|---|---|---|---|---|
| Buckled shape of column is shown by dashed line |  | | | | | |
| Theoretical *K* value | 0.5 | 0.7 | 1.0 | 1.0 | 2.0 | 2.0 |
| Recommended design value when ideal conditions are approximated | 0.65 | 0.80 | 1.2 | 1.0 | 2.1 | 2.0 |
| End condition code | Rotation fixed and translation fixed<br>Rotation free and translation fixed<br>Rotation fixed and translation free<br>Rotation free and translation free | | | | | |

(7) Joint restraint is distributed to the column above and below the joint in proportion to *EI/L* for the two columns.
(8) All columns buckle simultaneously.
(9) No significant axial compression force exists in the girders.

The alignment chart for sidesway inhibited frames shown in Figure C-A-7.1 is based on the following equation:

$$\frac{G_A G_B}{4}(\pi/K)^2 + \left(\frac{G_A + G_B}{2}\right)\left(1 - \frac{\pi/K}{\tan(\pi/K)}\right) + \frac{2\tan(\pi/2K)}{(\pi/K)} - 1 = 0 \qquad \text{(C-A-7-1)}$$

The alignment chart for sidesway uninhibited frames shown in Figure C-A-7.2 is based on the following equation:

$$\frac{G_A G_B(\pi/K)^2 - 36}{6(G_A + G_B)} - \frac{(\pi/K)}{\tan(\pi/K)} = 0 \qquad \text{(C-A-7-2)}$$

## EFFECTIVE LENGTH

The *effective length factor*, $K$, for calculation of member slenderness, $KL/r$, shall be determined in accordance with Chapter C or Appendix 7,

where

$L$ = laterally *unbraced length* of the member, in. (mm)

$r$ = radius of gyration, in. (mm)

**User Note:** For members designed on the basis of compression, the effective slenderness ratio $KL/r$ preferably should not exceed 200.

## FLEXURAL BUCKLING OF MEMBERS WITHOUT SLENDER ELEMENTS

This section applies to nonslender element compression members as defined in Section B4.1 for elements in uniform compression.

**User Note:** When the torsional *unbraced length* is larger than the lateral unbraced length, Section E4 may control the design of wide flange and similarly shaped *columns*.

The *nominal compressive strength*, $P_n$, shall be determined based on the *limit state* of *flexural buckling*.

$$P_n = F_{cr} A_g \quad \text{(E3-1)}$$

The *critical stress*, $F_{cr}$, is determined as follows:

(a) When $\dfrac{KL}{r} \le 4.71\sqrt{\dfrac{E}{F_y}}$ (or $\dfrac{F_y}{F_e} \le 2.25$)

$$F_{cr} = \left[0.658^{\frac{F_y}{F_e}}\right] F_y \quad \text{(E3-2)}$$

(b) When $\dfrac{KL}{r} > 4.71\sqrt{\dfrac{E}{F_y}}$ (or $\dfrac{F_y}{F_e} > 2.25$)

$$F_{cr} = 0.877 F_e \quad \text{(E3-3)}$$

where

$F_e$ = elastic *buckling* stress determined according to Equation E3-4, as specified in Appendix 7, Section 7.2.3(b), or through an elastic buckling analysis, as applicable, ksi (MPa)

$$F_e = \frac{\pi^2 E}{\left(\dfrac{KL}{r}\right)^2} \quad \text{(E3-4)}$$

# Table 4-22 (continued)
## Available Critical Stress for Compression Members

| $F_y$ = 35 ksi | | | $F_y$ = 36 ksi | | | $F_y$ = 42 ksi | | | $F_y$ = 46 ksi | | | $F_y$ = 50 ksi | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\frac{KL}{r}$ | $F_{cr}/\Omega_c$ | $\phi_c F_{cr}$ | $\frac{KL}{r}$ | $F_{cr}/\Omega_c$ | $\phi_c F_{cr}$ | $\frac{KL}{r}$ | $F_{cr}/\Omega_c$ | $\phi_c F_{cr}$ | $\frac{KL}{r}$ | $F_{cr}/\Omega_c$ | $\phi_c F_{cr}$ | $\frac{KL}{r}$ | $F_{cr}/\Omega_c$ | $\phi_c F_{cr}$ |
| | ksi | ksi | | ksi | ksi | | ksi | ksi | | ksi | ksi | | ksi | ksi |
| | ASD | LRFD | | ASD | LRFD | | ASD | LRFD | | ASD | LRFD | | ASD | LRFD |
| 121 | 9.91 | 14.9 | 121 | 10.0 | 15.0 | 121 | 10.2 | 15.4 | 121 | 10.3 | 15.4 | 121 | 10.3 | 15.4 |
| 122 | 9.79 | 14.7 | 122 | 9.85 | 14.8 | 122 | 10.1 | 15.2 | 122 | 10.1 | 15.2 | 122 | 10.1 | 15.2 |
| 123 | 9.67 | 14.5 | 123 | 9.72 | 14.6 | 123 | 9.93 | 14.9 | 123 | 9.94 | 14.9 | 123 | 9.94 | 14.9 |
| 124 | 9.55 | 14.3 | 124 | 9.59 | 14.4 | 124 | 9.78 | 14.7 | 124 | 9.78 | 14.7 | 124 | 9.78 | 14.7 |
| 125 | 9.43 | 14.2 | 125 | 9.47 | 14.2 | 125 | 9.62 | 14.5 | 125 | 9.62 | 14.5 | 125 | 9.62 | 14.5 |
| 126 | 9.31 | 14.0 | 126 | 9.35 | 14.0 | 126 | 9.47 | 14.2 | 126 | 9.47 | 14.2 | 126 | 9.47 | 14.2 |
| 127 | 9.19 | 13.8 | 127 | 9.22 | 13.9 | 127 | 9.32 | 14.0 | 127 | 9.32 | 14.0 | 127 | 9.32 | 14.0 |
| 128 | 9.07 | 13.6 | 128 | 9.10 | 13.7 | 128 | 9.17 | 13.8 | 128 | 9.17 | 13.8 | 128 | 9.17 | 13.8 |
| 129 | 8.95 | 13.4 | 129 | 8.98 | 13.5 | 129 | 9.03 | 13.6 | 129 | 9.03 | 13.6 | 129 | 9.03 | 13.6 |
| 130 | 8.83 | 13.3 | 130 | 8.85 | 13.3 | 130 | 8.89 | 13.4 | 130 | 8.89 | 13.4 | 130 | 8.89 | 13.4 |
| 131 | 8.71 | 13.1 | 131 | 8.73 | 13.1 | 131 | 8.76 | 13.2 | 131 | 8.76 | 13.2 | 131 | 8.76 | 13.2 |
| 132 | 8.60 | 12.9 | 132 | 8.61 | 12.9 | 132 | 8.63 | 13.0 | 132 | 8.63 | 13.0 | 132 | 8.63 | 13.0 |
| 133 | 8.48 | 12.7 | 133 | 8.49 | 12.8 | 133 | 8.50 | 12.8 | 133 | 8.50 | 12.8 | 133 | 8.50 | 12.8 |
| 134 | 8.37 | 12.6 | 134 | 8.37 | 12.6 | 134 | 8.37 | 12.6 | 134 | 8.37 | 12.6 | 134 | 8.37 | 12.6 |
| 135 | 8.25 | 12.4 | 135 | 8.25 | 12.4 | 135 | 8.25 | 12.4 | 135 | 8.25 | 12.4 | 135 | 8.25 | 12.4 |
| 136 | 8.13 | 12.2 | 136 | 8.13 | 12.2 | 136 | 8.13 | 12.2 | 136 | 8.13 | 12.2 | 136 | 8.13 | 12.2 |
| 137 | 8.01 | 12.0 | 137 | 8.01 | 12.0 | 137 | 8.01 | 12.0 | 137 | 8.01 | 12.0 | 137 | 8.01 | 12.0 |
| 138 | 7.89 | 11.9 | 138 | 7.89 | 11.9 | 138 | 7.89 | 11.9 | 138 | 7.89 | 11.9 | 138 | 7.89 | 11.9 |
| 139 | 7.78 | 11.7 | 139 | 7.78 | 11.7 | 139 | 7.78 | 11.7 | 139 | 7.78 | 11.7 | 139 | 7.78 | 11.7 |
| 140 | 7.67 | 11.5 | 140 | 7.67 | 11.5 | 140 | 7.67 | 11.5 | 140 | 7.67 | 11.5 | 140 | 7.67 | 11.5 |
| 141 | 7.56 | 11.4 | 141 | 7.56 | 11.4 | 141 | 7.56 | 11.4 | 141 | 7.56 | 11.4 | 141 | 7.56 | 11.4 |
| 142 | 7.45 | 11.2 | 142 | 7.45 | 11.2 | 142 | 7.45 | 11.2 | 142 | 7.45 | 11.2 | 142 | 7.45 | 11.2 |
| 143 | 7.35 | 11.0 | 143 | 7.35 | 11.0 | 143 | 7.35 | 11.0 | 143 | 7.35 | 11.0 | 143 | 7.35 | 11.0 |
| 144 | 7.25 | 10.9 | 144 | 7.25 | 10.9 | 144 | 7.25 | 10.9 | 144 | 7.25 | 10.9 | 144 | 7.25 | 10.9 |
| 145 | 7.15 | 10.7 | 145 | 7.15 | 10.7 | 145 | 7.15 | 10.7 | 145 | 7.15 | 10.7 | 145 | 7.15 | 10.7 |
| 146 | 7.05 | 10.6 | 146 | 7.05 | 10.6 | 146 | 7.05 | 10.6 | 146 | 7.05 | 10.6 | 146 | 7.05 | 10.6 |
| 147 | 6.96 | 10.5 | 147 | 6.96 | 10.5 | 147 | 6.96 | 10.5 | 147 | 6.96 | 10.5 | 147 | 6.96 | 10.5 |
| 148 | 6.86 | 10.3 | 148 | 6.86 | 10.3 | 148 | 6.86 | 10.3 | 148 | 6.86 | 10.3 | 148 | 6.86 | 10.3 |
| 149 | 6.77 | 10.2 | 149 | 6.77 | 10.2 | 149 | 6.77 | 10.2 | 149 | 6.77 | 10.2 | 149 | 6.77 | 10.2 |
| 150 | 6.68 | 10.0 | 150 | 6.68 | 10.0 | 150 | 6.68 | 10.0 | 150 | 6.68 | 10.0 | 150 | 6.68 | 10.0 |
| 151 | 6.59 | 9.91 | 151 | 6.59 | 9.91 | 151 | 6.59 | 9.91 | 151 | 6.59 | 9.91 | 151 | 6.59 | 9.91 |
| 152 | 6.51 | 9.78 | 152 | 6.51 | 9.78 | 152 | 6.51 | 9.78 | 152 | 6.51 | 9.78 | 152 | 6.51 | 9.78 |
| 153 | 6.42 | 9.65 | 153 | 6.42 | 9.65 | 153 | 6.42 | 9.65 | 153 | 6.42 | 9.65 | 153 | 6.42 | 9.65 |
| 154 | 6.34 | 9.53 | 154 | 6.34 | 9.53 | 154 | 6.34 | 9.53 | 154 | 6.34 | 9.53 | 154 | 6.34 | 9.53 |
| 155 | 6.26 | 9.40 | 155 | 6.26 | 9.40 | 155 | 6.26 | 9.40 | 155 | 6.26 | 9.40 | 155 | 6.26 | 9.40 |
| 156 | 6.18 | 9.28 | 156 | 6.18 | 9.28 | 156 | 6.18 | 9.28 | 156 | 6.18 | 9.28 | 156 | 6.18 | 9.28 |
| 157 | 6.10 | 9.17 | 157 | 6.10 | 9.17 | 157 | 6.10 | 9.17 | 157 | 6.10 | 9.17 | 157 | 6.10 | 9.17 |
| 158 | 6.02 | 9.05 | 158 | 6.02 | 9.05 | 158 | 6.02 | 9.05 | 158 | 6.02 | 9.05 | 158 | 6.02 | 9.05 |
| 159 | 5.95 | 8.94 | 159 | 5.95 | 8.94 | 159 | 5.95 | 8.94 | 159 | 5.95 | 8.94 | 159 | 5.95 | 8.94 |
| 160 | 5.87 | 8.82 | 160 | 5.87 | 8.82 | 160 | 5.87 | 8.82 | 160 | 5.87 | 8.82 | 160 | 5.87 | 8.82 |

| ASD | LRFD |
|---|---|
| $\Omega_c = 1.67$ | $\phi_c = 0.90$ |