Tables for Equal Single Angles in Compression

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The design of single angles in compression is a time consuming, iterative procedure. A computer program was developed to perform these time consuming calculations and generate tables for grades 36 ksi and 50 ksi equal leg angles. The program uses the recently published allowable stresses given in Reference 1.

The tables are generated using the following criteria:

1. The angle is pinned at the support points. ($K = 1.0$)
2. The common loading case where the axial load is applied on one side by a gusset plate. (See Fig. 1.)
3. No axial load is given when L/r exceeds 200.

The following example will illustrate the procedure used by the program:

Given:

Determine the maximum axial load that can be applied as shown in Fig. 1 for an L4×4×¼ grade 36 ksi with an unbraced length of 5 ft 0 in.

Angle Properties:

$A = 1.94$ in.^{2}
$I_x = 3.04$ in.^{4}
$Y = 1.09$ in.
$r_z = .795$ in.
$J = .0438$ in.^{4}
$r_o = 2.23$ in.
$H = .627$
$F_y = 36$ ksi
$E = 29{,}000$ ksi
$G = 11{,}200$ ksi
$t_g = \frac{3}{8}$ in.

Solution:

Determine Q.

$$\frac{b}{t} = \frac{4}{¼} = 16 \quad \frac{76}{\sqrt{F_y}} = \frac{76}{\sqrt{36}} = 12.7 \quad \frac{155}{\sqrt{F_y}} = \frac{155}{\sqrt{36}} = 25.8$$

since $12.7 < 16 < 25.8$, use $Q = 1.340 - .00447\left(\frac{b}{t}\right)\sqrt{F_y}$

$$Q = 1.340 - .00447(16)\sqrt{36} = .911$$

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Determine angle properties with respect to the W and Z axes.

$$I_z = Ar_z^2 = 1.94(.795)^2 = 1.23 \text{ in.}^4$$

$$I_w = I_x + I_y - I_z = 2(3.04) - 1.23 = 4.85 \text{ in.}^4$$

$$r_w = \sqrt{\frac{I_w}{A}} = \sqrt{\frac{4.85}{1.94}} = 1.58 \text{ in.}$$

$$E_w = \frac{.7071}{2}(L_g + t_g) = \frac{.7071}{2}(4 + .375) = 1.55 \text{ in.}$$

$$E_z = y\sqrt{2} - \frac{.7071}{2}(L_g - t_g)$$

$$= 1.09\sqrt{2} - \frac{.7071}{2}(4 - .375) = .260 \text{ in.}$$

$$C_w = .7071(L_g) = .7071(4) = 2.83 \text{ in.}$$

$$C_z = y\sqrt{2} = 1.09\sqrt{2} = 1.54 \text{ in.}$$

$$S_w = \frac{I_w}{C_w} = \frac{4.85}{2.83} = 1.71 \text{ in.}^3$$

$$S_z = \frac{I_z}{C_z} = \frac{1.23}{1.54} = .799 \text{ in.}^3$$

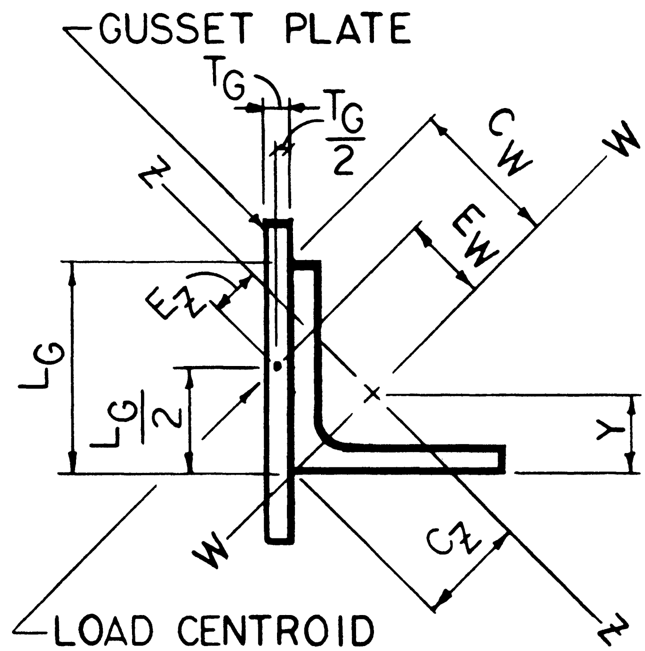

Fig. 1. Angle plan view.

Determine the Equivalent L/r for flexural-torsional buckling.

$$F_{ej} = \frac{GJ}{Ar_o^2} = \frac{11{,}200(.0438)}{1.94(2.23)^2} = 50.8 \text{ ksi}$$

$$F_{ew} = \frac{\pi^2 E}{\left(\frac{L}{r_w}\right)^2} = \frac{\pi^2(29{,}000)}{\left(\frac{5(12)}{1.58}\right)^2} = 198.5 \text{ ksi}$$

$$F_e = \frac{F_{ew} + F_{ej}}{2H}\left(1 - \sqrt{1 - \frac{4(F_{ew})(F_{ej})H}{(F_{ew} + F_{ej})^2}}\right)$$

$$F_e = \frac{198.5+50.8}{2(.627)}\left(1 - \sqrt{1 - \frac{4(198.5)(50.8)(.627)}{(198.5 + 50.8)^2}}\right) = 45.7 \text{ ksi}$$

$$\left(\frac{L}{r}\right)_{equiv} = \pi\sqrt{\frac{E}{F_e}} = \pi\sqrt{\frac{29{,}000}{45.7}} = 79.1$$

$$\frac{L}{r_z} = \frac{5(12)}{.795} = 75.5$$

since 79.1 > 75.5, flexural-torsional buckling controls.

Determine F_a.

$$C_c' = \sqrt{\frac{2\pi^2 E}{QF_y}} = \sqrt{\frac{2\pi^2(29{,}000)}{.911(36)}} = 132.1$$

$$\frac{L/r}{C_c'} = \frac{79.1}{132.1} = .60 \text{ using Ref. 1 Table 3} \quad C_a = .440$$

$$F_a = C_a Q F_y = .440(.911)36 = 14.4 \text{ ksi}$$

Determine F_{bw}.

$$F_{ob} = \frac{28{,}250}{\frac{L}{t}} = \frac{28{,}250}{\frac{5(12)}{.25}} = 117.7 \text{ ksi}$$

since 117.7 ksi > 36 ksi, use $F_{bw} = (0.95 - .50\sqrt{\frac{F_y}{F_{ob}}})F_y \leq .66\, F_y$

$$F_{bw} = (0.95 - .50\sqrt{\frac{36}{117.7}})36 = 24.2 \text{ ksi}$$

$$.66(36) = 23.8 \text{ ksi}$$

Check b/t provisions.

since $b/t > \frac{76}{\sqrt{F_y}}$, use $F_{bw} = .60QF_y$

$$F_{bw} = .60(.911)36 = 19.7 \text{ ksi} \leftarrow \text{governs}$$

Determine F_{bz}.

since $b/t > \frac{76}{\sqrt{F_y}}$ use $F_{bz} = .60QF_y = 19.7$ ksi

Solve for the maximum allowable axial load using:

$$\frac{P}{AF_a} + \frac{PE_w}{\left(1 - \frac{P}{AF'_{ew}}\right)S_w F_{bw}} + \frac{PE_z}{\left(1 - \frac{P}{AF'_{ez}}\right)S_z F_{bz}} \leq 1.0$$

$F'_{ew} = 103.4$ ksi $\quad F'_{ez} = 26.2$ ksi using Ref. 1 Table 8

$$\frac{P}{1.94(14.4)} + \frac{P(1.55)}{\left(1 - \frac{P}{1.94(103.4)}\right)1.71(19.7)} + \frac{P(.260)}{\left(1 - \frac{P}{1.94(26.2)}\right).799(19.7)} \leq 1.0$$

$P = 9.6$ kips

REFERENCES

1. American Institute of Steel Construction, *Manual of Steel Construction,* 9th ed., (Chicago: AISC, 1989).

Allowable Axial Load in Kips

L8.0×8.0

KL (ft)	Grade 36.0 ksi 1⅛	1	⅞	¾	⅝	9/16	½	Grade 50.0 ksi 1⅛	1	⅞	¾	⅝	9/16	½
1	99.9	92.0	83.7	73.8	59.2	51.7	43.9	137.7	126.6	114.8	94.7	75.8	65.3	54.4
2	99.6	91.8	83.4	73.6	59.0	51.6	43.8	137.3	126.1	114.4	94.4	75.6	65.2	54.3
3	99.2	91.3	83.1	73.2	58.9	51.4	43.6	136.4	125.3	113.7	93.8	75.2	64.9	54.1
4	98.5	90.7	82.6	72.8	58.5	51.2	43.5	135.0	124.2	112.7	93.2	74.6	64.5	53.8
5	97.3	89.9	81.9	72.3	58.1	50.9	43.2	132.9	122.7	111.5	92.2	74.0	63.9	53.4
6	95.4	88.3	81.1	71.6	57.6	50.4	42.8	129.5	119.8	109.8	91.0	73.2	63.3	52.9
7	93.4	86.4	79.2	70.7	57.0	49.9	42.5	125.6	116.2	106.6	89.6	72.1	62.5	52.3
8	91.0	84.3	77.3	69.0	56.2	49.4	42.1	121.4	112.2	102.9	86.8	71.0	61.6	51.6
9	88.5	81.9	75.1	67.1	55.2	48.7	41.6	116.7	108.0	99.1	83.6	69.2	60.5	50.9
10	85.8	79.3	72.8	65.0	53.6	47.7	41.0	111.8	103.3	94.8	80.3	66.5	59.0	50.0
11	82.9	76.6	70.3	62.8	51.8	46.3	40.2	106.6	98.4	90.2	76.5	63.7	56.6	48.8
12	79.8	73.7	67.6	60.5	49.9	44.7	38.9	101.0	93.1	85.4	72.7	60.7	54.1	46.8
13	76.6	70.7	64.9	58.0	48.0	43.0	37.5	95.0	87.6	80.3	68.5	57.4	51.4	44.5
14	73.2	67.6	62.0	55.4	45.9	41.2	36.1	88.6	81.6	74.8	64.0	54.0	48.5	42.3
15	69.6	64.2	58.8	52.7	43.6	39.3	34.5	82.4	75.8	69.1	59.4	50.3	45.3	39.7
16	65.7	60.6	55.6	49.7	41.3	37.3	32.9	76.6	70.4	63.9	55.3	46.7	42.2	37.2
17	61.8	56.9	52.2	46.6	38.9	35.2	31.1	71.4	65.3	59.2	51.5	43.6	39.4	34.6
18	58.1	53.5	48.9	43.5	36.4	33.1	29.3	66.5	60.7	55.0	47.9	40.5	36.8	32.4
19	54.6	50.2	46.0	40.7	34.2	31.1	27.5	62.0	56.5	51.2	44.6	37.7	34.2	30.3
20	51.5	47.2	43.1	38.1	32.2	29.2	25.9	57.9	52.7	47.8	41.5	35.2	31.9	28.2
21	48.5	44.5	40.5	35.8	30.2	27.5	24.5	54.2	49.3	44.6	38.8	32.8	29.8	26.4
22	45.8	42.0	38.1	33.7	28.4	25.8	23.0	50.8	46.2	41.8	36.3	30.7	27.9	24.7
23	43.2	39.5	35.8	31.6	26.7	24.3	21.6	47.6	43.3	39.1	34.0	28.8	26.1	23.1
24	40.8	37.3	33.8	29.9	25.2	22.9	20.3	44.7	40.7	36.8	32.0	27.1	24.5	21.7
25	38.6	35.3	31.9	28.2	23.7	21.6	19.2	42.1	38.4	34.6	30.1	25.4	23.0	20.3
26	36.6	33.3	30.1	26.6	22.4	20.4	18.1	39.8	36.1	32.6	28.3	23.9	21.7	19.1

L6.0×6.0

KL (ft)	Grade 36.0 ksi 1	⅞	¾	⅝	9/16	½	7/16	⅜	5/16	Grade 50.0 ksi 1	⅞	¾	⅝	9/16	½	7/16	⅜	5/16
1	61.3	56.2	50.5	44.4	40.6	34.7	29.9	24.2	18.2	84.7	77.5	69.5	57.0	52.1	45.5	37.9	30.0	21.8
2	61.0	55.9	50.3	44.1	40.5	34.5	29.8	24.1	18.2	84.1	77.0	69.0	56.6	51.8	45.2	37.8	29.9	21.7
3	60.3	55.5	49.9	43.7	40.1	34.3	29.6	24.0	18.1	82.9	76.0	68.2	56.1	51.3	44.8	37.5	29.7	21.6
4	59.0	54.3	49.2	43.3	39.7	33.9	29.3	23.7	17.9	80.5	74.0	67.0	55.2	50.5	44.2	37.0	29.3	21.4
5	57.5	52.9	47.8	42.5	39.1	33.4	29.0	23.5	17.8	77.6	71.4	64.6	54.0	49.6	43.5	36.5	28.9	21.1
6	55.7	51.2	46.3	41.1	38.0	32.8	28.5	23.2	17.6	74.3	68.4	61.7	51.6	47.8	42.4	35.8	28.4	20.9
7	53.6	49.3	44.6	39.6	36.6	31.7	27.9	22.8	17.3	70.6	64.9	58.6	49.1	45.4	40.4	34.8	27.9	20.5
8	51.4	47.2	42.6	37.9	35.0	30.3	26.8	22.3	17.1	66.6	61.1	55.1	46.4	42.8	38.1	33.0	27.2	20.2
9	49.1	45.0	40.6	36.1	33.2	29.0	25.6	21.4	16.7	62.2	57.0	51.4	43.4	39.9	35.7	31.1	25.7	19.7
10	46.4	42.6	38.4	34.1	31.4	27.4	24.3	20.4	16.2	57.4	52.5	47.3	40.0	36.9	33.1	28.9	24.2	18.9
11	43.6	40.0	36.0	32.0	29.4	25.7	22.9	19.2	15.5	52.3	47.8	42.9	36.4	33.5	30.2	26.6	22.4	17.8
12	40.7	37.2	33.4	29.7	27.4	23.9	21.4	18.1	14.6	47.7	43.4	38.9	33.1	30.5	27.4	24.2	20.5	16.5
13	37.5	34.3	30.7	27.3	25.1	22.0	19.7	16.8	13.7	43.5	39.6	35.2	30.1	27.7	24.9	22.1	18.7	15.2
14	34.7	31.7	28.3	25.1	22.9	20.3	18.1	15.4	12.7	39.8	36.2	32.0	27.5	25.2	22.7	20.1	17.1	13.9
15	32.1	29.2	26.1	23.0	21.0	18.7	16.7	14.3	11.8	36.5	33.0	29.2	25.1	22.9	20.6	18.3	15.6	12.9
16	29.7	27.1	24.1	21.2	19.3	17.2	15.4	13.2	10.9	33.6	30.3	26.7	23.0	20.9	18.8	16.7	14.2	11.7
17	27.6	25.0	22.4	19.5	17.8	15.9	14.2	12.1	10.2	30.8	27.8	24.6	21.1	19.2	17.3	15.3	13.0	10.7
18	25.7	23.3	20.7	18.0	16.4	14.7	13.1	11.2	9.4	28.5	25.6	22.6	19.4	17.6	15.9	14.0	12.0	9.9
19	23.9	21.7	19.2	16.8	15.3	13.6	12.2	10.4	8.7	26.3	23.7	20.9	18.0	16.3	14.6	13.0	11.0	9.1
20									8.0									8.4

L5.0×5.0

KL (ft)	Grade 36.0 ksi ⅞	¾	⅝	½	7/16	⅜	5/16	Grade 50.0 ksi ⅞	¾	⅝	½	7/16	⅜	5/16
1	42.8	39.1	34.6	29.5	24.6	21.0	16.4	59.2	54.0	47.6	37.8	32.9	26.9	20.5
2	42.5	38.8	34.4	29.2	24.4	21.0	16.4	58.5	53.5	47.1	37.5	32.6	26.7	20.3
3	41.6	38.2	33.9	28.9	24.2	20.7	16.3	56.9	52.3	46.4	36.9	32.1	26.3	20.1
4	40.3	37.1	33.0	28.4	23.7	20.4	16.0	54.6	50.2	44.6	36.1	31.4	25.9	19.8
5	38.8	35.6	31.7	27.4	23.2	20.1	15.8	51.9	47.7	42.3	34.4	30.4	25.3	19.4
6	37.2	34.1	30.3	26.1	22.2	19.4	15.4	48.9	44.7	39.8	32.4	28.7	24.2	18.9
7	35.3	32.4	28.8	24.8	21.1	18.5	14.9	45.4	41.6	36.9	30.1	26.7	22.6	18.1
8	33.2	30.4	27.0	23.2	19.8	17.4	14.2	41.6	38.0	33.6	27.5	24.5	20.8	16.8
9	31.0	28.3	25.0	21.6	18.4	16.2	13.3	37.4	34.1	30.1	24.7	22.0	19.0	15.5
10	28.6	26.0	23.0	19.7	17.0	14.9	12.3	33.5	30.4	26.8	22.1	19.6	17.0	13.9
11	26.0	23.6	20.8	17.9	15.4	13.6	11.2	30.1	27.3	23.8	19.7	17.6	15.2	12.5
12	23.6	21.5	18.9	16.0	14.0	12.3	10.2	27.1	24.5	21.3	17.6	15.6	13.6	11.2
13	21.6	19.6	17.2	14.5	12.6	11.2	9.3	24.5	22.1	19.1	15.8	14.0	12.2	10.1
14	19.8	17.8	15.6	13.2	11.6	10.1	8.5	22.2	19.9	17.2	14.2	12.6	11.0	9.1
15	18.2	16.3	14.3	12.0	10.6	9.1	7.7	20.2	18.0	15.7	12.9	11.4	9.8	8.2
16	16.7	15.0	13.1	11.0	9.7	8.4	7.0	18.4	16.5	14.3	11.7	10.4	9.0	7.4

Allowable Axial Load in Kips (cont.)

L4.0×4.0

KL (ft)	Grade 36.0 ksi							Grade 50.0 ksi						
	3/4	5/8	1/2	7/16	3/8	5/16	1/4	3/4	5/8	1/2	7/16	3/8	5/16	1/4
1	27.7	24.9	21.6	19.5	17.2	13.7	10.3	38.4	34.4	29.7	26.9	22.1	17.6	12.8
2	27.3	24.5	21.4	19.3	17.1	13.6	10.2	37.6	33.8	29.3	26.4	21.8	17.4	12.7
3	26.5	23.8	20.8	18.9	16.7	13.4	10.1	36.0	32.2	28.3	25.8	21.3	17.0	12.5
4	25.3	22.7	19.9	18.1	16.2	13.0	9.9	33.8	30.4	26.5	24.1	20.3	16.5	12.2
5	23.9	21.4	18.7	17.1	15.2	12.4	9.6	31.3	28.1	24.5	22.3	18.8	15.5	11.8
6	22.4	20.0	17.5	15.9	14.2	11.6	9.1	28.5	25.4	22.2	20.2	17.1	14.1	11.0
7	20.7	18.4	16.1	14.6	13.0	10.6	8.5	25.2	22.5	19.5	17.7	15.1	12.6	10.0
8	18.7	16.7	14.4	13.2	11.7	9.7	7.7	22.1	19.6	16.9	15.2	13.1	11.0	8.8
9	16.6	14.8	12.8	11.6	10.3	8.6	7.0	19.3	17.1	14.6	13.2	11.4	9.6	7.7
10	14.9	13.2	11.3	10.2	9.0	7.6	6.2	17.0	15.0	12.7	11.4	9.9	8.4	6.7
11	13.4	11.8	10.1	9.1	8.0	6.7	5.4	15.1	13.2	11.2	10.1	8.7	7.3	5.9
12	12.0	10.5	9.0	8.1	7.1	6.0	4.9	13.5	11.7	9.9	8.9	7.6	6.5	5.2
13			8.1	7.2	6.3	5.4	4.3			8.8	7.9	6.8	5.7	4.6

L3.5×3.5

KL (ft)	Grade 36.0 ksi					Grade 50.0 ksi				
	1/2	7/16	3/8	5/16	1/4	1/2	7/16	3/8	5/16	1/4
1	17.7	16.1	14.5	11.7	9.3	24.3	22.1	18.6	15.7	11.7
2	17.4	15.8	14.3	11.5	9.1	23.8	21.7	18.3	15.5	11.6
3	16.7	15.2	13.8	11.2	8.9	22.5	20.6	17.5	15.0	11.3
4	15.7	14.3	13.0	10.6	8.7	20.7	18.9	16.2	14.0	10.9
5	14.6	13.3	12.1	9.9	8.1	18.7	17.0	14.6	12.6	9.9
6	13.3	12.1	11.0	9.1	7.4	16.3	14.9	12.8	11.1	8.8
7	11.9	10.8	9.8	8.1	6.7	14.0	12.6	10.9	9.4	7.6
8	10.4	9.4	8.5	7.1	5.9	12.0	10.7	9.4	8.1	6.6
9	9.0	8.3	7.4	6.2	5.1	10.2	9.3	8.1	6.9	5.5
10	8.0	7.2	6.4	5.5	4.5	8.9	7.9	7.0	6.0	4.9
11	7.1	6.3	5.6	4.7	3.9	7.8	6.9	6.0	5.2	4.2

L3.0×3.0

KL (ft)	Grade 36.0 ksi						Grade 50.0 ksi					
	1/2	7/16	3/8	5/16	1/4	3/16	1/2	7/16	3/8	5/16	1/4	3/16
1	14.0	12.8	11.6	10.1	7.9	5.5	19.2	17.7	15.9	13.0	10.3	6.9
2	13.5	12.4	11.3	9.9	7.7	5.4	18.5	17.0	15.4	12.6	10.1	6.8
3	12.8	11.8	10.7	9.4	7.5	5.3	17.2	15.7	14.3	11.9	9.6	6.5
4	11.8	10.9	9.9	8.7	7.0	5.1	15.4	14.2	12.8	10.6	8.8	6.2
5	10.8	9.9	8.9	7.8	6.3	4.7	13.3	12.2	11.1	9.2	7.6	5.5
6	9.5	8.6	7.8	6.9	5.5	4.1	11.2	10.2	9.2	7.7	6.3	4.7
7	8.1	7.4	6.7	5.9	4.7	3.6	9.4	8.6	7.6	6.5	5.3	4.0
8	7.0	6.4	5.7	4.9	4.0	3.1	8.0	7.2	6.4	5.4	4.4	3.3
9	6.0	5.5	4.9	4.2	3.5	2.6	6.8	6.1	5.4	4.6	3.8	2.8

L2.5×2.5

KL (ft)	Grade 36.0 ksi					Grade 50.0 ksi				
	1/2	3/8	5/16	1/4	3/16	1/2	3/8	5/16	1/4	3/16
1	10.4	8.8	7.7	6.5	4.7	14.3	12.1	10.6	8.4	6.0
2	9.8	8.4	7.4	6.3	4.6	13.4	11.4	10.1	8.0	5.8
3	9.1	7.8	6.8	5.9	4.4	12.1	10.2	9.1	7.2	5.4
4	8.3	6.9	6.1	5.2	3.9	10.5	8.7	7.7	6.2	4.7
5	7.2	6.0	5.3	4.5	3.4	8.5	7.0	6.2	5.0	3.9
6	6.0	5.0	4.3	3.7	2.8	7.0	5.8	4.9	4.1	3.1
7	5.0	4.1	3.6	3.1	2.3	5.7	4.6	4.0	3.4	2.5
8	4.3	3.5	3.1	2.6	2.0	4.8	3.9	3.3	2.7	2.1

L2.0×2.0

KL (ft)	Grade 36.0 ksi					Grade 50.0 ksi				
	3/8	5/16	1/4	3/16	1/8	3/8	5/16	1/4	3/16	1/8
1	6.0	5.4	4.7	3.7	2.2	8.3	7.5	6.5	4.8	2.8
2	5.6	5.1	4.4	3.5	2.2	7.6	6.8	5.9	4.5	2.7
3	5.0	4.5	3.9	3.1	2.0	6.4	5.7	5.0	3.8	2.4
4	4.3	3.8	3.2	2.6	1.7	5.1	4.5	3.8	3.0	2.0
5	3.4	3.0	2.6	2.1	1.4	3.9	3.5	3.0	2.3	1.5
6	2.8	2.5	2.1	1.7	1.1	3.1	2.7	2.3	1.8	1.2