Tables for the Design Strength of Eccentrically-Loaded Single Angle Struts

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ABSTRACT

The design of eccentrically-loaded single angle struts is a tedious and lengthy procedure. A computer program was developed to perform these time consuming calculations and generate design tables for 36 ksi and 50 ksi equal and unequal leg angles. The program uses the less conservative approach permitted by the AISC *Specification for Load and Resistance Factor Design of Single-Angle Members* (AISC, 1993). This approach involves applying the interaction equation separately at the corner and the two leg tips of the angle, with the proper signs for compression and tension. Two step-by-step numerical examples are presented in this paper to outline the procedure implemented to generate load tables for equal and unequal leg angles.

INTRODUCTION

Single angles are the most basic shape of hot rolled steel sections. They are typically attached by one leg at their ends to gusset plates or other structural elements. In spite of the simplicity of their cross-section, single-angle compression members are among the most difficult structural elements to analyze and design.

The AISC *Manual of Steel Construction, Load and Resistance Factor Design* (AISC, 1994) requires that such members be designed as beam-columns. The design is governed by the AISC *Specification for Load and Resistance Factor Design of Single-Angle Members* (AISC, 1993), which is reproduced in Part 6 of the AISC *Manual of Steel Construction*.

A numerical example is given in that Manual to outline this procedure. The load is assumed to act at the mid-plane of the gusset plate and at the center of the attached leg as shown in Figure 1. The example as presented did not illustrate the less conservative and more correct approach allowed by the AISC *Specification for Load and Resistance Factor Design of Single-Angle Members*. No numerical examples were provided to illustrate the application of the interaction equation to unequal-leg single-angle struts. The evaluation of the axial capacity of equal-leg single angle struts with due consideration of the sign of the stress was later addressed by Lutz (1996). It was shown that consideration of the sign of the stress at a location when evaluating the interaction expression leads to a significant increase in axial capacity. In addition, practicing engineers find the AISC LRFD procedure for the design of single angle struts connected by one leg tedious and lengthy for what appears to be a simple structural element. Tables for the allowable axial load of equal-leg single angles in compression were presented by Walker (1991). No design tables, based on the LRFD approach, are available for single angle compression members connected by one leg. The lack of design tables and the amount of effort involved in hand calculations make practicing engineers tend to use very conservative approximate methods for the design of such structural elements.

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DESIGN TABLES

The purpose of this paper is to provide tables (see Table 1) for the design strength of equal and unequal leg single-angles connected by one leg to gusset plates. Two steel strengths are included in the design tables, 36 ksi and 50 ksi. The basis for the design method is contained in the AISC LRFD *Manual* (AISC, 1994) and is illustrated in this paper by two step-by-step examples. The following assumptions were made:

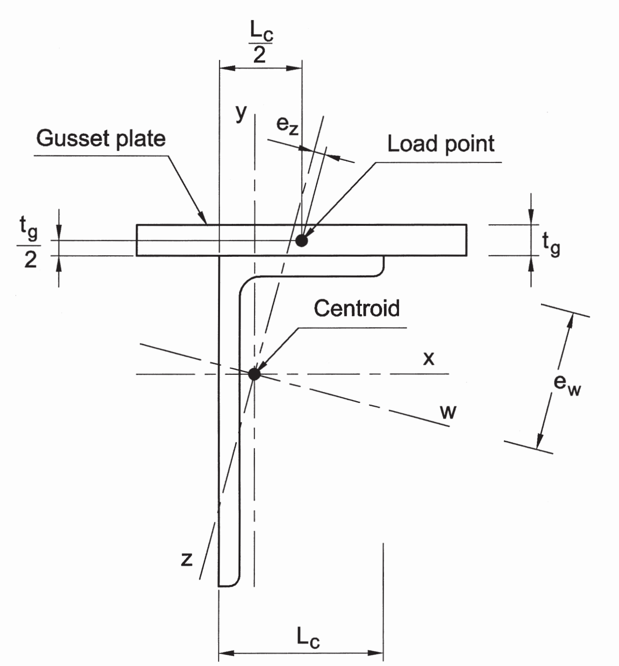

Fig. 1. Angle plan view.

1. The eccentric axial load is applied at the center of the gusset plate and at the center of the connected leg.
2. The maximum slenderness ratio with respect to the minor principal axis, the z-axis, is 200.
3. The effective length factors about the principal axes, K_z and K_w, are equal.
4. The gusset plate thickness is 1.5 times the angle thickness.

For common structures, the practical range of the gusset plate thickness may vary from 1.0 to 2.0 times the angle thickness. Increasing the gusset plate thickness increases the eccentricity about the x-axis which, in turn, decreases the load carrying capacity. For a 4×4×½ angle with a slenderness ratio of 200 and yield stress of 50 ksi, changing the gusset plate thickness from 1.0 to 2.0 times the angle thickness changes the design strength from 16.6 to 15.6 kips (i.e. the design strength decreases by about 6 percent). For the same angle with a slenderness ratio of 60, changing the gusset plate thickness from 1.0 to 2.0 times the angle thickness changes the design strength from 70.0 to 60.4 kips (i.e. about 14 percent decrease in the design strength). This justifies the use of a gusset plate thickness of 1.5 times the angle thickness in producing the design tables. The tabulated values are conservative if the gusset plate thickness is less than 1.5 times the angle thickness and it is not common to have a gusset plate thickness greater than 1.5 times the angle thickness.

The following examples illustrate the procedure used by the program for the case of unequal-leg single angles. Example I shows the case of an angle attached by the short leg while example II illustrates the case of an angle attached by the long leg.

NUMERICAL EXAMPLE I

Given:

An angle 8×4×½ is attached by the short leg to a gusset plate. The gusset plate thickness is 0.75 in. as shown in Figure 2. The effective length *KL* is 100.0 in. Calculate the maximum factored compressive load which may be applied through the center of the gusset plate.

Angle Properties:

$A = 5.75$ in.^{2}

$I_x = 38.5$ in.^{4} $\quad I_y = 6.74$ in.^{4}

$r_x = 2.59$ in. $\quad r_y = 1.08$ in.

$y = 2.86$ in. $\quad x = 0.859$ in.

$r_z = 0.865$ in.

$\alpha = 14.95^o$

$F_y = 50$ ksi $\quad E = 29{,}000$ ksi

Solution:

Determine the angle properties with respect to the principal *w* and *z* axis.

$I_z = Ar_z^2 = 5.75\ (0.865)^2 = 4.30$ in.^{4}

$I_w = I_x + I_y - I_z = 38.50 + 6.74 - 4.30 = 40.94$ in.^{4}

$$r_w = \sqrt{\frac{I_w}{A}} = 2.67 \text{ in.}$$

The distances between Points A, B, and C and the angle principal axes are shown in Figure 2.

At the angle tip of the connected leg (Point A)

$S_z = 4.30/2.36 = 1.82$ in.^{3}

$S_w = 40.94/3.33 = 12.29$ in.^{3}

At the angle corner (Point B)

$S_z = 4.30/1.57 = 2.74$ in.^{3}

$S_w = 40.94/2.54 = 16.12$ in.^{3}

At the angle tip of the outstanding leg (Point C)

$S_z = 4.30/0.74 = 5.81$ in.^{3}

$S_w = 40.94/5.12 = 8.00$ in.^{3}

The angle concentric design compressive strength $\phi P_n = 84.7$ kips (from AISC LRFD *Manual* Single Angle Columns Table for L8×4×½ with $KL = 8.33$ ft).

The interaction of flexure and axial compression shall be evaluated for the principal bending axes at the angle corner and tips using LRFD Single Angle Spec. Equations 6-1a and 6-1b. The flexural terms are either added to or subtracted from the axial load term depending on the sense of flexural stresses at the considered point.

For a tiny load applied at Point D, stresses at the angle tips and corner could be calculated as follows:

$$\sigma = \frac{P}{A} + \frac{Pe_z}{S_z} + \frac{Pe_w}{S_w}$$

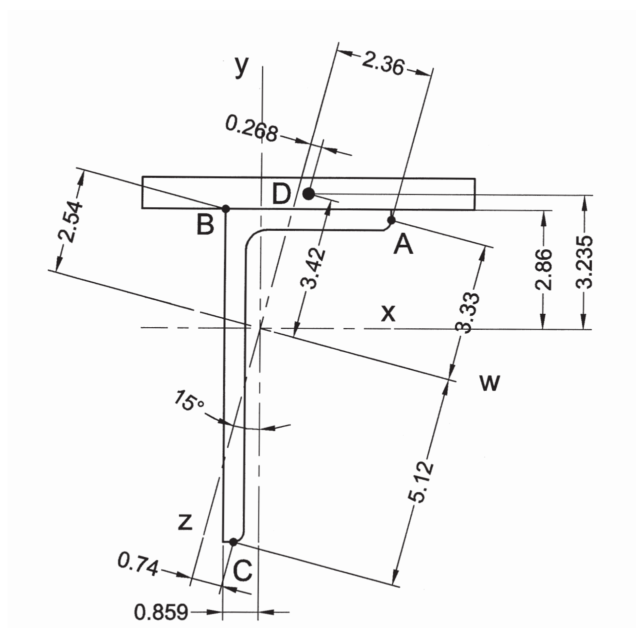

Fig. 2. Angle configuration for Example I.

$$\sigma_A = \frac{P}{5.75} + \frac{P(0.268)}{1.82} + \frac{P(3.42)}{12.29} = 0.60\ P\ \text{(compression)}$$

$$\sigma_B = \frac{P}{5.75} - \frac{P(0.268)}{2.74} + \frac{P(3.42)}{16.12} = 0.29\ P\ \text{(compression)}$$

$$\sigma_C = \frac{P}{5.75} + \frac{P(0.268)}{5.81} - \frac{P(3.42)}{8.0} = -0.21\ P\ \text{(tension)}$$

The interaction of flexure and axial compression shall be evaluated at Points A and B where the resultant stress is compression. However, the interaction equation need not be checked at Point C as the resultant stress at that point is tension. The load carrying capacity of the angle will not be governed by evaluating the interaction equation at Point C.

Evaluation of P_u at Point A (angle tip in compression)

$$M_{ob} = 4.9E\frac{I_z}{l^2}C_b\left[\sqrt{\beta_w^2 + 0.052(lt/r_z)^2} + \beta_w\right]$$
$$= 4.9(29{,}000)(\frac{4.3}{100^2})(1.0)$$
$$\times\left[\sqrt{5.48^2 + 0.052(100\times 0.5/0.865)^2} + 5.48\right]$$
$$= 1207 \quad \text{kip-in.}$$

According to Section 5.3.2 of the AISC *Load and Resistance Factor Design Specification for Single Angle Members*,

$M_y = F_yS_w = 50(12.29) = 614.5$ kip-in.

Since $M_{ob} > M_y$ (Section 5.1.3),

$$M_{nw} = \left[1.58 - 0.83\sqrt{806.0/1207}\right]M_y$$
$$= 0.902M_y < 1.25M_y$$

As per Section 5.1.1, for the limit state of local buckling when the tip of an angle leg is in compression

$$b/t = 4/0.5 = 8 < 0.392\sqrt{E/F_y} = 9.4$$

which permits an $M_n = 1.25M_y$

$\therefore M_{nw} = 0.988M_y = 0.988\ (614.5) = 607$ kip-in.

Regarding minor axis buckling, Single Angle Specification Section 5.1.1 should be used as the angle tip (Point A) is in compression.

As the limit state of local buckling of the attached leg permits an $M_n = 1.25M_y$

$\therefore M_{nz} = 1.25M_y = 1.25\ (50)(1.82) = 113.8$ kip-in.

The elastic buckling loads about the major and minor principal axes are calculated as follows:

$P_{ew} = \pi^2EI_w/l^2 = \pi^2(29000)(40.94)/(100)^2 = 1172$ kips

$P_{ez} = \pi^2EI_z/l^2 = \pi^2(29000)(4.30)/(100)^2 = 123$ kips

As both of the flexural terms are producing compression at Point A, the corresponding M_u should be multiplied by B_1.

$$\therefore B_{1w} = \frac{C_m}{1-\frac{P_u}{P_{ew}}} = \frac{1}{1-\frac{P_u}{1172}} \quad \text{and} \quad B_{1z} = \frac{C_m}{1-\frac{P_u}{P_{ez}}} = \frac{1}{1-\frac{P_u}{123}}$$

The C_m factor is taken as 1 for all values of B_1 and should also have been one in Example 3-8 as reported by Lutz (1996).

Applying Equation 6-1a at Point A in Figure 1 yields:

$$\frac{P_u}{84.7} + \frac{8}{9}\left(\frac{0.268P_u}{0.9(113.8)\left(1-\frac{P_u}{123}\right)} + \frac{3.42P_u}{0.9(607)\left(1-\frac{P_u}{1172}\right)}\right) = 1$$

In the above equation, $P_u = 47.0$ kips. It can be readily seen that Point A will govern the load carrying capacity of the angle. However, Point B will be checked to illustrate the problem.

Evaluation of P_u at Point B (angle corner)

$M_{ob} = 1207$ kip-in. (as calculated for point A)

$M_y = F_yS_w = 50(16.12) = 806.0$ kip-in.

Since $M_{ob} > M_y$ (Section 5.1.3),

$$M_{nw} = \left[1.58 - 0.83\sqrt{806.0/1207}\right]M_y$$
$$= 0.902M_y < 1.25M_y$$

As per Section 5.1.1, for the limit state of local buckling when the tip of an angle leg is in compression

$$b/t = 4/0.5 = 8 < 0.392\sqrt{E/F_y} = 9.4$$

which permits an $M_n = 1.25M_y$.

$\therefore M_{nw} = 0.902M_y = 0.902(806.0) = 727.0$ kip-in.

Based on the position of the load, it is clear that the moment about the minor axis, M_{uz}, should be assigned a negative value since it produces tension at Point B. Single Angles Specification Section 5.1.1 should be used to calculate M_{nz} (angle tips in compression).

$\therefore M_{nz} = 1.25M_y = 1.25(50)(2.74) = 171.3$ kip-in.

As the moment about the minor principal axis, M_{uz}, produces tension at point B, the flexural strength M_{nz} shall not be multiplied by B_1.

$$\therefore B_{1w} = \frac{C_m}{1-\frac{P_u}{P_{ew}}} = \frac{1}{1-\frac{P_u}{1172}} \text{ and } B_{1z} = 1$$

Applying Equation 6-1a at Point A in Figure 1 yields:

$$\frac{P_u}{84.7} + \frac{8}{9}\left(\frac{-0.268P_u}{0.9(171.3)} + \frac{3.42P_u}{0.9(727.0)\left(1-\frac{P_u}{1172}\right)}\right) = 1$$

In the above interaction expression, P_u = 65.8 kips.

Therefore, P_u = 47.3 kips based on the application of the interaction equation at Point A (the angle tip of the connected leg).

NUMERICAL EXAMPLE II

Given:

Rework Example I if the long leg is attached to the gusset plate.

Solution:

All angle properties are the same as calculated in Example I. The distances between Points A, B, and C and the angle principal axes are shown in Figure 3.

At the angle tip (Point A)
S_z = 4.30/0.74 = 5.81 in.^{3}
S_w = 40.94/5.12 = 8.00 in.^{3}

At the angle corner (Point B)
S_z = 4.30/1.57 = 2.74 in.^{3}
S_w = 40.94/2.54 = 16.12 in.^{3}

At the angle tip (Point C)
S_z = 4.30/2.36 = 1.82 in.^{3}
S_w = 40.94/3.33 = 12.29 in.^{3}

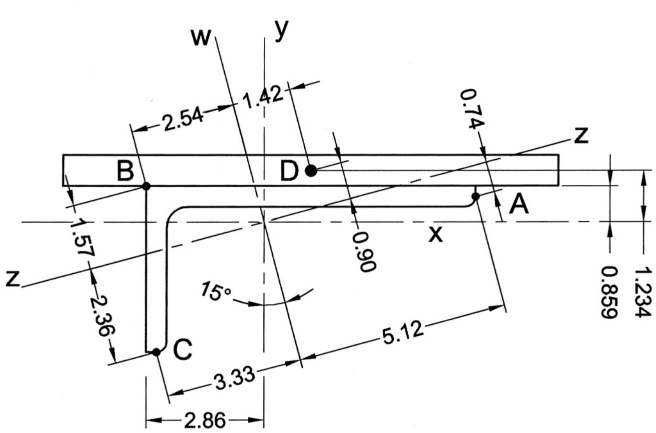

Fig. 3. Angle configuration for Example II.

For a tiny load applied at Point D, stresses at the angle tips and corner could be calculated as follows:

$$\sigma = \frac{P}{A} + \frac{Pe_z}{S_z} + \frac{Pe_w}{S_w}$$

$$\sigma_A = \frac{P}{5.75} - \frac{P(0.90)}{5.81} + \frac{P(1.42)}{8.00} = 0.20\,P \text{ (compression)}$$

$$\sigma_B = \frac{P}{5.75} + \frac{P(0.90)}{2.74} - \frac{P(1.42)}{16.12} = 0.41\,P \text{ (compression)}$$

$$\sigma_C = \frac{P}{5.75} - \frac{P(0.90)}{1.82} - \frac{P(1.42)}{12.29} = -0.44\,P \text{ (tension)}$$

As explained in Example I, the interaction of flexure and axial compression need to be evaluated at Points A and B where the resultant stress is compression. The interaction equation need not be checked at Point C as the resultant stress at that point is tension.

The angle concentric design compressive strength ϕP_n = 84.7 kips (the same as in Example I).

Evaluation of P_u at Point A (angle tip in compression)

According to Single Angle Specification Section 5.3.2,

$$M_{ob} = 4.9E\frac{I_z}{l^2}C_b\left[\sqrt{\beta_w^2 + 0.052(lt/r_z)^2} + \beta_w\right]$$

$$= 4.9(29{,}000)\left(\frac{4.3}{100^2}\right)(1.0)$$

$$\times\left[\sqrt{(-5.48)^2 + 0.052\left(\frac{100\times 0.5}{0.865}\right)^2} - 5.48\right]$$

$$= 537 \text{ kip-in.}$$

β_w is assigned a negative sign as the angle long leg is in compression.

$$M_y = F_yS_w = 50(8.00) = 400.0 \text{ kip-in.}$$

Since $M_{ob} > M_y$ (Section 5.1.3),

$$M_{nw} = \left[1.58 - 0.83\sqrt{400.0/537.0}\right]M_y$$

$$= 0.863M_y < 1.25M_y$$

As per Section 5.1.1, for the limit state of local buckling when the tip of an angle leg is in compression

$$0.446\sqrt{E/F_y} = 10.7 < b/t = 8/0.5 = 16 < 0.91\sqrt{E/F_y} = 21.9$$

From Equation 4-3b

$$Q = 1.34 - 0.761\frac{b}{t}\sqrt{\frac{F_y}{E}}$$

$$= 1.34 - 0.761\frac{8}{0.5}\sqrt{\frac{50}{29{,}000}}$$

$$= 0.834$$

which permits an $M_n = QM_y = 0.834M_y$. This is less than the lateral-torsional buckling limit of $0.863M_y$.

$$\therefore M_{nw} = 0.834M_y = 0.834(400.0) = 333.6 \text{ kip-in.}$$

Regarding minor axis buckling, Single Angle Specification Section 5.1.2 should be used as the angle tip (Point A) is in tension.

$$\therefore M_{nz} = 1.25M_y = 1.25(50)(5.82) = 363.8 \text{ kip-in.}$$

As the moment about the minor principal axis, M_{uz}, produces tension at point A, the flexural strength M_{nz} shall not be multiplied by B_1.

$$\therefore B_{1w} = \frac{C_m}{1-\dfrac{P_u}{P_{ew}}} = \frac{1}{1-\dfrac{P_u}{1172}} \text{ and } B_{1z} = 1$$

Applying Equation 6-1a at Point A in Figure 1 yields:

$$\frac{P_u}{84.7} + \frac{8}{9}\left(\frac{-0.90P_u}{0.9(363.8)} + \frac{1.42P_u}{0.9(333.6)\left(1-\dfrac{P_u}{1172}\right)}\right) = 1$$

In the above equation, $P_u = 72.2$ kips.

Evaluation of P_u at Point B (angle corner)

$M_{ob} = 537$ kip-in. (as calculated for point A)

$M_y = F_yS_w = 50(16.12) = 806.0$ kip-in.

Since $M_{ob} < M_y$ (Section 5.1.3),

$$\begin{aligned} M_{nw} &= [0.92 - 0.17(537/806)]M_{ob} \\ &= 0.807M_{ob} = 0.807 \times 537 \\ &= 433 \text{ kip-in.} \end{aligned}$$

Section 5.1.1 shall not be checked as the major axis bending moment produces tension in the angle corner (Point B).

As can be shown in Figure 3, the minor axis, M_{uz}, produces compression at Point B. Single Angle Specification Section 5.1.2 should be used to calculate M_{nz} (angle tips in tension).

$$\therefore M_{nz} = 1.25M_y = 1.25(50)(2.74) = 171.3 \text{ kip-in.}$$

As the moments about the major principal axis, M_{uw}, produce tension at point B, then, the flexural strength M_{nw} shall not be multiplied by B_{1w}.

$$\therefore B_{1w} = 1 \text{ and } B_{1z} = \frac{C_m}{1-\dfrac{P_u}{P_{ew}}} = \frac{1}{1-\dfrac{P_u}{123}}$$

Applying Single Angle Specification Equation 6-1a at Point B in Figure 1 yields:

$$\frac{P_u}{84.7} + \frac{8}{9}\left(\frac{0.90P_u}{0.9(171.3)\left(1-\dfrac{P_u}{123}\right)} + \frac{-1.42P_u}{0.9(433)}\right) = 1$$

In the above interaction expression, $P_u = 55.5$ kips.

Therefore, $P_u = 55.5$ kips based on the application of the interaction equation at Point B (the angle corner).

As concluded from the results of the computer program, the critical point on the cross-section is either the tip of the connected leg, Point A, or the angle corner, Point B. Applying the interaction equation at the tip of the outstanding leg, Point C, did not govern the load carrying capacity of any case shown in the tables.

REFERENCES

AISC (1994), *Manual of Steel Construction, Load and Resistance Factor Design*, 2nd Ed., Vol. I, American Institute of Steel Construction, Chicago, IL.

AISC (1993), *Specification for Load and Resistance Factor Design of Single-Angle Members*, American Institute of Steel Construction, Chicago, IL.

Lutz, L. A. (1996), "A Closer Examination of the Axial Capacity of Eccentrically Loaded Single Angle Struts", *Engineering Journal*, American Institute of Steel Construction, Vol. 33, No. 2, 2nd Quarter, pp. 73-76.

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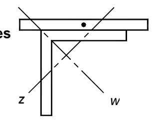
Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
Design Strength in kips (t_g = 1.5t)



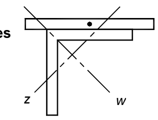
Effective length in feet, KL

Size	8 x 8													
Thick.	1 1/8		1		7/8		3/4		5/8		9/16		1/2	
Wt./ft	56.9		51.0		45.0		38.9		32.7		29.6		26.4	
F_y	36	50	36	50	36	50	36	50	36	50	36	50	36	50
1	245	339	235	324	222	305	205	248	144	182	121	151	99	122
2	242	333	232	317	218	296	199	240	139	174	117	144	95	115
3	240	327	229	312	215	291	196	237	137	171	115	141	93	113
4	236	322	226	306	212	285	193	234	136	169	114	140	92	111
5	231	312	222	299	208	279	190	232	135	168	113	138	92	110
6	224	299	215	287	204	272	187	229	134	166	112	137	91	109
7	216	284	207	272	196	257	182	226	133	164	111	136	90	108
8	207	268	198	256	187	242	175	216	131	162	110	134	90	107
9	197	252	189	240	178	226	166	206	129	158	109	132	89	106
10	188	236	179	224	169	211	157	195	124	151	107	129	88	105
11	178	219	169	208	159	195	148	180	119	143	103	123	87	103
12	168	204	159	193	150	180	138	166	114	134	98	116	83	98
13	158	188	150	178	140	166	129	152	108	126	94	109	80	93
14	148	173	140	163	131	152	121	139	102	117	89	102	76	87
15	138	159	131	149	122	138	112	126	97	109	84	95	72	82
16	129	145	122	136	113	126	104	115	91	100	80	88	69	76
17	120	133	113	125	105	115	96	105	85	91	75	81	65	70
18	111	123	105	115	97	106	89	96	79	84	70	75	61	65
19	103	114	97	106	90	97	82	88	73	78	65	69	57	60
20	96	105	90	98	83	90	76	81	67	71	60	64	53	56
21	90	98	84	91	77	83	70	75	62	66	56	59	49	52
22	84	91	78	84	72	77	65	70	58	61	52	54	46	48
23	79	85	73	79	67	72	61	65	54	56	49	50	43	44
24	74	79	69	73	63	67	57	60	50	52	45	47	40	41
25	69	74	64	69	59	63	53	56	47	49	42	44	37	39
26	65	70	60	64	55	59	50	53	44	46	40	41	35	36

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
Design Strength in kips (t_g = 1.5t)



Effective length in feet, KL

Size	5 x 5													
Thick.	7/8		3/4		5/8		1/2		7/16		3/8		5/16	
Wt./ft	27.2		23.6		20.0		16.2		14.3		12.3		10.3	
F_y	36	50	36	50	36	50	36	50	36	50	36	50	36	50
1	101	139	97	134	91	125	82	111	71	84	51	64	38	46
2	99	137	95	131	89	121	80	107	69	82	50	62	36	44
3	96	130	93	125	87	117	78	104	69	80	49	61	36	43
4	92	122	88	117	83	110	75	99	67	79	49	60	35	43
5	86	113	83	107	77	100	70	91	66	76	48	59	35	42
6	80	102	77	97	71	90	65	81	60	70	46	57	34	41
7	74	92	70	87	65	80	59	72	55	64	44	52	34	40
8	68	82	64	77	59	71	53	63	49	58	40	47	32	37
9	62	72	58	67	53	62	47	54	44	50	37	42	29	33
10	56	63	52	59	48	53	42	47	39	43	34	37	27	30
11	50	56	46	51	42	46	37	40	34	37	30	32	24	26
12	45	49	41	45	37	41	33	35	30	32	27	29	22	23
13	40	44	37	40	33	36	29	31	27	28	24	25	19	21
14	36	40	33	36	30	32	26	28	24	25	21	22	17	18
15	33	36	30	32	27	29	23	25	21	22	19	20	16	16
16	30	32	27	29	24	26	21	22	19	20	17	18	14	14

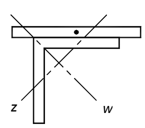
Effective length in feet, KL

Size	4 x 4													
Thick.	3/4		5/8		1/2		7/16		3/8		5/16		1/4	
Wt./ft	18.5		15.7		12.8		11.3		9.8		8.2		6.6	
F_y	36	50	36	50	36	50	36	50	36	50	36	50	36	50
1	65	90	63	86	58	79	54	74	50	60	35	44	24	29
2	64	87	61	83	56	76	53	71	48	59	34	42	23	28
3	60	81	58	77	54	72	51	68	47	57	34	42	23	27
4	56	73	54	70	50	64	47	61	44	54	33	41	22	27
5	52	65	49	61	45	56	42	53	39	49	31	38	22	26
6	47	57	44	53	40	48	37	45	35	41	28	34	21	25
7	42	49	39	46	35	41	33	38	30	35	26	29	19	22
8	37	42	34	38	30	34	28	32	26	29	23	25	17	19
9	32	36	29	33	26	29	24	26	22	24	20	21	15	16
10	28	31	25	28	23	24	21	22	19	20	17	18	13	14
11	25	27	22	24	20	21	18	19	16	17	14	15	11	12
12	22	24	20	21	17	18	16	17	14	15	12	13	10	10
13	---	---	---	---	15	16	14	15	12	13	11	11	9	9

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
Design Strength in kips (t_g = 1.5t)



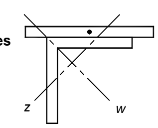
Effective length in feet, KL

Size	6 x 6																	
Thick.	1		7/8		3/4		5/8		9/16		1/2		7/16		3/8		5/16	
Wt./ft	37.4		33.1		28.7		24.2		21.9		19.6		17.2		14.9		12.4	
F_y	36	50	36	50	36	50	36	50	36	50	36	50	36	50	36	50	36	50
1	144	199	139	191	131	181	121	165	114	138	92	112	71	89	55	67	39	46
2	142	196	137	188	129	176	118	160	111	134	90	109	69	85	53	64	37	44
3	140	191	135	183	127	172	116	156	109	132	89	107	68	84	52	63	37	43
4	135	182	130	175	124	166	113	151	106	130	88	105	68	83	51	62	36	42
5	129	171	124	165	118	156	110	144	103	127	87	104	67	82	51	61	36	42
6	123	160	118	153	111	144	103	133	98	122	85	102	66	81	50	60	36	41
7	116	148	111	141	104	132	96	122	92	114	81	96	65	79	50	59	35	41
8	108	135	103	128	97	120	89	110	85	104	77	89	62	74	49	58	35	40
9	101	123	96	116	90	108	82	99	78	93	72	82	58	69	47	55	35	40
10	93	111	88	105	82	97	75	88	71	83	67	75	55	63	44	51	34	39
11	86	100	81	94	75	87	69	78	65	73	60	68	51	58	41	47	32	36
12	79	89	74	83	69	77	62	69	58	65	54	60	47	52	39	43	30	34
13	72	80	67	75	62	68	56	61	53	57	49	53	43	46	36	39	28	31
14	65	72	61	67	56	61	50	55	47	51	44	47	39	42	33	35	26	28
15	59	65	55	60	51	55	45	49	43	46	39	42	35	37	30	31	24	25
16	54	59	50	55	46	50	41	44	39	41	36	38	32	34	27	28	22	23
17	50	54	46	50	42	45	38	40	35	37	32	34	29	30	25	26	20	21
18	46	50	42	46	39	41	34	36	32	34	29	31	27	27	23	23	18	19
19	42	46	39	42	35	38	31	33	29	31	27	28	24	25	21	21	17	17

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
Design Strength in kips (t_g = 1.5t)



Effective length in feet, KL

Size	3 ½ x 3 ½									
Thick.	1/2		7/16		3/8		5/16		¼	
Wt./ft	11.1		9.8		8.5		7.2		5.8	
F_y	36	50	36	50	36	50	36	50	36	50
1	46.5	63.8	44.2	60.4	41.0	55.7	36.0	41.9	22.8	28.2
2	45.0	61.1	42.8	57.8	39.7	53.3	35.2	40.8	22.3	27.4
3	41.8	55.1	39.9	52.5	37.4	49.2	34.0	39.7	21.9	26.8
4	37.7	48.1	35.9	45.6	33.6	42.5	30.7	36.4	21.4	26.0
5	33.4	41.0	31.6	38.6	29.4	35.8	26.8	31.9	19.8	23.5
6	29.0	34.2	27.4	32.0	25.3	29.5	22.9	26.5	17.7	20.4
7	24.9	28.0	23.3	26.1	21.5	23.9	19.4	21.3	15.6	17.2
8	21.1	23.2	19.6	21.5	18.0	19.5	16.1	17.4	13.3	14.2
9	17.9	19.5	16.6	18.0	15.1	16.3	13.4	14.4	11.3	11.9
10	15.3	16.6	14.2	15.2	12.8	13.7	11.4	12.1	9.6	10.0
11	13.3	14.3	12.2	13.0	11.0	11.7	9.8	10.3	8.2	8.4

Effective length in feet, KL

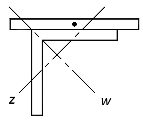
Size	3 x 3											
Thick.	1/2		7/16		3/8		5/16		1/4		3/16	
Wt./ft	9.4		8.3		7.2		6.1		4.9		3.71	
F_y	36	50	36	50	36	50	36	50	36	50	36	50
1	35.6	48.9	34.2	46.9	32.3	44.1	29.5	40.0	22.5	27.2	13.2	15.9
2	33.8	45.5	32.6	43.8	31.0	41.6	28.4	37.8	22.0	26.4	12.9	15.5
3	30.7	40.0	29.4	38.2	27.9	36.1	25.8	33.3	21.4	25.5	12.6	15.1
4	27.0	33.8	25.8	32.1	24.3	30.0	22.4	27.5	19.2	22.4	12.3	14.6
5	23.3	27.8	22.1	26.2	20.6	24.3	18.8	22.0	16.6	18.8	11.1	12.8
6	19.6	22.3	18.5	20.8	17.2	19.2	15.6	17.2	13.6	15.0	9.6	10.8
7	16.3	18.1	15.2	16.8	14.0	15.3	12.6	13.7	11.0	11.8	8.2	8.7
8	13.6	14.9	12.6	13.7	11.6	12.5	10.3	11.1	8.9	9.5	6.8	7.1
9	11.5	12.4	10.6	11.4	9.6	10.4	8.6	9.1	7.4	7.8	5.6	5.8

Table 1. Equal Leg Angles

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
Design Strength in kips (t_g = 1.5t)



Size	2 ½ x 2 ½									
Thick.	1/2		3/8		5/16		1/4		3/16	
Wt./ft	7.7		5.9		5.0		4.1		3.07	
F_y	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL: 1	25.6	35.1	23.9	32.6	22.3	30.4	19.9	26.8	12.5	15.5
2	23.6	31.5	22.0	29.2	20.7	27.4	18.8	24.8	12.2	15.0
3	20.9	26.7	19.2	24.3	17.9	22.6	16.2	20.3	11.6	14.2
4	17.8	21.6	16.0	19.2	14.8	17.6	13.3	15.7	10.1	11.8
5	14.7	16.9	13.0	14.7	11.9	13.3	10.6	11.7	8.4	9.3
6	11.9	13.3	10.3	11.4	9.4	10.2	8.2	8.8	6.7	7.2
7	9.7	10.7	8.3	9.0	7.4	8.0	6.5	6.9	5.3	5.6
8	8.0	8.8	6.8	7.3	6.1	6.5	5.2	5.6	4.3	4.4

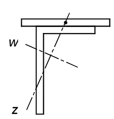
Size	2 x 2									
Thick.	3/8		5/16		1/4		3/16		1/8	
Wt./ft	4.7		3.92		3.19		2.44		1.65	
F_y	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL: 1	15.9	21.8	15.3	20.9	14.1	19.1	12.1	14.6	5.8	7.0
2	14.1	18.4	13.4	17.4	12.4	16.0	10.9	13.6	5.6	6.7
3	11.6	14.3	10.9	13.3	10.0	12.1	8.7	10.4	5.2	6.2
4	9.2	10.5	8.5	9.6	7.6	8.5	6.5	7.2	4.3	4.8
5	7.0	7.8	6.4	7.0	5.6	6.1	4.8	5.1	3.3	3.5
6	5.4	6.0	4.9	5.3	4.3	4.6	3.6	3.8	2.5	2.6

Table 1. Unequal Leg Angles with Short Leg Attached

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
by the Short Leg
Design Strength in kips (t_g = 1.5t)



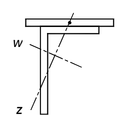
Size	8 x 6													
Thick.	1		7/8		3/4		5/8		9/16		1/2		7/16	
Wt./ft	44.2		39.1		33.8		28.5		25.7		23.0		20.2	
F_y	36	50	36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL: 1	202	278	191	263	158	217	126	162	109	128	86	97	62	76
2	199	272	188	256	155	211	123	157	106	123	83	93	60	72
3	196	267	185	252	154	208	122	154	104	121	82	92	59	71
4	192	258	182	243	152	205	120	152	103	120	81	91	58	70
5	185	244	175	230	149	199	119	150	102	118	80	89	58	69
6	176	229	167	216	145	192	116	146	100	116	79	88	57	69
7	167	213	158	200	140	180	113	140	98	112	78	86	57	67
8	157	197	148	185	134	167	107	132	93	108	76	84	56	66
9	147	181	139	169	126	154	101	122	88	102	73	80	54	64
10	137	165	129	153	118	140	95	113	83	96	70	76	53	61
11	127	149	119	138	109	126	89	103	78	89	67	72	51	58
12	118	134	110	124	101	112	82	93	73	82	63	67	48	55
13	108	120	101	110	92	99	76	84	67	74	58	62	46	51
14	99	108	92	99	84	88	70	75	62	67	54	57	43	48
15	90	97	83	89	75	79	63	68	56	60	49	52	40	44
16	82	88	76	80	68	71	58	61	51	55	45	48	38	40
17	75	80	69	72	62	64	53	55	47	50	41	44	35	37
18	69	73	63	66	56	59	48	50	43	45	38	40	32	34
19	63	67	58	60	52	53	44	46	40	42	35	37	30	32
20	58	61	53	55	47	49	41	42	37	38	32	34	28	29
21	54	56	49	51	44	45	38	39	34	35	30	31	26	27

Size	8 x 4													
Thick.	1		7/8		3/4		5/8		9/16		1/2		7/16	
Wt./ft	37.4		33.1		28.7		24.2		21.9		19.6		17.2	
F_y	36	50	36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL: 1	148	204	126	173	105	143	84	112	73	97	62	82	51	67
2	146	200	124	169	102	139	82	108	71	93	60	78	49	63
3	142	193	120	163	100	134	79	104	69	90	58	75	48	61
4	137	183	116	154	96	127	77	99	67	85	57	72	47	58
5	130	170	110	142	91	117	73	91	63	79	54	67	45	55
6	122	153	103	128	85	105	67	82	59	72	50	61	42	50
7	112	135	94	113	77	93	62	73	54	64	46	55	39	46
8	101	116	85	97	70	80	56	64	49	56	42	49	35	41
9	90	99	75	83	62	69	50	56	44	49	38	43	32	36
10	78	85	66	72	55	60	44	48	39	43	34	37	29	32
11	68	73	58	62	48	52	39	42	34	38	30	33	26	28
12	60	64	51	55	43	46	35	37	31	33	27	29	23	25
13	53	56	45	48	38	41	31	33	27	30	24	26	21	22
14	47	50	40	43	34	36	28	30	25	26	22	23	19	20

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
by the Short Leg
Design Strength in kips (t_g = 1.5t)



Size	7 x 4									
Thick.	3/4		5/8		1/2		7/16		3/8	
Wt./ft	26.2		22.1		17.9		15.7		13.6	
F_y	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL: 1	107	148	86	117	65	85	54	70	43	50
2	106	144	84	114	63	82	52	67	41	47
3	103	140	82	110	62	80	51	65	40	46
4	100	133	80	105	60	77	49	63	39	45
5	95	123	76	97	57	71	47	58	38	43
6	89	110	70	87	53	64	44	53	35	40
7	81	97	64	77	48	57	41	48	33	37
8	73	84	58	67	44	50	37	43	30	34
9	65	72	52	57	39	44	33	37	27	30
10	57	61	45	49	35	38	30	32	25	26
11	50	53	40	43	31	33	26	28	22	23
12	44	46	35	38	27	29	23	25	20	21
13	39	41	31	33	24	26	21	22	17	18
14	34	36	28	29	22	23	19	20	16	16

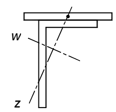
Size	6 x 4															
Thick.	7/8		3/4		5/8		9/16		1/2		7/16		3/8		5/16	
Wt./ft	27.2		23.6		20.0		18.1		16.2		14.3		12.3		10.3	
F_y	36	50	36	50	36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL: 1	112	154	106	146	89	122	78	107	68	91	57	74	45	53	28	34
2	109	150	104	142	88	119	77	104	66	88	55	72	44	51	27	32
3	106	143	101	136	86	116	75	101	65	86	54	71	43	50	27	32
4	101	132	96	125	82	109	73	97	63	82	53	68	42	49	26	31
5	94	120	89	113	78	100	69	88	60	76	51	63	41	47	25	30
6	86	107	81	100	72	89	64	79	56	68	47	57	38	44	25	29
7	78	93	73	87	66	78	58	70	51	60	43	51	35	40	23	27
8	70	81	65	75	59	67	52	60	46	52	39	45	32	36	22	25
9	62	69	58	63	52	57	46	51	41	45	35	38	29	31	20	23
10	54	59	50	54	45	48	40	43	36	38	31	33	25	27	19	20
11	47	51	44	47	39	41	35	38	31	33	27	29	22	24	17	18
12	42	45	38	41	34	36	31	33	27	29	24	25	20	21	15	16
13	37	40	34	36	30	31	27	29	24	25	21	22	17	18	14	14
14	33	35	30	32	27	28	24	25	22	22	19	19	16	16	12	13

Table 1. Unequal Leg Angles with Short Leg Attached

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
by the Short Leg
Design Strength in kips (t_g = 1.5t)



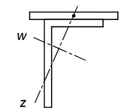
Size		6 x 3 1/2					
Thick.		1/2		3/8		5/16	
Wt./ft		15.3		11.7		9.8	
F_y		36	50	36	50	36	50
Effective length in feet, KL	1	59	79	40	52	30	29
	2	58	77	39	49	29	28
	3	56	74	38	48	28	27
	4	53	69	36	45	27	26
	5	50	61	34	41	26	25
	6	45	54	31	37	24	23
	7	40	46	28	32	22	21
	8	35	39	25	27	19	19
	9	30	33	21	23	17	17
	10	26	28	19	20	15	15
	11	23	24	16	17	13	13
	12	20	21	14	15	12	12

Size		5 x 3 ½													
Thick.		3/4		5/8		1/2		7/16		3/8		5/16		1/4	
Wt./ft		19.8		16.8		13.6		12.0		10.4		8.7		7.0	
F_y		36	50	36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL	1	80	110	75	104	62	84	52	70	43	56	32	35	19	22
	2	78	106	74	100	60	82	51	68	42	54	31	34	18	21
	3	74	99	70	93	59	79	50	66	41	52	31	33	18	21
	4	69	89	65	83	56	72	48	61	39	49	30	32	17	20
	5	63	78	58	73	51	64	44	54	36	44	28	30	17	20
	6	56	68	52	62	46	55	39	47	33	39	26	28	16	19
	7	50	57	46	52	41	46	35	40	29	33	23	25	15	17
	8	43	48	39	43	35	38	30	33	26	28	20	21	14	15
	9	37	40	34	36	30	31	26	28	22	23	18	19	12	13
	10	32	34	29	31	25	26	22	23	19	20	15	16	11	12
	11	28	30	25	26	22	22	19	20	16	17	13	14	10	10
	12	24	26	22	23	19	19	17	17	14	15	12	12	9	9

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
by the Short Leg
Design Strength in kips (t_g = 1.5t)



Size		4 x 3											
Thick.		5/8		1/2		7/16		3/8		5/16		1/4	
Wt./ft		13.6		11.1		9.8		8.5		7.2		5.8	
F_y		36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL	1	53.3	73.4	49.7	68.1	47.0	64.1	38.8	52.8	30.8	39.2	20.7	23.3
	2	51.3	69.6	48.0	64.5	45.5	60.6	38.0	51.2	30.1	38.1	20.2	22.6
	3	47.6	62.3	44.1	57.3	41.7	54.0	36.3	48.0	29.1	36.4	19.8	22.0
	4	42.8	54.0	39.4	49.3	37.1	46.2	33.4	41.8	26.8	32.9	19.0	20.9
	5	37.7	45.7	34.4	41.2	32.2	38.4	29.4	35.0	23.8	28.2	17.6	19.1
	6	32.6	37.6	29.4	33.5	27.5	31.0	25.2	28.1	20.6	23.3	15.7	16.8
	7	27.6	30.6	24.7	26.9	22.9	24.7	20.9	22.1	17.4	18.8	13.5	14.2
	8	23.2	25.2	20.5	22.0	18.9	20.0	17.1	17.8	14.4	15.3	11.3	11.9
	9	19.6	21.2	17.2	18.2	15.8	16.5	14.1	14.6	12.1	12.6	9.5	10.0
	10	16.8	18.0	14.6	15.3	13.3	13.8	11.9	12.2	10.2	10.5	8.1	8.4

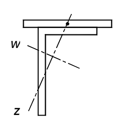
Size		3 ½ x 3									
Thick.		½		7/16		3/8		5/16		1/4	
Wt./ft		10.2		9.1		7.9		6.6		5.4	
F_y		36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL	1	42.7	58.6	40.7	55.6	37.9	51.4	31.8	41.3	21.6	25.0
	2	40.5	54.3	38.6	51.6	36.0	47.7	31.2	40.1	21.2	24.3
	3	36.8	47.8	35.0	45.2	32.7	42.0	29.6	37.4	20.6	23.6
	4	32.7	40.8	30.9	38.2	28.6	35.1	25.8	31.0	19.4	22.0
	5	28.4	33.8	26.6	31.3	24.5	28.5	21.8	25.0	17.6	19.4
	6	24.2	27.2	22.5	25.1	20.5	22.7	18.1	19.8	15.2	16.4
	7	20.2	21.9	18.6	20.1	16.9	18.0	14.8	15.7	12.4	13.0
	8	16.7	18.0	15.4	16.4	13.8	14.6	12.1	12.7	10.1	10.5
	9	14.1	15.0	12.9	13.6	11.6	12.2	10.0	10.5	8.4	8.6
	10	12.0	12.7	10.9	11.5	9.8	10.2	8.5	8.8	7.0	7.2

Size		3 ½ x 2 ½									
Thick.		1/2		7/16		3/8		5/16		¼	
Wt./ft		9.4		8.3		7.2		6.1		4.9	
F_y		36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL	1	38.7	53.1	37.0	50.6	33.4	45.5	26.5	35.7	19.7	24.2
	2	36.6	49.0	35.1	46.6	32.1	43.2	25.7	34.2	19.2	23.4
	3	32.9	42.0	31.3	39.8	29.2	37.1	24.0	30.6	18.1	22.0
	4	28.4	34.6	26.9	32.6	25.0	30.1	21.0	25.4	16.0	19.2
	5	23.8	27.4	22.4	25.6	20.8	23.5	17.8	20.2	13.7	15.6
	6	19.4	21.3	18.2	19.7	16.7	17.9	14.5	15.6	11.3	12.2
	7	15.7	17.0	14.6	15.6	13.3	14.0	11.6	12.2	9.1	9.7
	8	12.9	13.8	11.9	12.6	10.8	11.2	9.4	9.7	7.4	7.8
	9	--	--	--	--	--	--	7.7	7.9	6.2	6.4

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
by the Short Leg
Design Strength in kips (t_g = 1.5t)



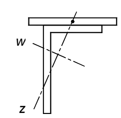
Size		5 x 3											
Thick.		5/8		1/2		7/16		3/8		5/16		1/4	
Wt./ft		15.7		12.8		11.3		9.8		8.2		6.6	
F_y		36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL	1	69.3	95.2	52.6	72.0	44.6	60.2	36.6	48.2	28.3	35.7	18.9	19.0
	2	67.4	91.6	51.4	69.6	43.5	58.2	35.6	46.5	27.4	34.3	18.2	18.3
	3	64.0	84.4	49.2	65.4	41.7	54.9	34.2	44.1	26.5	32.8	17.7	17.8
	4	58.4	73.6	45.9	58.3	39.0	48.9	31.9	39.4	24.8	30.2	17.0	16.9
	5	51.6	62.2	41.2	50.0	34.8	42.0	28.6	34.2	22.4	26.6	15.9	15.8
	6	44.6	50.9	36.0	41.3	30.5	35.0	25.1	28.8	19.8	22.7	14.4	14.3
	7	37.6	40.8	30.7	33.4	26.0	28.4	21.5	23.6	17.2	18.9	12.7	12.6
	8	31.1	33.4	25.6	27.4	21.8	23.4	18.1	19.6	14.6	15.8	11.0	11.0
	9	26.1	27.6	21.5	22.8	18.4	19.6	15.4	16.4	12.4	13.3	9.5	9.6
	10	22.1	23.2	18.3	19.2	15.7	16.6	13.2	13.9	10.7	11.3	8.2	8.3

Size		4 x 3 ½											
Thick.		5/8		1/2		7/16		3/8		5/16		¼	
Wt./ft		14.7		11.9		10.6		9.1		7.7		6.2	
F_y		36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL	1	58.0	79.9	53.9	73.7	50.8	69.0	45.4	60.8	34.9	39.0	21.3	26.1
	2	55.9	75.6	51.8	69.6	48.6	65.0	44.4	58.8	34.2	38.0	20.8	25.4
	3	52.1	68.7	48.2	63.1	45.4	59.2	41.8	54.1	33.4	37.1	20.5	24.9
	4	47.6	60.8	43.6	55.3	41.0	51.4	37.7	46.8	32.0	35.3	20.1	24.2
	5	42.7	52.7	38.8	47.1	36.2	43.5	33.0	39.3	29.1	32.1	19.2	23.0
	6	37.7	44.7	33.9	39.4	31.4	36.3	28.4	32.6	25.0	28.1	17.8	20.8
	7	32.9	37.2	29.2	32.6	26.9	29.8	24.3	26.6	21.2	23.0	16.1	18.2
	8	28.3	31.0	24.8	26.9	22.8	24.5	20.5	21.8	17.8	18.8	14.3	15.4
	9	24.1	26.2	21.0	22.5	19.2	20.4	17.2	18.1	14.9	15.6	12.3	12.7
	10	20.8	22.4	18.0	19.2	16.4	17.3	14.6	15.3	12.6	13.1	10.4	10.7
	11	18.1	19.3	15.6	16.4	14.1	14.8	12.6	13.1	10.8	11.2	8.9	9.1
	12	--	--	13.6	14.3	12.3	12.9	10.9	11.4	9.4	9.7	7.7	7.8

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
by the Short Leg
Design Strength in kips (t_g = 1.5t)



Size		3 x 2 1/2											
Thick.		1/2		7/16		3/8		5/16		1/4		3/16	
Wt./ft		8.5		7.6		6.6		5.6		4.5		3.39	
F_y		36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL	1	32.0	44.0	30.9	42.4	29.3	40.0	27.0	36.4	20.7	25.6	11.4	14.0
	2	29.8	39.7	28.7	38.0	27.2	35.9	25.0	32.8	20.2	24.7	11.2	13.6
	3	26.5	33.8	25.3	32.2	23.8	30.1	21.8	27.4	18.7	22.6	10.8	13.1
	4	22.8	27.7	21.6	26.1	20.2	24.2	18.4	21.6	16.0	18.4	10.0	11.8
	5	19.0	21.9	17.9	20.4	16.6	18.6	14.9	16.5	12.8	14.0	8.8	10.0
	6	15.5	17.2	14.5	15.8	13.3	14.3	11.8	12.6	10.0	10.5	7.5	8.1
	7	12.6	13.7	11.7	12.5	10.6	11.3	9.4	9.8	7.9	8.2	6.1	6.3
	8	10.4	11.2	9.6	10.2	8.6	9.1	7.6	7.9	6.4	6.6	5.0	5.0

Size		3 x 2											
Thick.		1/2		7/16		3/8		5/16		1/4		3/16	
Wt./ft		7.7		6.8		5.9		5.0		4.1		3.07	
F_y		36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL	1	28.2	38.8	27.4	37.5	26.1	35.6	21.9	29.8	16.6	22.0	11.0	12.8
	2	26.0	34.5	25.2	33.1	24.0	31.3	20.6	27.4	15.8	20.6	10.6	12.2
	3	22.5	28.0	21.5	26.6	20.3	25.0	18.1	22.4	14.0	17.0	9.5	11.0
	4	18.4	21.4	17.5	20.2	16.4	18.7	14.8	16.8	11.5	13.1	8.0	9.0
	5	14.4	15.9	13.5	14.8	12.5	13.5	11.4	12.1	8.9	9.6	6.4	6.8
	6	11.2	12.2	10.4	11.2	9.6	10.2	8.6	9.0	6.8	7.2	4.9	5.2
	7	9.0	9.6	8.3	8.8	7.5	7.9	6.7	6.9	5.4	5.6	3.9	4.1

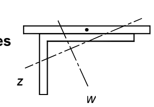
Size		2 ½ x 2							
Thick.		3/8		5/16		1/4		3/16	
Wt./ft		5.3		4.5		3.62		2.75	
F_y		36	50	36	50	36	50	36	50
Effective length in feet, KL	1	21.0	28.7	19.8	26.8	17.4	23.6	11.9	13.8
	2	18.8	24.4	17.6	22.8	15.8	20.4	11.4	13.1
	3	15.7	19.3	14.6	17.8	13.0	15.7	9.9	11.4
	4	12.6	14.4	11.5	13.1	10.2	11.3	8.0	9.0
	5	9.7	10.6	8.8	9.4	7.6	8.0	6.1	6.4
	6	7.5	8.0	6.7	7.1	5.7	6.0	4.6	4.7
	7	6.0	6.3	5.2	5.5	4.4	4.6	3.5	3.6

Table 1. Unequal Leg Angles with Long Leg Attached

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
by the Long Leg
Design Strength in kips (t_g = 1.5t)



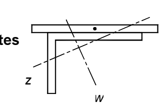
Size	8 x 6													
Thick.	1		7/8		3/4		5/8		9/16		1/2		7/16	
Wt./ft	44.2		39.1		33.8		28.5		25.7		23.0		20.2	
F_y	36	50	36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL														
1	172	239	166	231	158	219	147	190	127	156	102	124	80	95
2	170	235	164	226	155	213	142	183	122	149	98	118	76	89
3	168	230	161	221	152	208	139	180	120	147	97	116	75	87
4	164	222	158	214	149	202	137	176	119	144	96	114	74	86
5	158	212	152	204	144	193	133	172	117	142	94	112	73	85
6	151	199	145	191	138	181	127	165	115	138	93	110	72	83
7	143	186	138	178	130	168	121	154	111	133	91	107	71	82
8	135	172	129	164	122	155	113	143	107	127	88	103	69	80
9	127	158	121	150	114	142	106	130	100	119	84	98	67	77
10	118	144	112	137	106	129	98	118	93	111	80	92	64	73
11	110	131	104	124	97	116	90	107	85	101	76	86	61	69
12	101	119	96	112	90	105	83	96	78	91	71	79	58	64
13	94	107	88	101	82	94	76	85	72	81	66	72	55	59
14	86	97	81	91	75	84	69	77	65	72	61	65	51	54
15	79	88	74	83	69	76	62	69	59	65	55	59	47	49
16	72	81	68	75	63	69	57	62	54	59	50	53	43	45
17	67	74	62	69	57	63	52	57	49	53	46	48	40	41
18	61	68	57	63	53	58	48	52	45	48	42	44	36	37
19	57	63	53	58	49	53	44	47	41	44	38	40	33	34
20	53	58	49	53	45	49	40	43	38	41	35	36	31	31
21	49	54	46	49	42	45	37	40	35	37	32	33	28	28

Size	8 x 4													
Thick.	1		7/8		3/4		5/8		9/16		1/2		7/16	
Wt./ft	37.4		33.1		28.7		24.2		21.7		19.6		17.2	
F_y	36	50	36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL														
1	108	150	106	147	104	143	99	133	94	126	88	116	80	102
2	105	145	103	142	100	137	95	126	90	118	83	108	74	94
3	101	137	99	134	96	129	91	118	86	111	79	102	71	91
4	96	127	94	124	90	119	85	109	80	102	75	94	67	85
5	90	116	87	112	83	107	78	98	74	93	69	86	63	78
6	83	104	80	100	76	95	71	87	67	82	63	77	57	70
7	76	93	73	88	69	83	64	76	60	72	56	67	52	61
8	68	81	65	77	62	72	57	66	54	62	50	58	46	53
9	61	71	58	67	55	62	50	57	47	53	44	50	41	46
10	55	62	52	58	48	54	44	49	41	46	39	43	36	40
11	49	55	46	51	43	47	39	43	36	40	34	38	31	34
12	44	49	41	46	38	42	34	38	32	35	30	33	28	30
13	40	44	37	41	34	37	31	33	29	31	27	29	25	27
14	36	39	33	36	31	33	27	30	26	28	24	26	22	24

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
by the Long Leg
Design Strength in kips (t_g = 1.5t)



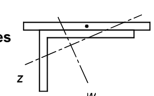
Size	6 x 3 ½					
Thick.	1/2		3/8		5/16	
Wt./ft	15.3		11.7		9.8	
F_y	36	50	36	50	36	50
Effective length in feet, KL						
1	66	89	89	72	41	48
2	63	84	84	68	40	46
3	60	78	78	64	38	44
4	55	70	70	59	37	42
5	49	61	61	52	35	40
6	44	52	52	45	33	36
7	38	44	44	38	29	32
8	33	37	37	32	25	28
9	28	32	32	27	22	24
10	24	27	27	23	19	20
11	21	23	23	20	16	17
12	19	20	20	17	14	15

Size	5 x 3 ½													
Thick.	3/4		5/8		1/2		7/16		3/8		5/16		1/4	
Wt./ft	19.8		16.8		13.6		12.0		10.4		8.7		7.0	
F_y	36	50	36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL														
1	64	88	62	85	58	80	55	75	51	68	39	47	25	29
2	62	85	60	82	56	77	54	72	49	65	38	46	24	28
3	59	79	57	76	53	71	51	67	47	61	37	44	24	27
4	55	71	52	68	49	63	47	60	43	55	36	42	23	26
5	50	63	47	60	44	55	42	52	39	48	34	39	22	25
6	45	55	42	51	39	47	37	44	34	41	31	35	21	24
7	40	47	37	44	34	40	32	37	30	34	27	31	20	21
8	35	40	32	37	29	33	28	31	25	29	23	26	18	19
9	30	34	28	31	25	28	24	26	22	24	20	22	16	16
10	27	30	24	27	22	24	20	22	19	20	17	18	14	14
11	24	26	21	24	19	21	18	19	16	17	14	16	12	12
12	21	23	19	21	17	18	15	17	14	15	13	13	10	10

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
by the Long Leg
Design Strength in kips (t_g = 1.5t)



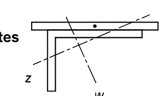
Size	7 x 4									
Thick.	3/4		5/8		1/2		7/16		3/8	
Wt./ft	26.2		22.1		17.9		15.7		13.6	
F_y	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL										
1	94	130	90	124	82	109	75	99	61	71
2	91	125	87	118	79	103	71	93	58	67
3	88	118	83	111	75	98	68	88	56	65
4	83	109	78	102	71	90	65	82	55	63
5	76	98	72	92	65	82	60	75	53	60
6	70	87	66	81	59	72	54	67	49	56
7	63	77	59	71	53	63	49	59	44	51
8	57	67	53	61	47	55	44	51	40	46
9	50	57	46	52	41	47	38	43	35	39
10	44	50	41	45	36	40	34	37	31	34
11	39	44	36	40	32	35	29	32	27	29
12	35	39	32	35	28	31	26	28	24	26
13	31	34	28	31	25	27	23	25	21	22
14	28	31	25	28	22	24	20	22	18	20

Size	6 x 4															
Thick.	7/8		3/4		5/8		9/16		1/2		7/16		3/8		5/16	
Wt./ft	27.2		23.6		20.0		18.1		16.2		14.3		12.3		10.3	
F_y	36	50	36	50	36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL																
1	87	120	84	117	81	112	78	108	75	102	70	93	58	70	41	47
2	85	116	82	113	79	108	76	104	73	97	67	88	56	67	39	45
3	81	110	79	107	76	102	73	98	70	92	65	84	55	65	38	44
4	77	102	75	99	71	94	69	90	66	85	61	78	53	63	37	43
5	72	93	69	89	65	84	63	81	60	76	56	71	51	60	36	41
6	66	83	63	79	59	74	57	71	54	67	51	63	47	55	35	39
7	60	73	57	69	53	64	51	62	49	58	45	54	42	50	33	36
8	54	64	51	60	48	56	45	53	43	50	40	47	37	43	30	33
9	48	56	46	52	42	48	40	45	38	43	35	40	32	37	27	29
10	43	49	40	45	37	41	35	39	33	37	31	34	28	31	25	26
11	38	43	36	40	32	36	31	34	29	32	27	29	25	27	22	22
12	34	38	32	35	29	32	27	30	25	28	24	26	22	23	19	19
13	31	34	28	31	26	28	24	26	23	25	21	23	19	20	17	17
14	28	30	25	28	23	25	22	23	20	22	19	20	17	18	15	15

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
by the Long Leg
Design Strength in kips (t_g = 1.5t)



Size	5 x 3											
Thick.	5/8		1/2		7/16		3/8		5/16		1/4	
Wt./ft	15.7		12.8		11.3		9.8		8.2		6.6	
F_y	36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL												
1	51.7	71.4	49.3	68.0	47.4	64.6	44.3	59.0	39.0	48.9	25.9	29.8
2	49.6	67.4	47.1	63.8	45.2	60.5	42.1	55.1	37.0	46.5	24.8	28.3
3	46.0	60.9	43.6	57.4	41.7	54.4	39.0	49.9	34.5	44.0	24.1	27.2
4	41.6	53.3	39.0	49.6	37.2	46.9	34.8	43.2	31.0	38.8	23.0	25.8
5	36.9	45.4	34.2	41.8	32.4	39.3	30.2	36.4	27.2	32.8	21.4	23.7
6	32.1	38.0	29.5	34.4	27.8	32.3	25.8	29.9	23.3	27.0	19.4	21.0
7	27.6	31.4	25.0	28.2	23.5	26.4	21.7	24.3	19.6	21.9	17.1	17.9
8	23.5	26.4	21.1	23.5	19.7	21.8	18.1	20.0	16.4	18.0	14.3	14.8
9	20.2	22.4	18.0	19.8	16.7	18.4	15.3	16.8	13.8	15.0	12.0	12.3
10	17.5	19.2	15.4	16.9	14.3	15.6	13.1	14.2	11.7	12.6	10.1	10.4

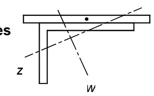
Size	4 x 3 1/2											
Thick.	5/8		1/2		7/16		3/8		5/16		1/4	
Wt./ft	14.7		11.9		10.6		9.1		7.7		6.2	
F_y	36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL												
1	53.8	74.4	50.6	69.9	48.2	66.4	45.0	61.6	35.6	44.3	24.0	29.0
2	52.4	71.6	49.5	67.7	47.2	64.4	44.0	60.0	34.8	43.1	23.4	28.1
3	49.3	66.0	46.7	62.5	44.8	60.2	42.3	57.3	34.0	41.9	23.0	27.5
4	45.3	58.9	42.6	55.6	40.9	53.5	39.0	51.1	32.5	39.6	22.4	26.7
5	40.8	51.4	38.2	48.1	36.6	46.0	34.7	43.6	29.8	35.5	21.4	25.1
6	36.2	44.1	33.6	40.7	32.1	38.6	30.2	36.2	26.8	30.9	19.6	22.6
7	31.8	37.1	29.2	33.8	27.7	31.9	25.9	29.7	23.5	26.1	17.6	19.6
8	27.5	31.2	25.1	28.1	23.6	26.3	22.0	24.3	20.1	21.5	15.4	16.5
9	23.7	26.5	21.4	23.6	20.0	22.0	18.5	20.2	16.8	17.8	13.2	13.9
10	20.5	22.7	18.4	20.2	17.1	18.7	15.8	17.1	14.2	14.9	11.3	11.7
11	18.0	19.7	16.0	17.4	14.8	16.0	13.6	14.6	12.2	12.7	9.7	10.0
12	--	--	14.0	15.1	12.9	13.9	11.8	12.6	10.6	10.9	8.4	8.5

Table 1. Unequal Leg Angles with Long Leg Attached

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
by the Long Leg
Design Strength in kips (t_g = 1.5t)



Size		4 x 3											
Thick.		5/8		1/2		7/16		3/8		5/16		1/4	
Wt./ft		13.6		11.1		9.8		8.5		7.2		5.8	
F_y		36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL	1	44.6	61.5	42.6	58.8	41.0	56.5	38.7	53.2	35.5	45.8	24.6	29.6
	2	42.7	58.2	40.9	55.6	39.4	53.5	37.2	50.4	34.1	44.1	23.9	28.5
	3	39.6	52.5	37.7	49.8	36.3	47.9	34.5	45.4	31.8	41.2	23.2	27.5
	4	35.8	45.9	33.8	42.9	32.3	41.0	30.6	38.8	28.4	35.6	22.0	25.8
	5	31.7	39.1	29.5	36.0	28.1	34.2	26.4	32.2	24.5	29.6	20.1	23.0
	6	27.6	32.6	25.4	29.7	24.0	28.0	22.4	26.2	20.7	23.9	17.8	19.7
	7	23.6	26.9	21.5	24.3	20.2	22.8	18.8	21.1	17.2	19.2	15.3	16.2
	8	20.1	22.6	18.1	20.2	16.9	18.8	15.7	17.3	14.2	15.6	12.6	13.3
	9	17.2	19.1	15.4	17.0	14.4	15.8	13.2	14.4	11.9	12.9	10.4	10.9
	10	14.9	16.4	13.2	14.5	12.3	13.4	11.3	12.2	10.1	10.9	8.8	9.1

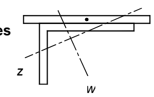
Size		3 ½ x 3									
Thick.		1/2		7/16		3/8		5/16		¼	
Wt./ft		10.2		9.1		7.9		6.6		5.4	
F_y		36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL	1	39.2	54.2	37.8	52.1	35.8	49.1	32.8	43.1	23.3	28.6
	2	37.7	51.3	36.5	49.6	34.6	47.0	31.9	41.7	22.8	27.8
	3	34.7	45.8	33.5	44.2	31.9	42.3	29.9	39.2	22.1	26.8
	4	31.0	39.3	29.7	37.8	28.2	36.0	26.6	33.8	20.7	24.7
	5	27.0	33.0	25.8	31.4	24.4	29.6	22.8	27.5	18.5	21.5
	6	23.1	26.9	21.9	25.5	20.6	23.8	19.0	21.9	16.1	17.9
	7	19.4	21.9	18.4	20.6	17.1	19.1	15.7	17.4	13.6	14.5
	8	16.3	18.2	15.3	16.9	14.2	15.6	12.9	14.1	11.2	11.7
	9	13.8	15.2	12.9	14.1	11.9	13.0	10.8	11.6	9.3	9.6
	10	11.9	13.0	11.0	12.0	10.1	10.9	9.1	9.8	7.8	8.0

Size		3 ½ x 2 ½									
Thick.		1/2		7/16		3/8		5/16		¼	
Wt./ft		9.4		8.3		7.2		6.1		4.9	
F_y		36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL	1	31.5	43.5	30.7	42.3	29.4	40.5	27.6	37.5	24.2	29.6
	2	29.6	39.9	28.8	38.8	27.7	37.2	26.0	34.6	22.9	28.3
	3	26.6	34.5	25.7	33.3	24.6	31.7	23.0	29.5	20.6	26.1
	4	23.1	28.6	22.2	27.4	21.0	25.8	19.5	23.9	17.6	21.4
	5	19.6	23.1	18.6	21.8	17.4	20.4	16.1	18.8	14.4	16.8
	6	16.2	18.4	15.3	17.2	14.2	16.0	13.0	14.6	11.6	12.9
	7	13.3	14.9	12.5	13.9	11.6	12.8	10.5	11.6	9.3	10.2
	8	11.2	12.3	10.4	11.4	9.6	10.4	8.6	9.4	7.6	8.2
	9	--	--	--	--	--	--	7.2	7.8	6.3	6.7

Fy = 36 ksi

Fy = 50 ksi

Eccentrically Loaded Columns
Single Angles Attached to Gusset Plates
by the Long Leg
Design Strength in kips (t_g = 1.5t)



Size		3 x 2 ½											
Thick.		1/2		7/16		3/8		5/16		1/4		3/16	
Wt./ft		8.5		7.6		6.6		5.6		4.5		3.39	
F_y		36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL	1	28.6	39.5	27.9	38.5	26.8	36.9	25.1	34.4	22.6	28.0	13.4	16.2
	2	26.8	36.2	26.2	35.2	25.2	33.9	23.8	32.0	21.6	26.8	13.1	15.6
	3	24.0	31.2	23.3	30.1	22.3	28.7	21.0	27.2	19.4	24.2	12.6	14.9
	4	20.8	25.7	20.0	24.6	19.0	23.3	17.8	21.8	16.3	19.8	11.5	13.3
	5	17.5	20.5	16.7	19.5	15.7	18.3	14.6	16.9	13.2	15.2	9.9	11.1
	6	14.4	16.3	13.6	15.3	12.7	14.2	11.7	13.0	10.5	11.6	8.2	8.7
	7	11.8	13.2	11.1	12.3	10.3	11.4	9.4	10.3	8.3	9.0	6.6	6.9
	8	9.9	10.9	9.2	10.1	8.5	9.2	7.7	8.3	6.7	7.2	5.4	5.5

Size		3 x 2											
Thick.		1/2		7/16		3/8		5/16		1/4		3/16	
Wt./ft		7.7		6.8		5.9		5.0		4.1		3.07	
F_y		36	50	36	50	36	50	36	50	36	50	36	50
Effective length in feet, KL	1	21.6	29.6	21.2	29.1	20.6	28.3	19.7	27.0	18.2	24.3	14.0	16.7
	2	19.7	26.2	19.2	25.5	18.6	24.6	17.8	23.4	16.4	21.3	13.3	15.7
	3	17.0	21.6	16.5	20.8	15.8	19.8	14.9	18.5	13.6	16.8	11.6	13.8
	4	14.2	16.9	13.6	16.1	12.8	15.1	11.9	13.9	10.8	12.5	9.2	10.7
	5	11.4	13.0	10.8	12.2	10.1	11.3	9.2	10.3	8.2	9.2	7.1	7.8
	6	9.1	10.2	8.6	9.5	7.9	8.8	7.2	7.9	6.4	7.0	5.4	5.8
	7	7.4	8.2	7.0	7.6	6.4	7.0	5.8	6.3	5.0	5.5	4.2	4.6

Size		2 ½ x 2							
Thick.		3/8		5/16		1/4		3/16	
Wt./ft		5.3		4.5		3.62		2.75	
F_y		36	50	36	50	36	50	36	50
Effective length in feet, KL	1	18.4	25.2	17.6	24.2	16.3	22.3	13.0	16.0
	2	16.6	21.9	15.8	20.9	14.8	19.5	12.4	15.0
	3	14.0	17.5	13.2	16.4	12.2	15.2	10.9	12.8
	4	11.3	13.2	10.5	12.3	9.6	11.1	8.4	9.7
	5	8.8	9.9	8.1	9.1	7.3	8.1	6.3	6.9
	6	6.9	7.6	6.3	6.9	5.6	6.1	4.8	5.2
	7	5.6	6.1	5.0	5.4	4.4	4.8	3.7	4.0