TECHNICAL NOTE

Effective Length Factors for Gusset Plates in Chevron Braced Frames

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In a previous paper by the author of this technical note (Dowswell, 2006), effective length factors were proposed for stability calculations of five different gusset plate configurations shown in Figure 1. These effective length factors will be referenced in the next edition of the AISC *Seismic Design Manual*.

The value of k for chevron braces (Figure 1e) has been discussed at several meetings of the AISC Committee on Manuals and Textbooks. Those discussions indicated that the value of $k = 0.75$ as recommended in Dowswell (2006) may be slightly conservative. In light of the common use of $k = 0.65$ for chevron gusset plates, the available test data were reevaluated to determine if the value of $k = 0.75$ as proposed in the original paper could be reduced.

The nominal values for $k = 0.75$ for chevron gussets from Dowswell (2006) are shown in Table 1 (Table 6 from Dowswell, 2006). Calculations for nonstiffened chevron gusset plates were made using $k = 0.65$ with the 13 specimens from Table 1. The nominal load, P_{calc}, was calculated with the actual yield strength reported for the tests and does not include a safety factor or reduction factor. The results for all specimens are shown in Table 2. An example calculation for specimen 1 is provided at the end of this technical note.

Using an effective length factor of 0.65, the mean ratio of experimental load to calculated capacity, P_{exp}/P_{calc} is 1.17 and the standard deviation is 0.19. Therefore, the use of $k =$ 0.65 for chevron gusset plates is safe and is proposed here for design use. Table 3 is a revised version of Table 7 of the original paper, updated to reflect this recommendation.

When a vertical stiffener is welded at the center of the gusset plate—as is common in seismic design—the behavior is similar to that of corner gusset plates (Tsai et al., 2004). In that case, the effective lengths proposed by Dowswell (2006) for compact, noncompact and extended corner gusset plates (Figures 1a, 1b and 1c) can be used.

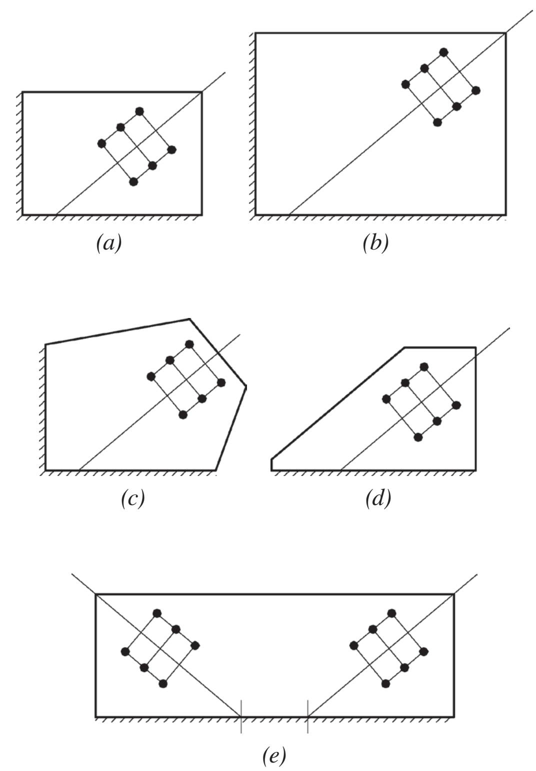

Fig. 1. Gusset plate configurations: (a) compact corner; (b) noncompact corner; (c) extended corner; (d) single brace; (e) chevron.

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Table 1. Details and Calculated Capacity of Chevron Brace Gusset Plates* $k = 0.75$								
Specimen	t (in.)	L_w (in.)	l_1 (in.)	F_y (ksi)	E (ksi)	P_{calc} (k)	P_{exp} (k)	$\frac{P_{exp}}{P_{calc}}$
Reference: Chakrabarti and Richard (1990)								
1	0.472	14.8	9.8	43.3	29000	252	286	1.14
2	0.315	14.8	6.4	40	29000	158	222	1.41
3	0.315	14.8	6.4	43.2	29000	169	264	1.56
4	0.315	14.8	9.8	72.3	29000	168.7	292	1.73
5	0.315	21.6	11.2	44.7	29000	174.1	175	1.01
6	0.394	14.8	9.6	36.8	29000	173	191	1.11
7	0.512	14.8	8.8	46.7	29000	309	429	1.39
8	0.394	14.8	6.0	82.9	29000	400	477	1.19
1-FE	0.472	14.8	9.8	43.3	29000	252	274	1.09
2-FE	0.315	14.8	6.4	40	29000	158	201	1.27
5-FE	0.315	21.6	11.2	44.7	29000	174.1	228	1.31
8-FE	0.394	14.8	6.0	82.9	29000	400	431	1.08
Reference: Astaneh (1992)								
3	0.25	4.96	4.0	36.0	29000	40.8	42.4	1.04

*Table 6 from Dowswell (2006).

Table 2. Details and Calculated Capacity of Chevron Brace Gusset Plates $k = 0.65$								
Specimen	t (in.)	L_w (in.)	l_1 (in.)	F_y (ksi)	E (ksi)	P_{calc} (k)	P_{exp} (k)	$\frac{P_{exp}}{P_{calc}}$
Reference: Chakrabarti and Richard (1990)								
1	0.472	14.8	9.8	43.3	29000	263	286	1.09
2	0.315	14.8	6.4	40	29000	165	222	1.35
3	0.315	14.8	6.4	43.2	29000	176	264	1.50
4	0.315	14.8	9.8	72.3	29000	200	292	1.46
5	0.315	21.6	11.2	44.7	29000	200	175	0.875
6	0.394	14.8	9.6	36.8	29000	182	191	1.05
7	0.512	14.8	8.8	46.7	29000	319	429	1.34
8	0.394	14.8	6.0	82.9	29000	419	477	1.14
1-FE	0.472	14.8	9.8	43.3	29000	263	274	1.04
2-FE	0.315	14.8	6.4	40	29000	165	201	1.22
5-FE	0.315	21.6	11.2	44.7	29000	200	228	1.14
8-FE	0.394	14.8	6.0	82.9	29000	419	431	1.03
Reference: Astaneh (1992)								
3	0.25	4.96	4.0	36.0	29000	41.7	42.4	1.02

Table 3. Summary of Proposed Effective Length Factors[a]			
Gusset Configuration	Effective Length Factor	Buckling Length	$\frac{P_{exp}}{P_{calc}}$
Compact corner	—[b]	—[b]	1.36
Noncompact corner	1.0	l_{avg}	3.08
Extended corner	0.6	l_1	1.45
Single brace	0.7	l_1	1.45
Chevron	0.65	l_1	1.17

[a] Table 7 from Dowswell (2006) with revisions.
[b] Yielding is the applicable limit state for compact corner gusset plates; therefore, the effective length factor and the buckling length are not applicable.

EXAMPLE CALCULATION FOR TABLE 2 (SPECIMEN 1)

$$r = \frac{t}{\sqrt{12}} = \frac{0.472 \text{ in.}}{\sqrt{12}} = 0.136 \text{ in.}$$

$$\frac{kl_1}{r} = \frac{(0.65)(9.8 \text{ in.})}{0.136 \text{ in.}} = 46.8$$

$$F_E = \frac{\pi^2 E}{\left(\frac{kl_1}{r}\right)^2} = \frac{\pi^2 (29{,}000 \text{ ksi})}{(46.8)^2} = 131 \text{ ksi}$$

$$F_{cr} = F_y\left(0.658^{F_y/F_e}\right) = (43.3 \text{ ksi})\left[0.658^{(43.3 \text{ ksi}/131 \text{ ksi})}\right] = 37.7 \text{ ksi}$$

$$P_{calc} = F_{cr}A_g = F_{cr}L_w t = (37.7 \text{ ksi})(14.8 \text{ in.})(0.472 \text{ in.}) = 263 \text{ kips}$$

REFERENCES

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