REFERENCES	CALCULATIONS	RESULTS
SkyCiv CLOUD STRUCTURAL SOFTWARE	**Brace to Column Flange Knee Brace Connection Calculations**	
	Column Section Properties: W14x90 - Column Size $d_c = 14$ in - Column Depth $t_{w,c} = 0.44$ in - Column Web Thickness $b_{f,c} = 14.5$ in - Column Flange Width $t_{f,c} = 0.71$ in - Column Flange Thickness $A_c = 26.5$ in^2 - Column Area **Column Grade Information:** A992 - Material Grade $F_{y,c} = 50$ ksi - Column Yield Stress $F_{u,c} = 65$ ksi - Column Tensile Stress	
	Brace Section Properties: 2L5x3-1/2x1/2-LLBB - Brace Size $A_{br} = 8$ in^2 - Brace Area $L_{on,gp,br} = 5$ in - Brace Leg on Gusset $L_{off,gp,br} = 3.5$ in - Brace Leg off Gusset $t_{br} = 0.5$ in - Brace Thickness $\theta_{br} = 45$ - Brace Slope from Support in Degrees $L_{b,br} = 8$ in - Brace Unbraced Length **Brace Grade Information:** A36 - Material Grade $F_{y,br} = 36$ ksi - Brace Yield Stress $F_{u,br} = 58$ ksi - Brace Tensile Stress	
	Design Loads: $T_{u,br} = 25$ kip - Brace Tension Load $C_{u,br} = 25$ kip - Brace Compression Load	
	Connection Information at Brace to Gusset Plate: $t_{gp} = 1$ in - Gusset Plate Thickness $W = 0.25$ in - Fillet Weld Size $L_w = 6$ in - Weld Length E70XX - Filler Metal Classification	
	Connection Information at Gusset Plate to Support: $W = 0.25$ in - Fillet Weld Size $L_{w1} = 12$ in - Weld Length 1 $L_{w2} = 11$ in - Weld Length 2 E70XX - Filler Metal Classification	

REFERENCES	CALCULATIONS	RESULTS

Brace Connection to Gusset Plate | AISC 360-16 LRFD

Check No. 1: Connection Detailing Limitations

Detailing Limitations	Limit Value (in)	Actual Value (in)	DCR	Result
Minimum Fillet Weld Size	0.188	0.250	0.752	PASS
Maximum Fillet Weld Size	0.438	0.250	0.571	PASS

Result:
Demand over Capacity Ratio

$DCR = \frac{d}{c} = \frac{(0.188)}{(0.25)} = 0.752$

PASS

Check No. 2: Design Capacity of the Welds at Brace to Gusset

Calculate the maximum fillet weld size in 16th of an inch for base metal check.

$t_{br} = 0.5\text{ in}$ - Brace Thickness
$F_{u,br} = 58\text{ ksi}$ - Brace Tensile Stress
$t_{gp} = 1\text{ in}$ - Gusset Plate Thickness
$F_{u,gp} = 65\text{ ksi}$ - Gusset Plate Tensile Stress

AISC 15th Ed. Part 9 Eq. (9-2)

D_{max} - Maximum Fillet Weld Size for Base Metal Strength

$$D_{max} = \frac{t_{br}\, F_{u,br} \leq t_{gp}\, F_{u,gp}}{3.09\text{ kip/in}}$$

$$D_{max} = \frac{(0.5\text{ in}) \times (58\text{ ksi}) \leq (1\text{ in}) \times (65\text{ ksi})}{(3.09\text{ kip/in})}$$

$$D_{max} = 9.3851$$

Calculate the total effective weld length for NS/FS fillet welds.

$W = 0.25\text{ in}$ - Fillet Weld Size
$L_w = 6\text{ in}$ - Weld Length
L_w - Total Effective Length of Weld

$$L_w = 4\,[L_w - 2\,(W \leq 0.3125\text{ in})]$$

$$L_w = 4 \times [(6\text{ in}) - 2 \times ((0.25\text{ in}) \leq (0.3125\text{ in}))]$$

$$L_w = 22\text{ in}$$

Calculate the design capacity of the weld.

$F_{EXX} = 70\text{ ksi}$ - Filler Metal Classification Strength
$W = 0.25\text{ in}$ - Fillet Weld Size

AISC 15th Ed. Part 9 Eq. (9-2)

$D_{max} = 9.3851$ - Maximum Fillet Weld Size for Base Metal Strength
$L_w = 22\text{ in}$ - Total Effective Length of Weld
$\phi = 0.75$ - Fillet Weld Resistance Factor

AISC 360-16 Chapter J2.4 Eq. (J2-4)

ϕR_n - Design Strength of Welds

$$\phi R_n = \phi\, 0.6\, F_{EXX}\, \frac{\sqrt{2}}{2} \left(W \leq \frac{D_{max}}{16}\right) L_w$$

$$\phi R_n = (0.75) \times 0.6 \times (70\text{ ksi}) \times \frac{\sqrt{2}}{2} \times \left((0.25\text{ in}) \leq \frac{(9.3851)}{(16)}\right) \times (22\text{ in})$$

$$\phi R_n = 122.51\text{ kip}$$

Result:
Demand over Capacity Ratio

$DCR = \frac{T_{u,br}}{\phi R_n} = \frac{(25\text{ kip})}{(122.51\text{ kip})} = 0.20407$

PASS

Check No. 3: Design Block Shear Capacity of the Gusset Plate

Calculate the net area of the gusset plate subject to tension.

$t_{gp} = 1\text{ in}$ - Gusset Plate Thickness
$L_{on,gp,br} = 5\text{ in}$ - Brace Leg on Gusset
A_{nt} - Net Area Subject to Tension (C-pattern)

$$A_{nt} = t_{gp}\, L_{on,gp,br}$$

$$A_{nt} = (1\text{ in}) \times (5\text{ in})$$

$$A_{nt} = 5\text{ in}^2$$

Calculate the gross area of the gusset plate subject to shear.

$t_{gp} = 1\text{ in}$ - Gusset Plate Thickness
$L_w = 6\text{ in}$ - Weld Length
A_{gv} - Gross Area Subject to Shear (C-pattern)

$$A_{gv} = 2\, t_{gp}\, L_w$$

$$A_{gv} = 2 \times (1\text{ in}) \times (6\text{ in})$$

$$A_{gv} = 12\text{ in}^2$$

Calculate the net area of the gusset plate subject to shear.

$t_{gp} = 1$ in - Gusset Plate Thickness
$L_w = 6$ in - Weld Length
A_{nv} - Net Area Subject to Shear (C-pattern)

$$A_{nv} = 2\, t_{gp}\, L_w$$

$$A_{nv} = 2 \times (1 \text{ in}) \times (6 \text{ in})$$

$$A_{nv} = 12 \text{ in}^2$$

AISC 360-16 Chapter J4.3 Eq. (J4-5)

Calculate the design block shear capacity of the gusset plate.
$F_{u,gp} = 65$ ksi - Gusset Plate Tensile Stress
$A_{nv} = 12 \text{ in}^2$ - Net Area Subject to Shear (C-pattern)
$U_{bs} = 1$ - Uniformity factor
$A_{nt} = 5 \text{ in}^2$ - Net Area Subject to Tension (C-pattern)
$F_{y,gp} = 50$ ksi - Gusset Plate Yield Stress
$A_{gv} = 12 \text{ in}^2$ - Gross Area Subject to Shear (C-pattern)
$\phi = 0.75$ - Block Shear Resistance Factor
ϕR_n - Design Block Shear Capacity of Section

$$\phi R_n = \phi\ (0.6\, F_{u,gp}\, A_{nv} + U_{bs}\, F_{u,gp}\, A_{nt} \leq 0.6\, F_{y,gp}\, A_{gv} + U_{bs}\, F_{u,gp}\, A_{nt})$$

$$\phi R_n = (0.75) \times \left(0.6 \times (65 \text{ ksi}) \times \left(12 \text{ in}^2\right) + (1) \times (65 \text{ ksi}) \times \left(5 \text{ in}^2\right) \leq 0.6 \times (50 \text{ ksi}) \times \left(12 \text{ in}^2\right) + (1) \times (65 \text{ ksi}) \times \left(5 \text{ in}^2\right)\right)$$

$$\phi R_n = 513.75 \text{ kip}$$

Result: **PASS**
Demand over Capacity Ratio
$DCR = \frac{T_{u,br}}{\phi R_n} = \frac{(25 \text{ kip})}{(513.75 \text{ kip})} = 0.048662$

Check No. 4: Design Capacity of the Brace in Tension
Calculate the tensile rupture capacity of the brace.

AISC 360-16 Chapter D3 (Table D3.1 case 2)

$\phi = 0.75$ - Tensile Rupture Resistance Factor
$F_{u,br} = 58$ ksi - Brace Tensile Stress
$A_{br} = 8 \text{ in}^2$ - Brace Area
$\bar{x} = 0.901$ in - Brace Centroid
$L_w = 6$ in - Weld Length
U - Shear Lag Factor

$$U = 1 - \frac{\bar{x}}{L_w}$$

$$U = 1 - \frac{(0.901 \text{ in})}{(6 \text{ in})}$$

$$U = 0.84983$$

AISC 360-16 Chapter J4.1 Eq. (J4-2)

ϕR_{n_tr} - Design Tension Rupture Capacity of Section

$$\phi R_{n\_tr} = \phi\, F_{u,br}\, U\, A_{br}$$

$$\phi R_{n\_tr} = (0.75) \times (58 \text{ ksi}) \times (0.84983) \times \left(8 \text{ in}^2\right)$$

$$\phi R_{n\_tr} = 295.74 \text{ kip}$$

Result: **PASS**
Demand over Capacity Ratio
$DCR = \frac{T_{u,br}}{\phi R_{n\_tr}} = \frac{(25 \text{ kip})}{(295.74 \text{ kip})} = 0.084533$

Check No. 5: Design Capacity of the Gusset Plate in Tension
Calculate the tensile yielding capacity of the gusset plate.

AISC 360-16 Chapter J4.1 Eq. (J4-1)

$\phi = 0.9$ - Tensile Yielding Resistance Factor
$F_{y,gp} = 50$ ksi - Gusset Plate Yield Stress
$t_{gp} = 1$ in - Gusset Plate Thickness
$W_{br} = 11.928$ in - Whitmore Section
ϕR_{n_ty} - Design Tension Yielding Capacity of Section

$$\phi R_{n\_ty} = \phi\, F_{y,gp}\, t_{gp}\, W_{br}$$

$$\phi R_{n\_ty} = (0.9) \times (50 \text{ ksi}) \times (1 \text{ in}) \times (11.928 \text{ in})$$

$$\phi R_{n\_ty} = 536.77 \text{ kip}$$

Result: **PASS**
Demand over Capacity Ratio
$DCR = \frac{T_{u,br}}{\phi R_{n\_ty}} = \frac{(25 \text{ kip})}{(536.77 \text{ kip})} = 0.046575$

Check No. 6: Design Capacity of the Gusset Plate in Compression
Calculate the compression buckling capacity of the gusset plate.
$\phi = 0.9$ - Compression Resistance Factor
$F_{y,gp} = 50$ ksi - Gusset Plate Yield Stress
$t_{gp} = 1$ in - Gusset Plate Thickness
$W_{br} = 11.928$ in - Whitmore Section
$K = 1.2$ - Effective Length Factor
$L_{b,br} = 8$ in - Brace Unbraced Length
$\frac{KL}{r} = 33.255$ - Effective Length Slenderness Ratio

AISC 360-16 Chapter E3 Eq. (E3-4)	Since, $\frac{KL}{r} > 25.$ F_e - Elastic Buckling Stress $$F_e = \frac{\pi^2\ E}{\left(\frac{KL}{r}\right)^2}$$ $$F_e = \frac{\pi^2 \times (29000\ \text{ksi})}{((33.255))^2}$$ $$F_e = 258.81\ \text{ksi}$$ $4.71\sqrt{\frac{E}{F_y}} = 113.43$ - Effective Length Slenderness Ratio Limiter Since, $\frac{KL}{r} \leq 4.71\sqrt{\frac{E}{F_y}}.$	
AISC 360-16 Chapter E3 Eq. (E3-2)	F_{cr} - Critical Buckling Stress $$F_{cr} = \left(0.658^{\frac{F_{y,gp}}{F_e}}\right)\ F_{y,gp}$$ $$F_{cr} = \left(0.658^{\frac{(50\ \text{ksi})}{(258.81\ \text{ksi})}}\right) \times (50\ \text{ksi})$$ $$F_{cr} = 46.116\ \text{ksi}$$	
AISC 360-16 Chapter E3 Eq. (E3-1)	ϕR_n - Design Compressive Capacity of Section $$\phi R_n = \phi\ F_{cr}\ t_{gp}\ W_{br}$$ $$\phi R_n = (0.9) \times (46.116\ \text{ksi}) \times (1\ \text{in}) \times (11.928\ \text{in})$$ $$\phi R_n = 495.07\ \text{kip}$$ **Result:** Demand over Capacity Ratio $DCR = \frac{C_{u,br}}{\phi R_n} = \frac{(25\ \text{kip})}{(495.07\ \text{kip})} = 0.050498$	**PASS**

Summary of Checks

Design Checks	Demand	Capacity	DCR	Result
Connection Detailing Limitations	0.188	0.250	0.752	**PASS**
Design Capacity of the Welds at Brace to Gusset	25.000	122.506	0.204	**PASS**
Design Block Shear Capacity of the Gusset Plate	25.000	513.750	0.049	**PASS**
Design Capacity of the Brace in Tension	25.000	295.742	0.085	**PASS**
Design Capacity of the Gusset Plate in Tension	25.000	536.769	0.047	**PASS**
Design Capacity of the Gusset Plate in Compression	25.000	495.074	0.050	**PASS**

REFERENCES	CALCULATIONS	RESULTS

Gusset Plate Connection to Support | AISC 360-16 LRFD

Check No. 1: Connection Detailing Limitations

Detailing Limitations	Limit Value (in)	Actual Value (in)	DCR	Result
Minimum Fillet Weld Size	0.250	0.250	1.000	PASS

Result:
Demand over Capacity Ratio

$DCR = \frac{d}{c} = \frac{(0.25)}{(0.25)} = 1$

PASS

Check No. 2: Design Capacity of Weld at Gusset to Support

Connection Information:

$\phi = 0.75$ - Fillet Weld Resistance Factor

$W = 0.25 \text{ in}$ - Fillet Weld Size

$F_{EXX} = 70 \text{ ksi}$ - Filler Metal Classification Strength

$t_{f,c} = 0.71 \text{ in}$ - Column Flange Thickness

$F_{u,c} = 65 \text{ ksi}$ - Column Tensile Stress

$t_{gp} = 1 \text{ in}$ - Gusset Plate Thickness

$F_{u,gp} = 65 \text{ ksi}$ - Gusset Plate Tensile Stress

$L_{WT} = 23 \text{ in}$ - Total Plate Length

Calculate Dmax:

AISC 15th Ed. Part 9 Eq. (9-2)

Maximum Fillet Weld Size for Base Metal Strength

$D_{max} = \frac{t_{f,c}\ F_{u,c} \le \frac{t_{gp}}{2}\ F_{u,gp}}{3.09 \text{ kip/in}} = \frac{(0.71 \text{ in}) \times (65 \text{ ksi}) \le (0.5 \text{ in}) \times (65 \text{ ksi})}{(3.09 \text{ kip/in})} = 10.518$

Calculate Total Weld Length:

Total Effective Length of Weld

$L_w = 2\ [L_{WT} - 2\ (W \le 0.3125 \text{ in})] = 2 \times [(23 \text{ in}) - 2 \times ((0.25 \text{ in}) \le (0.3125 \text{ in}))] = 45 \text{ in}$

Design Loads:

Moment Load at Gusset to Support

$M_{br} = \frac{N_{br}\ |L_{w1} - L_{w2}|}{2} = \frac{(17.678 \text{ kip}) \times |(12 \text{ in}) - (11 \text{ in})|}{2} = 0.73657 \text{ kip} \cdot \text{ft}$

Brace Component Perpendicular to Support

$N_{br} = T_{u,br}\ \sin(\theta_{br}) = (25 \text{ kip}) \times \sin((45)) = 17.678 \text{ kip}$

$N_{br,T} = \frac{8\ M_{br}}{L_w} + N_{br} = \frac{8 \times (0.73657 \text{ kipft})}{(45 \text{ in})} + (17.678 \text{ kip}) = 19.249 \text{ kip}$

Brace Component Along Support

$V_{br} = T_{u,br}\ \cos(\theta_{br}) = (25 \text{ kip}) \times \cos((45)) = 17.678 \text{ kip}$

Resultant Load

$R = \sqrt{(N_{br,T})^2 + (V_{br})^2} = \sqrt{((19.249 \text{ kip}))^2 + ((17.678 \text{ kip}))^2} = 26.135 \text{ kip}$

Loading Angle at Weld in Degrees

$\theta = \tan^{-1}\left(\frac{N_{br,T}}{V_{br}}\right) = \tan^{-1}\left(\frac{(19.249 \text{ kip})}{(17.678 \text{ kip})}\right) = 47.437$

Calculate Weld Capacity:

AISC 360-16 Chapter J2.4 Eq. (J2-4)

ϕR_n - Design Strength of Welds

$$\phi R_n = \phi\ 0.6\ F_{EXX}\ \frac{\sqrt{2}}{2}\left(W \le \frac{D_{max}}{16}\right)\left[1 + 0.5\ (\sin\theta)^{1.5}\right] L_w$$

$$\phi R_n = (0.75) \times 0.6 \times (70 \text{ ksi}) \times \frac{\sqrt{2}}{2} \times \left((0.25 \text{ in}) \le \frac{(10.518)}{(16)}\right) \times \left[1 + 0.5 \times (\sin(47.437))^{1.5}\right] \times (45 \text{ in})$$

$$\phi R_n = 329.78 \text{ kip}$$

Result:
Demand over Capacity Ratio

$DCR = \frac{R}{\phi R_n} = \frac{(26.135 \text{ kip})}{(329.78 \text{ kip})} = 0.07925$

PASS

Check No. 3: Design Capacity of the Support

Calculate the web local crippling capacity of the Support.

$\phi = 0.75$ - Web Local Crippling Resistance Factor

$t_{w,c} = 0.44 \text{ in}$ - Column Web Thickness

$l_b = 11.5 \text{ in}$ - Bearing Length: Half Gusset Plate Length along Support

$d_c = 14 \text{ in}$ - Column Depth

$t_{f,c} = 0.71 \text{ in}$ - Column Flange Thickness

$F_{y,c} = 50 \text{ ksi}$ - Column Yield Stress

$E = 29000 \text{ ksi}$ - Modulus for Steel

AISC 360-16 Chapter J10.3 Eq. (J10-4)

ϕR_{n_wlc} - Design Web Local Crippling Capacity of Support

$$\phi R_{n\_wlc} = \phi\ 0.8\ (t_{w,c})^2\left[1 + 3\left(\frac{l_b}{d_c}\right)\left(\frac{t_{w,c}}{t_{f,c}}\right)^{1.5}\right]\sqrt{\frac{E\ F_{y,c}\ t_{f,c}}{t_{w,c}}}\ Q_f$$

$$\phi R_{n\_wlc} = (0.75) \times 0.8 \times ((0.44 \text{ in}))^2 \times \left[1 + 3 \times \left(\frac{(11.5 \text{ in})}{(14 \text{ in})}\right) \times \left(\frac{(0.44 \text{ in})}{(0.71 \text{ in})}\right)^{1.5}\right] \times \sqrt{\frac{(29000 \text{ ksi}) \times (50 \text{ ksi}) \times (0.71 \text{ in})}{(0.44 \text{ in})}} \times (1)$$

$$\phi R_{n\_wlc} = 391.29 \text{ kip}$$

Calculate the web local yielding capacity of the Support.

$\phi = 1$ - Web Local Yielding Resistance Factor

$F_{y,c} = 50 \text{ ksi}$ - Column Yield Stress

$t_{w,c} = 0.44 \text{ in}$ - Column Web Thickness

$k_{des,c} = 1.31 \text{ in}$ - Column kdes

	$l_b = 11.5 \text{ in}$ - Bearing Length: Half Gusset Plate Length along Support	
AISC 360-16 Chapter J10.2 Eq. (J10-2)	ϕR_{n_wly} - Design Web Local Yielding Capacity of Support $$\phi R_{n\_wly} = \phi\, F_{y,c}\, t_{w,c}\, \left(5\, k_{des,c} + l_b\right)$$ $$\phi R_{n\_wly} = (1) \times (50 \text{ ksi}) \times (0.44 \text{ in}) \times (5 \times (1.31 \text{ in}) + (11.5 \text{ in}))$$ $$\phi R_{n\_wly} = 397.1 \text{ kip}$$	
	Calculate for the governing design capacity of the Support.	
AISC 360-16 Chapter J10	ϕR_n - Governing Design Capacity of the Support $$\phi R_n = min\left(\phi R_{n\_wlc}, \phi R_{n\_wly}\right)$$ $$\phi R_n = min\left((391.29 \text{ kip}), (397.1 \text{ kip})\right)$$ $$\phi R_n = 391.29 \text{ kip}$$	
	$N_{br,at,support} = 9.6245 \text{ kip}$ - Required Load: Half total Nbr	
	Result: Demand over Capacity Ratio $DCR = \frac{N_{br,at,support}}{\phi R_n} = \frac{(9.6245 \text{ kip})}{(391.29 \text{ kip})} = 0.024597$	**PASS**

Summary of Checks

Design Checks	Demand	Capacity	DCR	Result
Connection Detailing Limitations	0.250	0.250	1.000	**PASS**
Design Capacity of Weld at Gusset to Support	26.135	329.777	0.079	**PASS**
Design Capacity of the Support	9.625	391.294	0.025	**PASS**