

Beam to Column

End Plate Shear Connection

Code=AISC 360-10 LRFD

Result Summary

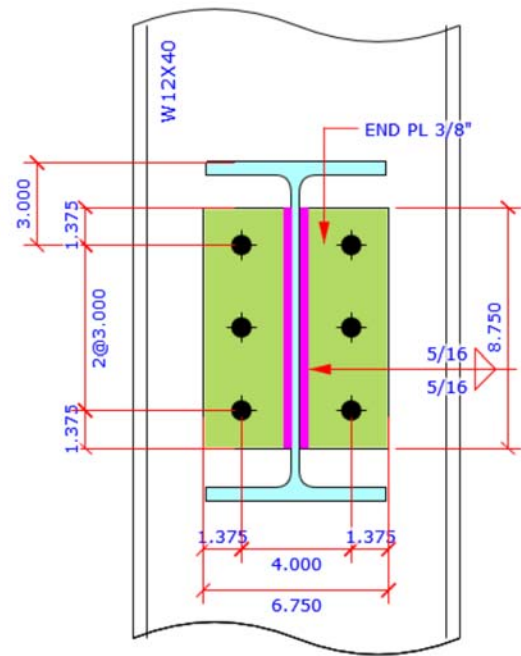
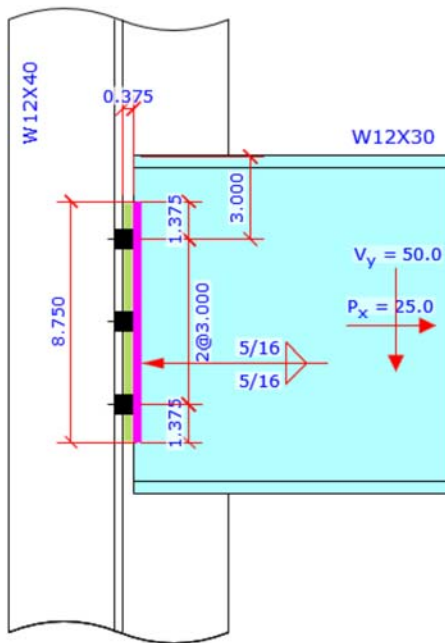
geometries & weld limitations = **PASS**

limit states max ratio = **0.90** **PASS**

Sketch

Shear Connection

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Members & Components Summary

Member

Shear Connection

Code=AISC 360-10 LRFD

End Plate

Plate

W = 6.750 [in]

L = 8.750 [in]

t = 0.375 [in]

Steel Grade A992

F_y = 50.0 [ksi]

F_u = 65.0 [ksi]

Bolt

end plate bolt

Bolt

dia = 0.750 [in]

grade = A325-N

F_u = 120.0 [ksi]

F_{nt} = 90.0 [ksi]

F_{nv} = 54.0 [ksi]

slip critical

SC = No

Geometry Restriction Check - End Plate to Column			PASS
Min Bolt Edge Distance - End Plate to Column			
Bolt diameter	$d_b =$	= 0.750 [in]	
Min edge distance allowed	$L_{e-min} =$	= 1.000 [in]	AISC 14 th Table J3.4
Min edge distance in End Plate to Column	$L_e =$	= 1.375 [in]	
		> L_{e-min}	OK
Min Bolt Spacing - End Plate to Column			
Bolt diameter	$d_b =$	= 0.750 [in]	
Min bolt spacing allowed	$L_{s-min} = 2.667 d_b$	= 2.000 [in]	AISC 14 th J3.3
Min Bolt spacing in End Plate to Column	$L_s =$	= 3.000 [in]	
		> L_{s-min}	OK

Weld Limitation Check - Beam Web to End Plate			PASS
Min Fillet Weld Size			
Thinner part joined thickness	$t =$	= 0.260 [in]	
Min fillet weld size allowed	$w_{min} =$	= 0.188 [in]	AISC 14 th Table J2.4
Fillet weld size provided	$w =$	= 0.313 [in]	
		> w_{min}	OK
Min Fillet Weld Length			
Fillet weld size provided	$w =$	= 0.313 [in]	
Min fillet weld length allowed	$L_{min} = 4 \times w$	= 1.250 [in]	AISC 14 th J2.2b
Min fillet weld length	$L =$	= 8.750 [in]	
		> L_{min}	OK

Beam Web - Shear Yielding		ratio = 50.00 / 95.94	= 0.52	PASS
Plate Shear Yielding Check				
Plate size	width $b_p = 12.300$ [in]	thickness $t_p = 0.260$ [in]		
Plate yield strength	$F_y = 50.0$ [ksi]			
Plate gross area in shear	$A_{gv} = b_p t_p$	= 3.198 [in ²]		
Shear force required	$V_u =$	= 50.00 [kips]		
Plate shear yielding strength	$R_n = 0.6 F_y A_{gv}$	= 95.94 [kips]		AISC 14 th Eq J4-3
Resistance factor-LRFD	$\phi = 1.00$			AISC 14 th Eq J4-3
	$\phi R_n =$	= 95.94 [kips]		
	ratio = 0.52	> V_u	OK	

Beam Web - Shear Rupture		ratio = 50.00 / 93.54	= 0.53	PASS
Plate Shear Rupture Check				
Plate size	width $b_p = 12.300$ [in]	thickness $t_p = 0.260$ [in]		
Plate tensile strength	$F_u = 65.0$ [ksi]			
Plate net area in shear	$A_{nv} = b_p t_p$	= 3.198 [in ²]		
Shear force in demand	$V_u =$	= 50.00 [kips]		
Plate shear rupture strength	$R_n = 0.6 F_u A_{nv}$	= 124.72 [kips]		AISC 14 th Eq J4-4
Resistance factor-LRFD	$\phi = 0.75$			AISC 14 th Eq J4-4
	$\phi R_n =$	= 93.54 [kips]		
	ratio = 0.53	> V_u	OK	

Beam Web - Tensile Yielding		ratio = 25.00 / 395.55	= 0.06	PASS
Gross area subject to tension	$A_g =$	= 8.790 [in ²]		
Steel yield strength	$F_y =$	= 50.0 [ksi]		
Tensile force required	$P_u =$	= 25.00 [kips]		
Tensile yielding strength	$R_n = F_y A_g$	= 439.50 [kips]		AISC 14 th Eq D2-1
Resistance factor-LRFD	$\phi = 0.90$			AISC 14 th D2 (a)
	$\phi R_n =$	= 395.55 [kips]		AISC 14 th Eq D2-1
	ratio = 0.06	> P_u	OK	

Beam Web - Tensile Rupture		ratio = 25.00 / 102.98	= 0.24	PASS
End Plate Direct Connect Length Calc				
Beam web-end plate weld length	$L =$	= 8.750 [in]		
Beam web-end plate fillet weld size	$w =$	= 0.313 [in]		
Beam web-end plate connect length	$L_w = L - 2 w$	= 8.125 [in]		
Plate Tensile Rupture Check				
Plate size	width $b_p = 8.125$ [in]	thickness $t_p = 0.260$ [in]		
Plate tensile strength	$F_u = 65.0$ [ksi]			
Plate net area in tension	$A_{nt} = b_p t_p$	= 2.113 [in ²]		
Tensile force in demand	$P_u =$	= 25.00 [kips]		
Plate tensile rupture strength	$R_n = F_u A_{nt}$	= 137.31 [kips]		AISC 14 th Eq J4-2
Resistance factor-LRFD	$\phi = 0.75$			AISC 14 th Eq J4-2
	$\phi R_n =$	= 102.98 [kips]		AISC 14 th Eq J4-2
	ratio = 0.24	> P_u	OK	

End Plate - Shear Yield		ratio = 25.00 / 98.44	= 0.25	PASS
Plate Shear Yielding Check				
Plate size	width $b_p = 8.750$ [in]	thickness $t_p = 0.375$ [in]		
Plate yield strength	$F_y = 50.0$ [ksi]			
Plate gross area in shear	$A_{gv} = b_p t_p$	= 3.281 [in ²]		
Shear force required	$V_u =$	= 25.00 [kips]		
Plate shear yielding strength	$R_n = 0.6 F_y A_{gv}$	= 98.44 [kips]		AISC 14 th Eq J4-3
Resistance factor-LRFD	$\phi = 1.00$			AISC 14 th Eq J4-3
	$\phi R_n =$	= 98.44 [kips]		
	ratio = 0.25	> V_u	OK	

End Plate - Shear Rupture		ratio = 25.00 / 67.18	= 0.37	PASS
Plate Shear Rupture Check				
Bolt hole diameter	bolt dia $d_b = 3/4$ [in]	bolt hole dia $d_h = 7/8$ [in]		AISC 14 th B4.3b
Number of bolt	$n = 3$			
Plate size	width $b_p = 8.750$ [in]	thickness $t_p = 0.375$ [in]		
Plate tensile strength	$F_u = 65.0$ [ksi]			
Plate net area in shear	$A_{nv} = (b_p - n d_h) t_p$	= 2.297 [in ²]		
Shear force required	$V_u =$	= 25.00 [kips]		
Plate shear rupture strength	$R_n = 0.6 F_u A_{nv}$	= 89.58 [kips]		AISC 14 th Eq J4-4
Resistance factor-LRFD	$\phi = 0.75$			AISC 14 th Eq J4-4
	$\phi R_n =$	= 67.18 [kips]		
	ratio = 0.37	> V_u	OK	

End Plate - Block Shear - Center Strip		ratio = 50.00 / 170.93	= 0.29	PASS
Plate Block Shear - Center Strip				
Bolt hole diameter	bolt dia $d_b = 3/4$ [in]	bolt hole dia $d_h = 7/8$ [in]		AISC 14 th B4.3b
Plate thickness	$t_p = 0.375$ [in]			
Plate strength	$F_y = 50.0$ [ksi]	$F_u = 65.0$ [ksi]		
Bolt no in ver & hor dir	$n_v = 2$	$n_h = 3$		
Bolt spacing in ver & hor dir	$s_v = 4.000$ [in]	$s_h = 3.000$ [in]		
Bolt edge dist in ver & hor dir	$e_v = 1.375$ [in]	$e_h = 1.375$ [in]		
Gross area subject to shear	$A_{gv} = [(n_h - 1) s_h + e_h] t_p \times 2$	= 5.531 [in ²]		
Net area subject to shear	$A_{nv} = A_{gv} - [(n_h - 1) + 0.5] d_h t_p \times 2$	= 3.891 [in ²]		
Net area subject to tension when sheared out by center strip	$A_{nt} = (n_v - 1) (s_v - d_h) t_p$	= 1.172 [in ²]		
Block shear strength required	$V_u =$	= 50.00 [kips]		
Uniform tension stress factor	$U_{bs} = 1.00$			AISC 14 th Fig C-J4.2
Bolt shear resistance provided	$R_n = \min(0.6F_u A_{nv}, 0.6F_y A_{gv}) + U_{bs} F_u A_{nt}$	= 227.91 [kips]		AISC 14 th Eq J4-5
Resistance factor-LRFD	$\phi = 0.75$			AISC 14 th Eq J4-5
	$\phi R_n =$	= 170.93 [kips]		
	ratio = 0.29	> V_u	OK	

End Plate - Block Shear - 2-Side Strip		ratio = 50.00 / 148.08	= 0.34	PASS
Plate Block Shear - 2 Side Strips				
Bolt hole diameter	bolt dia $d_b = 3/4$ [in]	bolt hole dia $d_h = 7/8$ [in]		AISC 14 th B4.3b
Plate thickness	$t_p = 0.375$ [in]			
Plate strength	$F_y = 50.0$ [ksi]	$F_u = 65.0$ [ksi]		
Bolt no in ver & hor dir	$n_v = 2$	$n_h = 3$		
Bolt spacing in ver & hor dir	$s_v = 4.000$ [in]	$s_h = 3.000$ [in]		
Bolt edge dist in ver & hor dir	$e_v = 1.375$ [in]	$e_h = 1.375$ [in]		
Gross area subject to shear	$A_{gv} = [(n_h - 1) s_h + e_h] t_p \times 2$	= 5.531 [in ²]		
Net area subject to shear	$A_{nv} = A_{gv} - [(n_h - 1) + 0.5] d_h t_p \times 2$	= 3.891 [in ²]		
Net area subject to tension when sheared out by 2 side strips	$A_{nt} = (e_v - 0.5 d_h) t_p \times 2$	= 0.703 [in ²]		
Block shear strength required	$V_u =$	= 50.00 [kips]		
Uniform tension stress factor	$U_{bs} = 1.00$			AISC 14 th Fig C-J4.2
Bolt shear resistance provided	$R_n = \min(0.6F_u A_{nv}, 0.6F_y A_{gv}) + U_{bs} F_u A_{nt}$	= 197.44 [kips]		AISC 14 th Eq J4-5
Resistance factor-LRFD	$\phi = 0.75$			AISC 14 th Eq J4-5
	$\phi R_n =$	= 148.08 [kips]		
	ratio = 0.34	> V_u	OK	

End Plate - Bolt Bearing on End Plate		ratio = 50.00 / 107.35	= 0.47	PASS
Single Bolt Shear Strength				
Bolt shear stress	bolt grade = A325-N	$F_{nv} = 54.0$	[ksi]	AISC 14 th Table J3.2
	bolt dia $d_b = 0.750$ [in]	bolt area $A_b = 0.442$	[in ²]	
Single bolt shear strength	$R_{n-bolt} = F_{nv} A_b$	= 23.86	[kips]	AISC 14 th Eq J3-1
Bolt Bearing/TearOut Strength on Plate				
Bolt hole diameter	bolt dia $d_b = 3/4$ [in]	bolt hole dia $d_h = 13/16$	[in]	AISC 14 th Table J3.3
Bolt spacing & edge distance	spacing $L_s = 3.000$ [in]	edge distance $L_e = 1.375$	[in]	
Plate tensile strength	$F_u = 65.0$		[ksi]	
Plate thickness	$t = 0.375$		[in]	
Interior Bolt				
Bolt hole edge clear distance	$L_c = L_s - d_h$	= 2.188	[in]	
Bolt tear out/bearing strength	$R_{n-t\&b-in} = 1.5 L_c t F_u \leq 3.0 d_b t F_u$ = 79.98 ≤ 54.84	= 54.84	[kips]	AISC 14 th Eq J3-6b
Bolt strength at interior	$R_{n-in} = \min (R_{n-t\&b-in}, R_{n-bolt})$	= 23.86	[kips]	
Edge Bolt				
Bolt hole edge clear distance	$L_c = L_e - d_h / 2$	= 0.969	[in]	
Bolt tear out/bearing strength	$R_{n-t\&b-ed} = 1.5 L_c t F_u \leq 3.0 d_b t F_u$ = 35.42 ≤ 54.84	= 35.42	[kips]	AISC 14 th Eq J3-6b
Bolt strength at edge	$R_{n-ed} = \min (R_{n-t\&b-ed}, R_{n-bolt})$	= 23.86	[kips]	
Number of bolt	interior $n_{in} = 4$	edge $n_{ed} = 2$		
Bolt bearing strength for all bolts	$R_n = n_{in} R_{n-in} + n_{ed} R_{n-ed}$	= 143.14	[kips]	
Required shear strength	$V_u =$	= 50.00	[kips]	
Bolt resistance factor-LRFD	$\phi = 0.75$			AISC 14 th J3-10
	$\phi R_n =$	= 107.35	[kips]	
	ratio = 0.47	> V_u	OK	

End Plate / Column - Bolt Shear		ratio = 50.00 / 107.35	= 0.47	PASS
Bolt shear stress	grade = A325-N	$F_{nv} = 54.0$	[ksi]	AISC 14 th Table J3.2
	bolt dia $d_b = 0.750$ [in]	bolt area $A_b = 0.442$	[in ²]	
Number of bolt carried shear	$n_s = 6.0$	shear plane $m = 1$		
Bolt group eccentricity coefficient	$C_{ec} =$	= 1.000		
Required shear strength	$V_u =$	= 50.00	[kips]	
Bolt shear strength	$R_n = F_{nv} A_b n_s m C_{ec}$	= 143.14	[kips]	AISC 14 th Eq J3-1
Bolt resistance factor-LRFD	$\phi = 0.75$			AISC 14 th Eq J3-1
	$\phi R_n =$	= 107.35	[kips]	
	ratio = 0.47	> V_u	OK	

End Plate / Column - Bolt Bearing on Column		ratio = 50.00 / 107.35	= 0.47	PASS
Single Bolt Shear Strength				
Bolt shear stress	bolt grade = A325-N	$F_{nv} = 54.0$	[ksi]	AISC 14 th Table J3.2
	bolt dia $d_b = 0.750$	[in]	bolt area $A_b = 0.442$	[in ²]
Single bolt shear strength	$R_{n-bolt} = F_{nv} A_b$	= 23.86	[kips]	AISC 14 th Eq J3-1
Bolt Bearing/TearOut Strength on Plate				
Bolt hole diameter	bolt dia $d_b = 3/4$	[in]	bolt hole dia $d_h = 13/16$	[in] AISC 14 th Table J3.3
Bolt spacing	spacing $L_s = 3.000$	[in]		
Plate tensile strength	$F_u = 65.0$	[ksi]		
Plate thickness	$t = 0.295$	[in]		
Interior Bolt				
Bolt hole edge clear distance	$L_c = L_s - d_h$	= 2.188	[in]	
Bolt tear out/bearing strength	$R_{n-t\&b-in} = 1.5 L_c t F_u \leq 3.0 d_b t m F_u$	= 43.14	[kips]	AISC 14 th Eq J3-6b
	= 62.92 ≤ 43.14			
Bolt strength at interior	$R_{n-in} = \min (R_{n-t\&b-in}, R_{n-bolt})$	= 23.86	[kips]	
Number of bolt				
	interior $n_{in} = 6$			
Bolt bearing strength for all bolts	$R_n = n_{in} R_{n-in}$	= 143.14	[kips]	
Required shear strength	$V_u =$	= 50.00	[kips]	
Bolt resistance factor-LRFD	$\phi = 0.75$			AISC 14 th J3-10
	$\phi R_n =$	= 107.35	[kips]	
	ratio = 0.47	> V_u		OK

Bolt Tensile Prying Action on End Plate		ratio = 4.17 / 6.91	= 0.60	PASS
Bolt group forces	shear V = 50.00 [kips]	axial P = -25.00	[kips]	
Single Bolt Tensile Capacity Without Considering Prying				
Bolt grade	grade = A325-N			
Nominal tensile/shear stress	$F_{nt} = 90.0$ [ksi]	$F_{nv} = 54.0$	[ksi]	AISC 14 th Table J3.2
	bolt dia $d_b = 0.750$ [in]	bolt area $A_b = 0.442$	[in ²]	
Bolt group shear force	shear V = 50.00 [kips]	no of bolt n = 6		
Shear stress required	$f_{rv} = V / (n A_b)$	= 18.86	[ksi]	
Resistance factor-LRFD	$\phi = 0.75$			AISC 14 th J3.7
Modified nominal tensile stress	$F'_{nt} = 1.3 F_{nt} - \frac{F_{nt}}{\phi F_{nv}} f_{rv} \leq F_{nt}$	= 75.08	[ksi]	AISC 14 th Eq J3-3a
Bolt nominal tensile strength	$r_n = F'_{nt} A_b$	= 33.17	[kips]	AISC 14 th Eq J3-1
Resistance factor-LRFD	$\phi = 0.75$			AISC 14 th J3.6
Single bolt tensile capacity	$\phi r_n =$	= 24.88	[kips]	
Single Bolt Tensile Capacity After Considering Prying				
End plate	width w = 6.750 [in]	bolt gage g = 4.000	[in]	
	web $t_w = 0.260$ [in]			
Dist from bolt center to plate edge	$a = 0.5 (w - g)$	= 1.375	[in]	
	$a' = a + 0.5 d_b \leq (1.25 b + 0.5 d_b)$	= 1.750	[in]	AISC 14 th Eq 9-27
Bolt hole diameter	bolt dia $d_b = 0.750$ [in]	bolt hole dia $d_h = 0.813$	[in]	AISC 14 th B4.3b
Dist from bolt center to face of web	$b = 0.5(g - t_w)$	= 1.870	[in]	
	$b' = b - 0.5 d_b$	= 1.495	[in]	AISC 14 th Eq 9-21
Bolt pitch spacing	$s_v = 3.000$			
Bolt tributary length	$p = s_v$ $p \leq 2b$ and $p \leq s_v$	= 2.917	[in]	AISC 14 th Page 9-11
	$\rho = b' / a'$	= 0.854		AISC 14 th Eq 9-26
	$\delta = 1 - d_h / p$	= 0.721		AISC 14 th Eq 9-24
Tensile capacity per bolt before considering prying	B = from calc shown in above section	= 24.88	[kips]	
Resistance factor-LRFD	$\phi = 0.90$			AISC 14 th Page 9-10
End plate thickness	t = 0.375 [in]	tensile $F_u = 65.0$	[ksi]	
Plate thickness req'd to develop bolt tensile capacity without prying	$t_c = \left(\frac{4 B b'}{\phi p F_u} \right)^{0.5}$	= 0.934	[in]	AISC 14 th Eq 9-30a
	$\alpha' = \frac{1}{\delta (1 + \rho)} \left[\left(\frac{t_c}{t} \right)^2 - 1 \right]$	= 3.887		AISC 14 th Eq 9-35
when $\alpha' > 1$	$Q = \left(\frac{t}{t_c} \right)^2 (1 + \delta)$	= 0.278		AISC 14 th Eq 9-34
Bolt tensile force per bolt in demand	T = from calc shown below	= 4.17	[kips]	
Tensile strength per bolt after considering prying	$\phi r_n = B \times Q$	= 6.91	[kips]	AISC 14 th Eq 9-31
	ratio = 0.60	> T	OK	
Calculate Max Single Bolt Tensile Load				
Bolt group force	axial P = 25.00 [kips]			
Bolt number	Bolt Row $n_h = 2$	Bolt Col $n_v = 3$		
Bolt tensile force per bolt	$T = P / (n_v n_h)$	= 4.17	[kips]	

Beam Web to End Plate Weld Strength		ratio = 6.88 / 7.61	= 0.90	PASS
Weld Group Forces				
	shear V = 50.00 [kips]		axial P = -25.00 [kips]	in tension
Beam web-end plate weld length	L =		= 8.750 [in]	
Beam web-end plate fillet weld size	w =		= 0.313 [in]	
Beam web-end plate weld length used for design	$L_w = L - 2w$		= 8.125 [in]	
Combined Weld Stress				
Weld stress from axial force	$f_a = P / L$		= -3.077 [kip/in]	in tension
Weld stress from shear force	$f_v = V / L$		= 6.154 [kip/in]	
Weld stress combined - max	$f_{max} = (f_a^2 + f_v^2)^{0.5}$		= 6.880 [kip/in]	AISC 14 th Eq 8-11
Weld stress load angle	$\theta = \tan^{-1} \left(\frac{f_a}{f_v} \right)$		= 26.6 [°]	
Fillet Weld Strength Calc				
Fillet weld leg size	$w = \frac{5}{16}$ [in]		load angle $\theta = 26.6$ [°]	
Electrode strength	$F_{EXX} = 70.0$ [ksi]		strength coeff $C_1 = 1.00$	AISC 14 th Table 8-3
Number of weld line	n = 2 for double fillet			
Load angle coefficient	$C_2 = (1 + 0.5 \sin^{1.5} \theta)$		= 1.15	AISC 14 th Page 8-9
Fillet weld shear strength	$R_{n-w} = 0.6 (C_1 \times 70 \text{ ksi}) 0.707 w n C_2$		= 21.334 [kip/in]	AISC 14 th Eq 8-1
<hr/>				
Base metal - beam web	thickness t = 0.260 [in]		tensile $F_u = 65.0$ [ksi]	
Base metal - beam web is in shear, <u>shear</u> rupture as per AISC 14 th Eq J4-4 is checked				AISC 14 th J2.4
Base metal shear rupture	$R_{n-b} = 0.6 F_u t$		= 10.140 [kip/in]	AISC 14 th Eq J4-4
<hr/>				
Double fillet linear shear strength	$R_n = \min (R_{n-w}, R_{n-b})$		= 10.140 [kip/in]	AISC 14 th Eq 9-2
Resistance factor-LRFD	$\phi = 0.75$			AISC 14 th Eq 8-1
	$\phi R_n =$		= 7.605 [kip/in]	
	ratio = 0.90		> f_{max}	OK