WEBSTER UNVI.

INTERDISCIPLINARY SCIENCE BUILDING

STRUCTURAL STEEL CONNECTION DESIGN

PROJECT No. 16013

PACKAGE NO. 1

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STATE OF MISSOURI
JOHN C. LYONS
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PROFESSIONAL ENGINEER

IT IS THE RESPONSIBILITY OF THE FABRICATOR TO COORDINATE DESIGN CALCULATIONS WITH STEEL SHOP DRAWINGS

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SC-01(F) BEAM TO W-SHAPE COLUMN FLANGE DOUBLE ANGLE CONNECTION (ALL BOLTED)

Connection ID	Beam Size	Beam Web Thickness (inch)	Design Reaction (kip)	Double Angle Size*	3/4" Dia. A325N Bolt Rows	Bolt Spacing (inch) "Spa."	Bolt Gage on Column Flange** (inch) "Ga."	Beam Side Bolt Edge Distance (inch)		Column Side Bolt Edge Distance (inch)	
								Vertical “L_{evb}”	Horizontal “L_{ehb}”	Vertical “L_{evc}”	Horizontal “L_{ehc}”
SC-01-1F	W8x18	1/4"	≤15	L4x4x5/16	2	3	6	1.25	1.25	1.25	
SC-01-2F	W10x17	1/4"	≤15	L4x4x5/16	2	3	6	1.25	1.25	1.25	
SC-01-3F	W12x19	1/4"	≤20	L4x4x5/16	2	3	6	1.25	1.25	1.25	
SC-01-4F	W14x22	1/4"	≤15	L4x4x5/16	3	3	6	1.25	1.25	1.25	
			≤25								
SC-01-5F	W16x26	1/4"	≤20	L4x4x5/16	3	3	6	1.25	1.25	1.25	
			≤40								
SC-01-6F	W16x31	1/4"	≤20	L4x4x5/16	3	3	6	1.25	1.25	1.25	
			≤40								
SC-01-7F			≤60		4						
SC-01-8F	W18x35	5/16"	≤20	L4x4x5/16	3	3	6	1.25	1.25	1.25	
			≤30								
SC-01-9F			≤60		4						
SC-01-10F	W18x65	7/16"	≤75	L4x4x5/16	5	3	6.25	1.25	1.25	1.25	
SC-01-11F	W21X44	3/8"	≤20	L4x4x5/16	4	3	6	1.25	1.25	1.25	
			≤45								
			≤60								Varies≥1.125"
SC-01-12F	W21x50	3/8"	≤20	L4x4x5/16	4	3	6	1.25	1.25	1.25	
SC-01-13F	W24x55	3/8"	≤20	L4x4x5/16	5	3	6	1.25	1.25	1.25	
			≤40								
			≤70								
			≤80								
SC-01-14F	W24x62	7/16"	≤100	L4x4x5/16	6	3	6.25	1.25	1.25	1.25	
SC-01-15F	W24x68	5	≤20	L4x4x5/16	5	3	6.25	1.25	1.25	1.25	
			≤40								
			≤60								
			≤80								
			≤90								
SC-01-16F	W24x84	1/2"	≤110	L4x4x5/16	6	3	6.25	1.25	1.25	1.25	
SC-01-17F	W27x84	7/16"	≤20	L4x4x5/16	5	3	6.25	1.25	1.25	1.25	
			≤40								
			≤60								
			≤80								

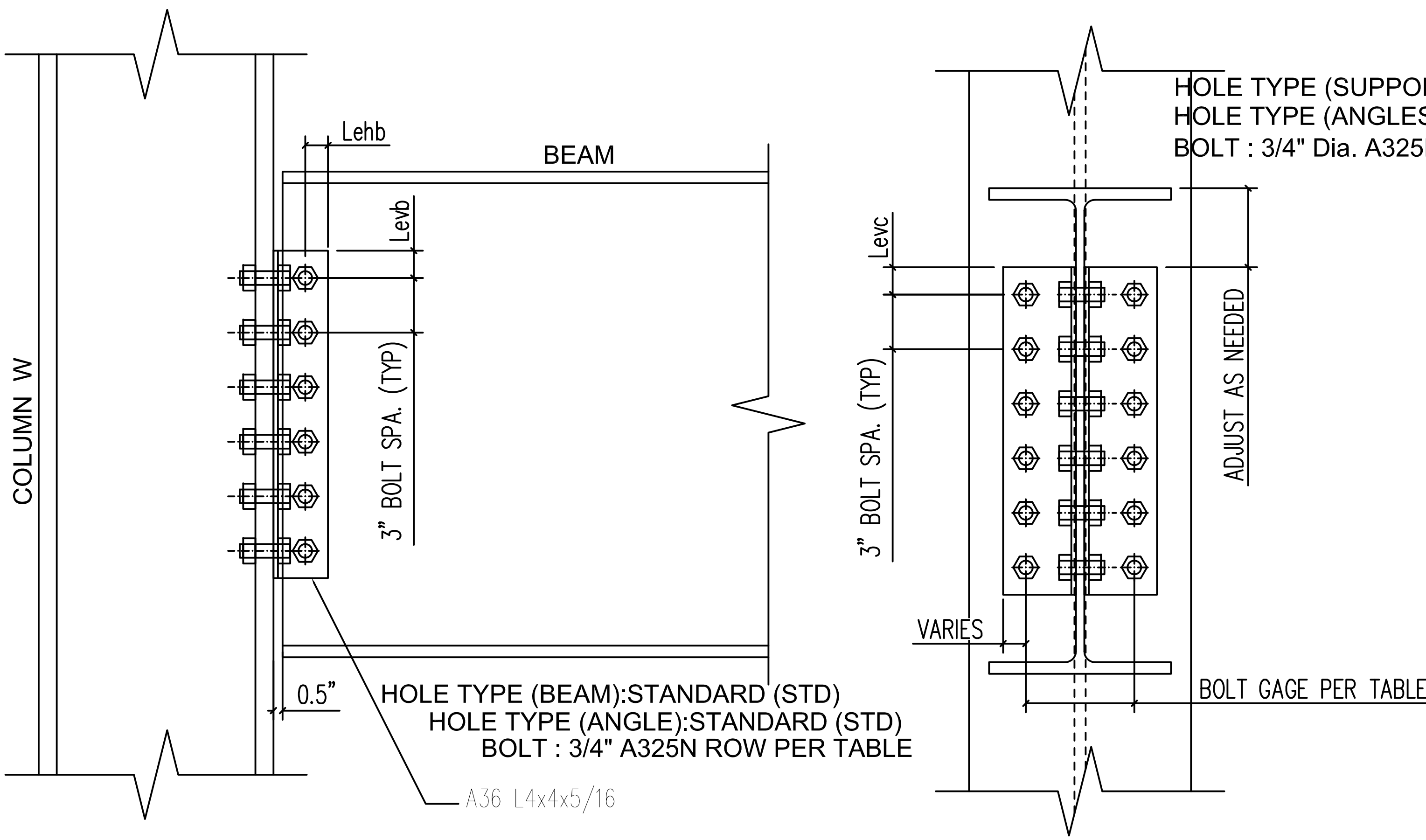
*Horizontal Short Slotted Hole on Angle Outstanding Legs against Support Column.

**Use L4X3 1/2x5/16 for Column W10x33,W10x39,W10x45, and W12x40. Short Angle Legs Agaist Column Flange. Bolt Gage =5". Use Stagger bolt pattern P=1.75 inch. See SC-03 Shear tab connection for connection detail if beam is not deep enough for stagger pattern.

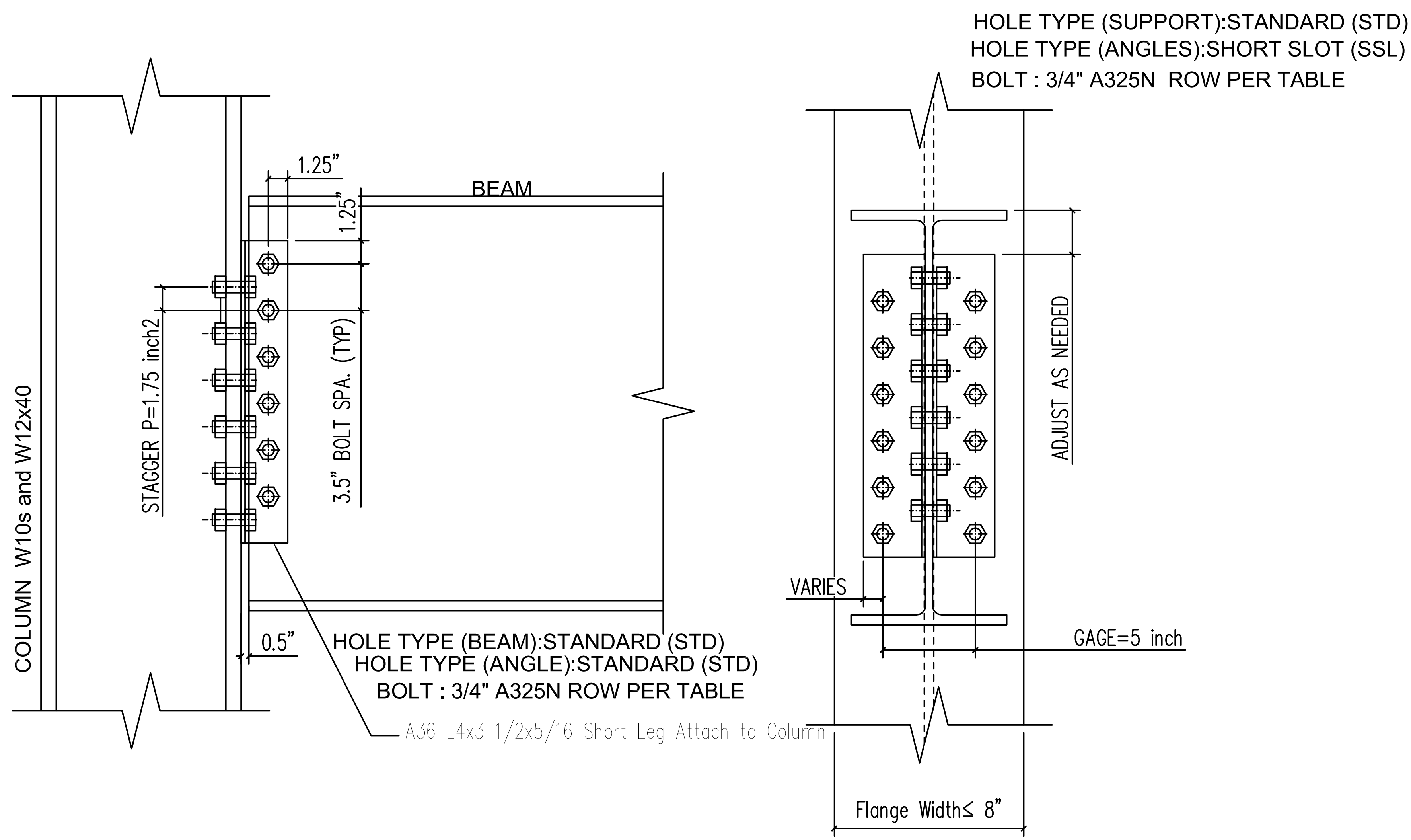
Horizontal SSL on supporting angles against column flanges

Date: 5/6/2016

SC-01F	Beam to WF Column Flange Double Angle Connection



SC-01F Beam to WF Column Flange Double Angle Connection



Current Date: 2016-05-05 9:48 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange2.cnx\

Steel connections

Results

Connection name : DA BCF All bolted

Connection ID : SC-01-1F

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W8x18

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	15.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	5.50	3.44	6.88	✔	p. 10-8
$L_{min} = T/2 = 6.88[\text{in}]/2 = \mathbf{3.44}[\text{in}]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 8.14[\text{in}] - \max(0.63[\text{in}], 0[\text{in}]) - \max(0.63[\text{in}], 0[\text{in}]) = \mathbf{6.88}[\text{in}]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[\text{in}] + 0[\text{in}] = \mathbf{1}[\text{in}]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.52	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.23$[in], 12 [in]$) =$ **5.52**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

<u>Angle (Support side)</u>

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

<u>Beam</u>

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

<u>Support</u>

Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

<u>Angle (Beam side)</u>

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	42.43	15.00	DL	0.35	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n)$ = 2 * (2*10.61[kip]) = **42.43**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	50.98	15.00	DL	0.29	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4* 0.75[in])*(2 - 1))*0.313[in]*58000[lb/in2]*1) = **50.98**[kip] — Eq. J3-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Kip]	49.50	15.00	DL	0.30	Eq. J4-3

$A_g = L_p*t_p$ = 5.5[in]*0.313[in] = **1.72**[in2] — Sec. D3-1

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*1.72[in2]) = **49.5**[kip] — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear rupture	[Kip]	40.78	15.00	DL	0.37	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 5.5[in] - 2*0.875[in] = **3.75**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 3.75[in]*0.313[in] = **1.17**[in2] — Sec. J4-2

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.17[in2]) = **40.78**[kip] — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear	[Kip]	43.41	15.00	DL	0.35	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)* 0.875[in])*0.313[in] = **0.254**[in2] — Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (2 - 1)*3[in])*0.313[in] = **1.33**[in2] — Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (2 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **0.918**[in2] — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

U_{bs} = 1 — Sec. J4-3

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*0.918[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]* 1.33[in2] + 1*58000[lb/in2]*0.254[in2])) = **43.41**[kip] — Eq. J4-5

<u>Angle (Support side)</u>

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	42.43	15.00	DL	0.35	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n)$ = 2 * (2*10.61[kip]) = **42.43**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	50.98	15.00	DL	0.29	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[\text{in}] - 0.813[\text{in}]/2) = \mathbf{0.844}[\text{in}]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[\text{in}] - 0.813[\text{in}]) = \mathbf{2.19}[\text{in}]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(2/(1*2))*(\min(1.2*0.844[\text{in}], 2.4*0.75[\text{in}]) + \min(1.2*2.19[\text{in}], 2.4*0.75[\text{in}])*(2 - 1))*0.313[\text{in}]*58000[\text{lb/in2}]*1) = \mathbf{50.98}[\text{kip}]$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 49.50 15.00 DL 0.30 Eq. J4-3

$A_g = L_p*t_p = 5.5[\text{in}]*0.313[\text{in}] = \mathbf{1.72}[\text{in2}]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[\text{lb/in2}]*1.72[\text{in2}]) = \mathbf{49.5}[\text{kip}]$ Eq. J4-3

Shear rupture [Kip] 40.78 15.00 DL 0.37 Eq. J4-4

$L_h = d_h + 1/16\ [\text{in}] = 0.813[\text{in}] + 1/16\ [\text{in}] = \mathbf{0.875}[\text{in}]$ Sec. D3-2

$L_e = L - n*L_h = 5.5[\text{in}] - 2*0.875[\text{in}] = \mathbf{3.75}[\text{in}]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 3.75[\text{in}]*0.313[\text{in}] = \mathbf{1.17}[\text{in2}]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[\text{lb/in2}]*1.17[\text{in2}]) = \mathbf{40.78}[\text{kip}]$ Eq. J4-4

Block shear [Kip] 39.45 15.00 DL 0.38 Eq. J4-5

$dh_h = d_h + 1/16\ [\text{in}] = 1[\text{in}] + 1/16\ [\text{in}] = \mathbf{1.06}[\text{in}]$ Sec. D3-2

$dh_v = d_h + 1/16\ [\text{in}] = 0.813[\text{in}] + 1/16\ [\text{in}] = \mathbf{0.875}[\text{in}]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[\text{in}] + (1 - 1)*5.5[\text{in}] - (1 - 0.5)*1.06[\text{in}])*0.313[\text{in}] = \mathbf{0.186}[\text{in2}]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[\text{in}] + (2 - 1)*3[\text{in}])*0.313[\text{in}] = \mathbf{1.33}[\text{in2}]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[\text{in}] + (2 - 1)*(3[\text{in}] - 0.875[\text{in}]) - 0.875[\text{in}]/2)*0.313[\text{in}] = \mathbf{0.918}[\text{in2}]$ Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[\text{lb/in2}]*0.918[\text{in2}] + 1*58000[\text{lb/in2}]*0.186[\text{in2}], 0.6*36000[\text{lb/in2}]*1.33[\text{in2}] + 1*58000[\text{lb/in2}]*0.186[\text{in2}])) = \mathbf{39.45}[\text{kip}]$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 8.65 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 15[\text{kip}]/(0.442[\text{in2}]*4) = \mathbf{8484.16}[\text{lb/in2}]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[\text{lb/in2}] - 90000[\text{lb/in2}]*8484.16[\text{lb/in2}]/(0.5*48000[\text{lb/in2}]), 0.0), 90000[\text{lb/in2}]) = \mathbf{85184.39}[\text{lb/in2}]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*85184.39[\text{lb/in2}]*0.442[\text{in2}] = \mathbf{18.83}[\text{kip}]$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 15[\text{kip}]/(0.442[\text{in2}]*4) = \mathbf{8484.16}[\text{lb/in2}]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[\text{lb/in2}] - 90000[\text{lb/in2}]*8484.16[\text{lb/in2}]/(0.5*48000[\text{lb/in2}]), 0.0), 90000[\text{lb/in2}]) = \mathbf{85184.39}[\text{lb/in2}]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*85184.39[\text{lb/in2}]*0.442[\text{in2}] = \mathbf{18.83}[\text{kip}]$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[\text{in}] + 0.75[\text{in}]/2, 1.25*2.22[\text{in}] + 0.75[\text{in}]/2) = \mathbf{1.5}[\text{in}]$ p. 9-12

$b' = b - d/2 = 2.22[\text{in}] - 0.75[\text{in}]/2 = \mathbf{1.84}[\text{in}]$ p. 9-12

$\rho = b'/a' = 1.84[\text{in}]/1.5[\text{in}] = \mathbf{1.23}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[\text{in}]/3[\text{in}] = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*18.83[\text{kip}]*1.84[\text{in}])/(0.5*3[\text{in}]*58000[\text{lb/}$

in2]))$^{0.5}$ = **1.15**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.23)))*((1.15[in]/0.313[in])^2 - 1) = **7.75** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta)$ = (0.313[in]/1.15[in])^2*(1 + 0.729) = **0.127** p. 9-13

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.22[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.22[in] - 0.75[in]/2 = **1.84**[in] p. 9-12

ρ = b'/a' = 1.84[in]/1.5[in] = **1.23** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/2.75[in] = **0.705** p. 9-11

t_c = ((3.33*B*b')/(($1/\Omega$)*p*F_u))$^{0.5}$ = ((3.33*18.83[kip]*1.84[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **1.2**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.23)))*((1.2[in]/0.313[in])^2 - 1) = **8.81** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta)$ = (0.313[in]/1.2[in])^2*(1 + 0.705) = **0.115** p. 9-13

HasEqualLengths → **False**

Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.115 + (2 - 2)*0.127)/2 = **0.115** p. 9-13

T_{avail} = 4 * (B*Q) = 4 * (18.83[kip]*0.115) = **8.65**[kip] p. 9-10

<u>Beam</u>

Bolt bearing under shear load	[Kip]	26.91	15.00	DL	0.56	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 2.57[in] - 0.813[in]/2) = **2.16**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = $(1/\Omega)$*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*2.16[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(2 - 1))*0.23[in]*65000[lb/in2]*1 = **26.91**[kip] Eq. J3-6

Shear yielding	[Kip]	37.44	15.00	DL	0.40	Eq. J4-3

A_g = L_p*t_p = 8.14[in]*0.23[in] = **1.87**[in2] Sec. D3-1

$(1/\Omega)R_n$ = $(1/\Omega)$*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*1.87[in2] = **37.44**[kip] Eq. J4-3

<u>Support</u>

Bolt bearing under shear load	[Kip]	145.08	15.00	DL	0.10	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($1/\Omega$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(2 - 1))*0.62[in]*65000[lb/in2]*1) = **145.08**[kip] Eq. J3-6

Global critical strength ratio **0.56**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-06 3:05 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange1.cnx\

Steel connections

Results

Connection name	:	**DA BCF All bolted**
Connection ID	:	**SC-01-2F**

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W10x17

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	15.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	5.50	4.42	8.84	✓	p. 10-8
$L_{min} = T/2 = 8.84[in]/2 = \mathbf{4.42}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 10.1[in] - \max(0.63[in], 0[in]) - \max(0.63[in], 0[in]) = \mathbf{8.84}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✓	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.76	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.24[in], 12 [in]) = **5.76**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0.125[in] = **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Support

Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

<u>Angle (Beam side)</u>

Bolts shear	[Kip]	42.43	15.00	DL	0.35	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$ — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (2*10.61\text{[kip]}) = \mathbf{42.43}\text{[kip]}$ — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	50.98	15.00	DL	0.29	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4* 0.75\text{[in]})*(2 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{50.98}\text{[kip]}$ — Eq. J3-6

Shear yielding	[Kip]	49.50	15.00	DL	0.30	Eq. J4-3

$A_g = L_p*t_p = 5.5\text{[in]}*0.313\text{[in]} = \mathbf{1.72}\text{[in2]}$ — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*1.72\text{[in2]}) = \mathbf{49.5}\text{[kip]}$ — Eq. J4-3

Shear rupture	[Kip]	40.78	15.00	DL	0.37	Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ — Sec. D3-2

$L_e = L - n*L_h = 5.5\text{[in]} - 2*0.875\text{[in]} = \mathbf{3.75}\text{[in]}$ — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 3.75\text{[in]}*0.313\text{[in]} = \mathbf{1.17}\text{[in2]}$ — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*1.17\text{[in2]}) = \mathbf{40.78}\text{[kip]}$ — Eq. J4-4

Block shear	[Kip]	43.41	15.00	DL	0.35	Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ — Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)* 0.875\text{[in]})*0.313\text{[in]} = \mathbf{0.254}\text{[in2]}$ — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (2 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{1.33}\text{[in2]}$ — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (2 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{0.918}\text{[in2]}$ — Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*0.918\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]}, 0.6*36000\text{[lb/in2]}* 1.33\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]})) = \mathbf{43.41}\text{[kip]}$ — Eq. J4-5

<u>Angle (Support side)</u>

Bolts shear	[Kip]	42.43	15.00	DL	0.35	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$ — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (2*10.61\text{[kip]}) = \mathbf{42.43}\text{[kip]}$ — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	50.98	15.00	DL	0.29	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(2/(1*2))*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(2 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{50.98}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	49.50	15.00	DL	0.30	Eq. J4-3

$A_g = L_p*t_p = 5.5\text{[in]}*0.313\text{[in]} = \mathbf{1.72}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*1.72\text{[in2]}) = \mathbf{49.5}\text{[kip]}$ Eq. J4-3

Shear rupture	[Kip]	40.78	15.00	DL	0.37	Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 5.5\text{[in]} - 2*0.875\text{[in]} = \mathbf{3.75}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 3.75\text{[in]}*0.313\text{[in]} = \mathbf{1.17}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*1.17\text{[in2]}) = \mathbf{40.78}\text{[kip]}$ Eq. J4-4

Block shear	[Kip]	39.45	15.00	DL	0.38	Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 1\text{[in]} + 1/16\text{ [in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13\text{[in]} + (1 - 1)*5.5\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.186}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (2 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{1.33}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (2 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{0.918}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*0.918\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]}, 0.6*36000\text{[lb/in2]}*1.33\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]})) = \mathbf{39.45}\text{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action	[Kip]	6.80	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 15\text{[kip]}/(0.442\text{[in2]}*4) = \mathbf{8484.16}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*8484.16\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{85184.39}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*85184.39\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{18.83}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 15\text{[kip]}/(0.442\text{[in2]}*4) = \mathbf{8484.16}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*8484.16\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{85184.39}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*85184.39\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{18.83}\text{[kip]}$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*18.83\text{[kip]}*2.34\text{[in]})/(0.5*3\text{[in]}*58000\text{[lb/}$

in2]))$^{0.5}$ = **1.3**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.3[in]/0.313[in])^2 - 1) = **8.72** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.3[in])^2*(1 + 0.729) = **0.1** p. 9-13

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

ρ = b'/a' = 2.34[in]/1.5[in] = **1.56** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/2.75[in] = **0.705** p. 9-11

t_c = ((3.33*B*b')/(($1/\Omega$)*p*F_u))$^{0.5}$ = ((3.33*18.83[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **1.36**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.36[in]/0.313[in])^2 - 1) = **9.9** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.36[in])^2*(1 + 0.705) = **0.0904** p. 9-13

HasEqualLengths → **False**

Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.0904 + (2 - 2)*0.1)/2 = **0.0904** p. 9-13

T_{avail} = 4 * (B*Q) = 4 * (18.83[kip]*0.0904) = **6.8**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	28.08	15.00	DL	0.53	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 3.55[in] - 0.813[in]/2) = **3.14**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

($1/\Omega$)R_n = ($1/\Omega$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*3.14[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(2 - 1))*0.24[in]*65000[lb/in2]*1 = **28.08**[kip] Eq. J3-6

Shear yielding	[Kip]	48.48	15.00	DL	0.31	Eq. J4-3

A_g = L_p*t_p = 10.1[in]*0.24[in] = **2.42**[in2] Sec. D3-1

($1/\Omega$)R_n = ($1/\Omega$)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*2.42[in2] = **48.48**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	210.60	15.00	DL	0.07	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

($1/\Omega$)R_n = 2 * (($1/\Omega$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(2 - 1))*0.9[in]*65000[lb/in2]*1) = **210.6**[kip] Eq. J3-6

Global critical strength ratio **0.53**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 9:44 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange2.cnx\

Steel connections

Results

Connection name : DA BCF All bolted

Connection ID : SC-01-3F

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W12x19

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	20.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	5.50	5.45	10.90	✔	p. 10-8
$L_{min} = T/2 = 10.9[in]/2 = \mathbf{5.45}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 12.2[in] - \max(0.65[in], 0[in]) - \max(0.65[in], 0[in]) = \mathbf{10.9}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.64	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.235[in], 12 [in]) = **5.64**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

<u>Angle (Support side)</u>

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0.125[in] = **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

<u>Beam</u>

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

<u>Support</u>

Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

<u>Angle (Beam side)</u>

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	42.43	20.00	DL	0.47	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = 2 * ($C*(1/\Omega)R_n$) = 2 * (2*10.61[kip]) = **42.43**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	50.98	20.00	DL	0.39	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*(min($k_1*L_{c\text{-}end}$, k_2*d) + min($k_1*L_{c\text{-}spa}$, k_2*d)*(n - 1))*
$t_p*F_u*n_c$) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*
0.75[in])*(2 - 1))*0.313[in]*58000[lb/in2]*1) = **50.98**[kip] — Eq. J3-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Kip]	49.50	20.00	DL	0.40	Eq. J4-3

$A_g = L_p*t_p$ = 5.5[in]*0.313[in] = **1.72**[in2] — Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)*0.60*F_y*A_g$) = 2 * (0.667*0.60*36000[lb/in2]*1.72[in2]) = **49.5**[kip] — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear rupture	[Kip]	40.78	20.00	DL	0.49	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 5.5[in] - 2*0.875[in] = **3.75**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 3.75[in]*0.313[in] = **1.17**[in2] — Sec. J4-2

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)*0.60*F_u*A_{nv}$) = 2 * (0.5*0.60*58000[lb/in2]*1.17[in2]) = **40.78**[kip] — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear	[Kip]	43.41	20.00	DL	0.46	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*
0.875[in])*0.313[in] = **0.254**[in2] — Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (2 - 1)*3[in])*0.313[in] = **1.33**[in2] — Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (2 - 1)*(3[in] - 0.875[in]) -
0.875[in]/2)*0.313[in] = **0.918**[in2] — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

U_{bs} = 1 — Sec. J4-3

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*min(0.6*F_u*A_{nv} + $U_{bs}*F_u*A_{nt}$, 0.6*F_y*A_{gv} + $U_{bs}*F_u*$
A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*0.918[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*
1.33[in2] + 1*58000[lb/in2]*0.254[in2])) = **43.41**[kip] — Eq. J4-5

<u>Angle (Support side)</u>

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	42.43	20.00	DL	0.47	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = 2 * ($C*(1/\Omega)R_n$) = 2 * (2*10.61[kip]) = **42.43**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	50.98	20.00	DL	0.39	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * ((1/Ω)*(C/(n_c*n))*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(2/(1*2))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(2 - 1))*0.313[in]*58000[lb/in2]*1) = **50.98**[kip] p. 7-18, Sec. J3.10

Shear yielding [Kip] 49.50 20.00 DL 0.40 Eq. J4-3

A_g = L_p*t_p = 5.5[in]*0.313[in] = **1.72**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ((1/Ω)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*1.72[in2]) = **49.5**[kip] Eq. J4-3

Shear rupture [Kip] 40.78 20.00 DL 0.49 Eq. J4-4

L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

L_e = L - n*L_h = 5.5[in] - 2*0.875[in] = **3.75**[in] DG4 Eq. 3-13

A_{nv} = L_e*t_p = 3.75[in]*0.313[in] = **1.17**[in2] Sec. J4-2

$(1/\Omega)R_n$ = 2 * ((1/Ω)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.17[in2]) = **40.78**[kip] Eq. J4-4

Block shear [Kip] 39.45 20.00 DL 0.51 Eq. J4-5

dh_h = d_h + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (2 - 1)*3[in])*0.313[in] = **1.33**[in2] Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (2 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **0.918**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n$ = 2 * ((1/Ω)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*0.918[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*1.33[in2] + 1*58000[lb/in2]*0.186[in2])) = **39.45**[kip] Eq. J4-5

Resulting tension capacity due prying action [Kip] 8.65 0.00 DL 0.00 p. 9-13, p. 9-10

f_v = F/(A_b*N_{bolts}) = 20[kip]/(0.442[in2]*4) = **11312.22**[lb/in2] Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/((1/Ω)*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*11312.22[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **74579.19**[lb/in2] Eq. J3-3

$(1/\Omega)R_n$ = (1/Ω)*F'_{nt}*A_b = 0.5*74579.19[lb/in2]*0.442[in2] = **16.48**[kip] Eq. J3-2

f_v = F/(A_b*N_{bolts}) = 20[kip]/(0.442[in2]*4) = **11312.22**[lb/in2] Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/((1/Ω)*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*11312.22[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **74579.19**[lb/in2] Eq. J3-3

$(1/\Omega)R_n$ = (1/Ω)*F'_{nt}*A_b = 0.5*74579.19[lb/in2]*0.442[in2] = **16.48**[kip] Eq. J3-2

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.22[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.22[in] - 0.75[in]/2 = **1.84**[in] p. 9-12

ρ = b'/a' = 1.84[in]/1.5[in] = **1.23** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/3[in] = **0.729** p. 9-11

t_c = ((3.33*B*b')/((1/Ω)*p*F_u))$^{0.5}$ = ((3.33*16.48[kip]*1.84[in])/(0.5*3[in]*58000[lb/

in2]))$^{0.5}$ = **1.08**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.23)))*((1.08[in]/0.313[in])^2 - 1) = **6.71** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.08[in])^2*(1 + 0.729) = **0.145** p. 9-13

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.22[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.22[in] - 0.75[in]/2 = **1.84**[in] p. 9-12

ρ = b'/a' = 1.84[in]/1.5[in] = **1.23** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/2.75[in] = **0.705** p. 9-11

t_c = ((3.33*B*b')/((1/Ω)*p*F_u))$^{0.5}$ = ((3.33*16.48[kip]*1.84[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **1.13**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.23)))*((1.13[in]/0.313[in])^2 - 1) = **7.64** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.13[in])^2*(1 + 0.705) = **0.131** p. 9-13

HasEqualLengths $\rightarrow$ **False**

Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.131 + (2 - 2)*0.145)/2 = **0.131** p. 9-13

T_{avail} = 4 * (B*Q) = 4 * (16.48[kip]*0.131) = **8.65**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	27.50	20.00	DL	0.73	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 4.6[in] - 0.813[in]/2) = **4.19**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = $(1/\Omega)$*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*4.19[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(2 - 1))*0.235[in]*65000[lb/in2]*1 = **27.5**[kip] Eq. J3-6

Shear yielding	[Kip]	57.34	20.00	DL	0.35	Eq. J4-3

A_g = L_p*t_p = 12.2[in]*0.235[in] = **2.87**[in2] Sec. D3-1

$(1/\Omega)R_n$ = $(1/\Omega)$*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*2.87[in2] = **57.34**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	101.79	20.00	DL	0.20	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($1/\Omega$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(2 - 1))*0.435[in]*65000[lb/in2]*1) = **101.79**[kip] Eq. J3-6

Global critical strength ratio **0.73**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-06 3:08 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange2.cnx\

Steel connections

Results

Connection name : DA BCF All bolted

Connection ID : SC-01-4F

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W14x22

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	25.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	8.50	6.11	12.23	✔	p. 10-8
$L_{min} = T/2 = 12.23[in]/2 = \mathbf{6.12}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 13.7[in] - \max(0.735[in], 0[in]) - \max(0.735[in], 0[in]) = \mathbf{12.23}[in]$						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.52	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $= \mathbf{2}$[in]						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.23$[in], 12 [in]$) = \mathbf{5.52}$[in]						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8$ [in]						p. 10-9
<u>Angle (Support side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $= \mathbf{1.13}$[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $= \mathbf{2}$[in]						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) = \mathbf{7.5}$[in]						Sec. J3.5
<u>Beam</u>						
Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5
<u>Support</u>						
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

<u>Angle (Beam side)</u>

Bolts shear	[Kip]	63.65	25.00	DL	0.39	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n)$ = 2 * (3*10.61[kip]) = **63.65**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	25.00	DL	0.30	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*
t_p*F_u*n_c) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*
0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] — Eq. J3-6

Shear yielding	[Kip]	76.50	25.00	DL	0.33	Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] — Sec. D3-1

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	63.89	25.00	DL	0.39	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 8.5[in] - 3*0.875[in] = **5.88**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 5.88[in]*0.313[in] = **1.84**[in2] — Sec. J4-2

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] — Eq. J4-4

Block shear	[Kip]	63.66	25.00	DL	0.39	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*
0.875[in])*0.313[in] = **0.254**[in2] — Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] — Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) -
0.875[in]/2)*0.313[in] = **1.58**[in2] — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

U_{bs} = 1 — Sec. J4-3

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*
A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*
2.27[in2] + 1*58000[lb/in2]*0.254[in2])) = **63.66**[kip] — Eq. J4-5

<u>Angle (Support side)</u>

Bolts shear	[Kip]	63.65	25.00	DL	0.39	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n)$ = 2 * (3*10.61[kip]) = **63.65**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	25.00	DL	0.30	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c)$ = 2 * (0.5*(3/(1*3))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] p. 7-18, Sec. J3.10

Shear yielding	[Kip]	76.50	25.00	DL	0.33	Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g)$ = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] Eq. J4-3

Shear rupture	[Kip]	63.89	25.00	DL	0.39	Eq. J4-4

$L_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$L_e = L - n*L_h$ = 8.5[in] - 3*0.875[in] = **5.88**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 5.88[in]*0.313[in] = **1.84**[in2] Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv})$ = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] Eq. J4-4

Block shear	[Kip]	59.70	25.00	DL	0.42	Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}))$ = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.186[in2])) = **59.7**[kip] Eq. J4-5

Resulting tension capacity due prying action	[Kip]	10.57	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts})$ = 25[kip]/(0.442[in2]*6) = **9426.85**[lb/in2] Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*9426.85[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **81649.32**[lb/in2] Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*81649.32[lb/in2]*0.442[in2] = **18.04**[kip] Eq. J3-2

$f_v = F/(A_b*N_{bolts})$ = 25[kip]/(0.442[in2]*6) = **9426.85**[lb/in2] Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*9426.85[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **81649.32**[lb/in2] Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*81649.32[lb/in2]*0.442[in2] = **18.04**[kip] Eq. J3-2

$a' = \text{Min}(a + d/2, 1.25*b + d/2)$ = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

$\rho = b'/a'$ = 2.34[in]/1.5[in] = **1.56** p. 9-12

$\delta = 1 - d'/p$ = 1 - 0.813[in]/3[in] = **0.729** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5}$ = ((3.33*18.04[kip]*2.34[in])/(0.5*3[in]*58000[lb/

$in2]))^{0.5} = \mathbf{1.27}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.27[in]/0.313[in])^2 - 1) =$
8.34 p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.27[in])^2*(1 + 0.729) = \mathbf{0.104}$ p. 9-13

$a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*18.04[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} = \mathbf{1.33}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.33[in]/0.313[in])^2 - 1) =$
9.46 p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.33[in])^2*(1 + 0.705) = \mathbf{0.0943}$ p. 9-13

$HasEqualLengths \rightarrow$ **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.0943 + (3 - 2)*0.104)/3 = \mathbf{0.0976}$ p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (18.04[kip]*0.0976) = \mathbf{10.57}[kip]$ p. 9-10

Beam

Bolt bearing under shear load	[Kip]	40.37	25.00	DL	0.62	Eq. J3-6

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 3.85[in] - 0.813[in]/2) = \mathbf{3.44}[in]$ Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*3.44[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.23[in]*65000[lb/in2]*1 = \mathbf{40.37}[kip]$ Eq. J3-6

Shear yielding	[Kip]	63.02	25.00	DL	0.40	Eq. J4-3

$A_g = L_p*t_p = 13.7[in]*0.23[in] = \mathbf{3.15}[in2]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*3.15[in2] = \mathbf{63.02}[kip]$ Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	235.17	25.00	DL	0.11	Eq. J3-6

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = \mathbf{1.20E+31}[in]$ Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.67[in]*65000[lb/in2]*1) = \mathbf{235.17}[kip]$ Eq. J3-6

Global critical strength ratio **0.62**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-06 3:10 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange2.cnx\

Steel connections

Results

Connection name : DA BCF All bolted

Connection ID : SC-01-5F

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W16x26

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	40.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	8.50	7.10	14.21	✔	p. 10-8

$L_{min} = T/2 = 14.21$[in]$/2 = \mathbf{7.1}$[in] — p. 10-8

$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 15.7$[in] $- \max(0.747$[in], 0[in]$) - \max(0.747$[in], 0[in]$) = \mathbf{14.21}$[in] — p. 10-8

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.00	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.25[in], 12\ [in]) = \mathbf{6}[in]$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8\ [in]$						p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0.125[in] = \mathbf{1.13}[in]$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.313[in], 12\ [in]) = \mathbf{7.5}[in]$						Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Support

Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

<u>Angle (Beam side)</u>

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	63.65	40.00	DL	0.63	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n)$ = 2 * (3*10.61[kip]) = **63.65**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	83.60	40.00	DL	0.48	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c)$ = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4* 0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] — Eq. J3-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Kip]	76.50	40.00	DL	0.52	Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g)$ = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear rupture	[Kip]	63.89	40.00	DL	0.63	Eq. J4-4

$L_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 8.5[in] - 3*0.875[in] = **5.88**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 5.88[in]*0.313[in] = **1.84**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv})$ = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear	[Kip]	63.66	40.00	DL	0.63	Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)* 0.875[in])*0.313[in] = **0.254**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt}))$ = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]* 2.27[in2] + 1*58000[lb/in2]*0.254[in2])) = **63.66**[kip] — Eq. J4-5

<u>Angle (Support side)</u>

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	63.65	40.00	DL	0.63	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n)$ = 2 * (3*10.61[kip]) = **63.65**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	83.60	40.00	DL	0.48	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(3 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{83.6}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 76.50 40.00 DL 0.52 Eq. J4-3

$A_g = L_p*t_p = 8.5\text{[in]}*0.313\text{[in]} = \mathbf{2.66}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*2.66\text{[in2]}) = \mathbf{76.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 63.89 40.00 DL 0.63 Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 8.5\text{[in]} - 3*0.875\text{[in]} = \mathbf{5.88}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88\text{[in]}*0.313\text{[in]} = \mathbf{1.84}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*1.84\text{[in2]}) = \mathbf{63.89}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 59.70 40.00 DL 0.67 Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 1\text{[in]} + 1/16\text{ [in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13\text{[in]} + (1 - 1)*5.5\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.186}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (3 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{2.27}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (3 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{1.58}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*1.58\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]}, 0.6*36000\text{[lb/in2]}*2.27\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]})) = \mathbf{59.7}\text{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 10.57 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 40\text{[kip]}/(0.442\text{[in2]}*6) = \mathbf{15082.96}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*15082.96\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{60438.91}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*60438.91\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{13.36}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 40\text{[kip]}/(0.442\text{[in2]}*6) = \mathbf{15082.96}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*15082.96\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{60438.91}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*60438.91\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{13.36}\text{[kip]}$ Eq. J3-2

$a' = \text{Min}(a + d/2, 1.25*b + d/2) = \text{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*13.36\text{[kip]}*2.34\text{[in]})/(0.5*3\text{[in]}*58000\text{[lb/}$

in2]))$^{0.5}$ = **1.09**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.09[in]/0.313[in])^2 - 1) = **6.03** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.09[in])^2*(1 + 0.729) = **0.141** p. 9-13

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

ρ = b'/a' = 2.34[in]/1.5[in] = **1.56** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/2.75[in] = **0.705** p. 9-11

t_c = ((3.33*B*b')/(($1/\Omega$)*p*F_u))$^{0.5}$ = ((3.33*13.36[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **1.14**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.14[in]/0.313[in])^2 - 1) = **6.86** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.14[in])^2*(1 + 0.705) = **0.127** p. 9-13

HasEqualLengths → **False**

Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.127 + (3 - 2)*0.141)/3 = **0.132** p. 9-13

T_{avail} = 6 * (B*Q) = 6 * (13.36[kip]*0.132) = **10.57**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	43.88	40.00	DL	0.91	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 4.85[in] - 0.813[in]/2) = **4.44**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

($1/\Omega$)R_n = ($1/\Omega$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*4.44[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.25[in]*65000[lb/in2]*1 = **43.88**[kip] Eq. J3-6

Shear yielding	[Kip]	78.50	40.00	DL	0.51	Eq. J4-3

A_g = L_p*t_p = 15.7[in]*0.25[in] = **3.93**[in2] Sec. D3-1

($1/\Omega$)R_n = ($1/\Omega$)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*3.93[in2] = **78.5**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	212.36	40.00	DL	0.19	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

($1/\Omega$)R_n = 2 * (($1/\Omega$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.605[in]*65000[lb/in2]*1) = **212.36**[kip] Eq. J3-6

Global critical strength ratio **0.91**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-06 3:12 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange2.cnx\

Steel connections

Results

Connection name : DA BCF All bolted

Connection ID : SC-01-6F

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W16x31

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	40.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	8.50	7.11	14.22	✔	p. 10-8
$L_{min} = T/2 = 14.22\text{[in]}/2 = \mathbf{7.11}\text{[in]}$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 15.9\text{[in]} - \max(0.842\text{[in]}, 0\text{[in]}) - \max(0.842\text{[in]}, 0\text{[in]}) = \mathbf{14.22}\text{[in]}$						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.60	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in]						Sec. J3.3
IsCorrosionConsidered → **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.275$[in], 12 [in]$) =$ **6.6**[in]						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8$ [in]						p. 10-9

<u>Angle (Support side)</u>

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in]						Sec. J3.3
IsCorrosionConsidered → **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in]						Sec. J3.5

<u>Beam</u>

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5

<u>Support</u>

Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

<u>Angle (Beam side)</u>

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	63.65	40.00	DL	0.63	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[\mathrm{lb/in2}]*0.442[\mathrm{in2}] = \mathbf{10.61}[\mathrm{kip}]$ — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61[\mathrm{kip}]) = \mathbf{63.65}[\mathrm{kip}]$ — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	83.60	40.00	DL	0.48	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[\mathrm{in}] - 0.813[\mathrm{in}]/2) = \mathbf{0.844}[\mathrm{in}]$ — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[\mathrm{in}] - 0.813[\mathrm{in}]) = \mathbf{2.19}[\mathrm{in}]$ — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844[\mathrm{in}], 2.4*0.75[\mathrm{in}]) + \min(1.2*2.19[\mathrm{in}], 2.4* 0.75[\mathrm{in}])*(3 - 1))*0.313[\mathrm{in}]*58000[\mathrm{lb/in2}]*1) = \mathbf{83.6}[\mathrm{kip}]$ — Eq. J3-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Kip]	76.50	40.00	DL	0.52	Eq. J4-3

$A_g = L_p*t_p = 8.5[\mathrm{in}]*0.313[\mathrm{in}] = \mathbf{2.66}[\mathrm{in2}]$ — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[\mathrm{lb/in2}]*2.66[\mathrm{in2}]) = \mathbf{76.5}[\mathrm{kip}]$ — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear rupture	[Kip]	63.89	40.00	DL	0.63	Eq. J4-4

$L_h = d_h + 1/16\ [\mathrm{in}] = 0.813[\mathrm{in}] + 1/16\ [\mathrm{in}] = \mathbf{0.875}[\mathrm{in}]$ — Sec. D3-2

$L_e = L - n*L_h = 8.5[\mathrm{in}] - 3*0.875[\mathrm{in}] = \mathbf{5.88}[\mathrm{in}]$ — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88[\mathrm{in}]*0.313[\mathrm{in}] = \mathbf{1.84}[\mathrm{in2}]$ — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[\mathrm{lb/in2}]*1.84[\mathrm{in2}]) = \mathbf{63.89}[\mathrm{kip}]$ — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear	[Kip]	63.66	40.00	DL	0.63	Eq. J4-5

$dh_h = d_h + 1/16\ [\mathrm{in}] = 0.813[\mathrm{in}] + 1/16\ [\mathrm{in}] = \mathbf{0.875}[\mathrm{in}]$ — Sec. D3-2

$dh_v = d_h + 1/16\ [\mathrm{in}] = 0.813[\mathrm{in}] + 1/16\ [\mathrm{in}] = \mathbf{0.875}[\mathrm{in}]$ — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[\mathrm{in}] + (1 - 1)*3[\mathrm{in}] - (1 - 0.5)* 0.875[\mathrm{in}])*0.313[\mathrm{in}] = \mathbf{0.254}[\mathrm{in2}]$ — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[\mathrm{in}] + (3 - 1)*3[\mathrm{in}])*0.313[\mathrm{in}] = \mathbf{2.27}[\mathrm{in2}]$ — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[\mathrm{in}] + (3 - 1)*(3[\mathrm{in}] - 0.875[\mathrm{in}]) - 0.875[\mathrm{in}]/2)*0.313[\mathrm{in}] = \mathbf{1.58}[\mathrm{in2}]$ — Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt})) = 2 * (0.5*\min(0.6*58000[\mathrm{lb/in2}]*1.58[\mathrm{in2}] + 1*58000[\mathrm{lb/in2}]*0.254[\mathrm{in2}], 0.6*36000[\mathrm{lb/in2}]* 2.27[\mathrm{in2}] + 1*58000[\mathrm{lb/in2}]*0.254[\mathrm{in2}])) = \mathbf{63.66}[\mathrm{kip}]$ — Eq. J4-5

<u>Angle (Support side)</u>

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	63.65	40.00	DL	0.63	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[\mathrm{lb/in2}]*0.442[\mathrm{in2}] = \mathbf{10.61}[\mathrm{kip}]$ — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61[\mathrm{kip}]) = \mathbf{63.65}[\mathrm{kip}]$ — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	83.60	40.00	DL	0.48	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(3 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{83.6}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 76.50 40.00 DL 0.52 Eq. J4-3

$A_g = L_p*t_p = 8.5\text{[in]}*0.313\text{[in]} = \mathbf{2.66}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*2.66\text{[in2]}) = \mathbf{76.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 63.89 40.00 DL 0.63 Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 8.5\text{[in]} - 3*0.875\text{[in]} = \mathbf{5.88}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88\text{[in]}*0.313\text{[in]} = \mathbf{1.84}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*1.84\text{[in2]}) = \mathbf{63.89}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 59.70 40.00 DL 0.67 Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 1\text{[in]} + 1/16\text{ [in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13\text{[in]} + (1 - 1)*5.5\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.186}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (3 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{2.27}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (3 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{1.58}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*1.58\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]}, 0.6*36000\text{[lb/in2]}*2.27\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]})) = \mathbf{59.7}\text{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 10.57 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 40\text{[kip]}/(0.442\text{[in2]}*6) = \mathbf{15082.96}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*15082.96\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{60438.91}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*60438.91\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{13.36}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 40\text{[kip]}/(0.442\text{[in2]}*6) = \mathbf{15082.96}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*15082.96\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{60438.91}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*60438.91\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{13.36}\text{[kip]}$ Eq. J3-2

$a' = \text{Min}(a + d/2, 1.25*b + d/2) = \text{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*13.36\text{[kip]}*2.34\text{[in]})/(0.5*3\text{[in]}*58000\text{[lb/}$

in2]))$^{0.5}$ = **1.09**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.09[in]/0.313[in])^2 - 1) = **6.03** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.09[in])^2*(1 + 0.729) = **0.141** p. 9-13

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

ρ = b'/a' = 2.34[in]/1.5[in] = **1.56** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/2.75[in] = **0.705** p. 9-11

t_c = ((3.33*B*b')/((1/Ω)*p*F_u))$^{0.5}$ = ((3.33*13.36[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **1.14**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.14[in]/0.313[in])^2 - 1) = **6.86** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.14[in])^2*(1 + 0.705) = **0.127** p. 9-13

HasEqualLengths → **False**

Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.127 + (3 - 2)*0.141)/3 = **0.132** p. 9-13

T_{avail} = 6 * (B*Q) = 6 * (13.36[kip]*0.132) = **10.57**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	48.26	40.00	DL	0.83	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 4.95[in] - 0.813[in]/2) = **4.54**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

(1/Ω)R_n = (1/Ω)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*4.54[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.275[in]*65000[lb/in2]*1 = **48.26**[kip] Eq. J3-6

Shear yielding	[Kip]	87.45	40.00	DL	0.46	Eq. J4-3

A_g = L_p*t_p = 15.9[in]*0.275[in] = **4.37**[in2] Sec. D3-1

(1/Ω)R_n = (1/Ω)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*4.37[in2] = **87.45**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	224.64	40.00	DL	0.18	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

(1/Ω)R_n = 2 * ((1/Ω)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.64[in]*65000[lb/in2]*1) = **224.64**[kip] Eq. J3-6

Global critical strength ratio **0.83**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 10:00 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange3.cnx\

Steel connections

Results

Connection name : DA BCF All bolted
Connection ID : SC-01-7F

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W16x31

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	60.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	11.50	7.11	14.22	✔	p. 10-8
$L_{min} = T/2 = 14.22$[in]$/2 = \mathbf{7.11}$[in]						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 15.9$[in] $- \max(0.842$[in], 0[in]$) - \max(0.842$[in], 0[in]$) = \mathbf{14.22}$[in]						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.60	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in]						Sec. J3.3
IsCorrosionConsidered → **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.275$[in]$, 12$ [in]$) =$ **6.6**[in]						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8$ [in]						p. 10-9
<u>Angle (Support side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in]						Sec. J3.3
IsCorrosionConsidered → **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in]$, 12$ [in]$) =$ **7.5**[in]						Sec. J3.5
<u>Beam</u>						
Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
<u>Support</u>						
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Angle (Beam side)</u>						
Bolts shear	[Kip]	84.86	60.00	DL	0.71	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$						Eq. J3-1
$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61[kip]) = \mathbf{84.86}[kip]$						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	116.23	60.00	DL	0.52	Eq. J3-6
$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$						Sec. J4.10
$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$						Sec. J4.10
$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4* 0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{116.23}[kip]$						Eq. J3-6
Shear yielding	[Kip]	103.50	60.00	DL	0.58	Eq. J4-3
$A_g = L_p*t_p = 11.5[in]*0.313[in] = \mathbf{3.59}[in2]$						Sec. D3-1
$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = \mathbf{103.5}[kip]$						Eq. J4-3
Shear rupture	[Kip]	87.00	60.00	DL	0.69	Eq. J4-4
$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$						Sec. D3-2
$L_e = L - n*L_h = 11.5[in] - 4*0.875[in] = \mathbf{8}[in]$						DG4 Eq. 3-13
$A_{nv} = L_e*t_p = 8[in]*0.313[in] = \mathbf{2.5}[in2]$						Sec. J4-2
$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = \mathbf{87}[kip]$						Eq. J4-4
Block shear	[Kip]	83.91	60.00	DL	0.72	Eq. J4-5
$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$						Sec. D3-2
$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$						Sec. D3-2
$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)* 0.875[in])*0.313[in] = \mathbf{0.254}[in2]$						Sec. J4-3
$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (4 - 1)*3[in])*0.313[in] = \mathbf{3.2}[in2]$						Sec. J4-3
$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{2.25}[in2]$						Sec. J4-3
$IsStressUniform \rightarrow$ **True**						
$U_{bs} = 1$						Sec. J4-3
$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]* 3.2[in2] + 1*58000[lb/in2]*0.254[in2])) = \mathbf{83.91}[kip]$						Eq. J4-5
<u>Angle (Support side)</u>						
Bolts shear	[Kip]	84.86	60.00	DL	0.71	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$						Eq. J3-1
$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61[kip]) = \mathbf{84.86}[kip]$						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	116.23	60.00	DL	0.52	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(4/(1*4))*(min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(4 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{116.23}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 103.50 60.00 DL 0.58 Eq. J4-3

$A_g = L_p*t_p = 11.5\text{[in]}*0.313\text{[in]} = \mathbf{3.59}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*3.59\text{[in2]}) = \mathbf{103.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 87.00 60.00 DL 0.69 Eq. J4-4

$L_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 11.5\text{[in]} - 4*0.875\text{[in]} = \mathbf{8}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8\text{[in]}*0.313\text{[in]} = \mathbf{2.5}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*2.5\text{[in2]}) = \mathbf{87}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 79.95 60.00 DL 0.75 Eq. J4-5

$dh_h = d_h + 1/16\ \text{[in]} = 1\text{[in]} + 1/16\ \text{[in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13\text{[in]} + (1 - 1)*5.5\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.186}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (4 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{3.2}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (4 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{2.25}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000\text{[lb/in2]}*2.25\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]}, 0.6*36000\text{[lb/in2]}*3.2\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]})) = \mathbf{79.95}\text{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 14.33 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 60\text{[kip]}/(0.442\text{[in2]}*8) = \mathbf{16968.33}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*16968.33\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{53368.78}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*53368.78\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{11.79}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 60\text{[kip]}/(0.442\text{[in2]}*8) = \mathbf{16968.33}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*16968.33\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{53368.78}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*53368.78\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{11.79}\text{[kip]}$ Eq. J3-2

$a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*11.79\text{[kip]}*2.34\text{[in]})/(0.5*3\text{[in]}*58000\text{[lb/}$

in2]))$^{0.5}$ = **1.03**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.03[in]/0.313[in])^2 - 1) = **5.26** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.03[in])^2*(1 + 0.729) = **0.16** p. 9-13

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

ρ = b'/a' = 2.34[in]/1.5[in] = **1.56** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/2.75[in] = **0.705** p. 9-11

t_c = ((3.33*B*b')/((1/Ω)*p*F_u))$^{0.5}$ = ((3.33*11.79[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **1.07**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.07[in]/0.313[in])^2 - 1) = **5.99** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.07[in])^2*(1 + 0.705) = **0.144** p. 9-13

HasEqualLengths $\rightarrow$ **False**

Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.144 + (4 - 2)*0.16)/4 = **0.152** p. 9-13

T_{avail} = 8 * (B*Q) = 8 * (11.79[kip]*0.152) = **14.33**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	64.35	60.00	DL	0.93	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 3.45[in] - 0.813[in]/2) = **3.04**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

(1/Ω)R_n = (1/Ω)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*3.04[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.275[in]*65000[lb/in2]*1 = **64.35**[kip] Eq. J3-6

Shear yielding	[Kip]	87.45	60.00	DL	0.69	Eq. J4-3

A_g = L_p*t_p = 15.9[in]*0.275[in] = **4.37**[in2] Sec. D3-1

(1/Ω)R_n = (1/Ω)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*4.37[in2] = **87.45**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	262.08	60.00	DL	0.23	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

(1/Ω)R_n = 2 * ((1/Ω)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.56[in]*65000[lb/in2]*1) = **262.08**[kip] Eq. J3-6

Global critical strength ratio **0.93**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 9:29 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange1.cnx\

Steel connections

Results

Connection name : DA BCF All bolted

Connection ID : SC-01-8F

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W18x35

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	30.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	8.50	8.02	16.05	✔	p. 10-8
$L_{min} = T/2 = 16.05[in]/2 = \mathbf{8.02}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 17.7[in] - \max(0.827[in], 0[in]) - \max(0.827[in], 0[in]) = \mathbf{16.05}[in]$						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.00	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.00	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.20	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.3$[in], 12 [in]$) =$ **7.2**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Beam

Horizontal edge distance	[in]	2.50	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Support

Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Angle (Beam side)</u>						
Bolts shear	[Kip]	63.65	30.00	DL	0.47	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$						Eq. J3-1
$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61[kip]) = \mathbf{63.65}[kip]$						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	78.16	30.00	DL	0.38	Eq. J3-6
$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1[in] - 0.813[in]/2) = \mathbf{0.594}[in]$						Sec. J4.10
$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$						Sec. J4.10
$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*$ $t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.594[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*$ $0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{78.16}[kip]$						Eq. J3-6
Shear yielding	[Kip]	76.50	30.00	DL	0.39	Eq. J4-3
$A_g = L_p*t_p = 8.5[in]*0.313[in] = \mathbf{2.66}[in2]$						Sec. D3-1
$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = \mathbf{76.5}[kip]$						Eq. J4-3
Shear rupture	[Kip]	63.89	30.00	DL	0.47	Eq. J4-4
$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$						Sec. D3-2
$L_e = L - n*L_h = 8.5[in] - 3*0.875[in] = \mathbf{5.88}[in]$						DG4 Eq. 3-13
$A_{nv} = L_e*t_p = 5.88[in]*0.313[in] = \mathbf{1.84}[in2]$						Sec. J4-2
$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = \mathbf{63.89}[kip]$						Eq. J4-4
Block shear	[Kip]	57.45	30.00	DL	0.52	Eq. J4-5
$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$						Sec. D3-2
$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$						Sec. D3-2
$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1[in] + (1 - 1)*3[in] - (1 - 0.5)*$ $0.875[in])*0.313[in] = \mathbf{0.176}[in2]$						Sec. J4-3
$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1[in] + (3 - 1)*3[in])*0.313[in] = \mathbf{2.19}[in2]$						Sec. J4-3
$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1[in] + (3 - 1)*(3[in] - 0.875[in]) -$ $0.875[in]/2)*0.313[in] = \mathbf{1.5}[in2]$						Sec. J4-3
$IsStressUniform \rightarrow$ **True**						
$U_{bs} = 1$						Sec. J4-3
$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*$ $A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*1.5[in2] + 1*58000[lb/in2]*0.176[in2], 0.6*36000[lb/in2]*$ $2.19[in2] + 1*58000[lb/in2]*0.176[in2])) = \mathbf{57.45}[kip]$						Eq. J4-5
<u>Angle (Support side)</u>						
Bolts shear	[Kip]	63.65	30.00	DL	0.47	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$						Eq. J3-1
$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61[kip]) = \mathbf{63.65}[kip]$						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	83.60	30.00	DL	0.36	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*(C/(n_c*n))*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] p. 7-18, Sec. J3.10

Shear yielding	[Kip]	76.50	30.00	DL	0.39		Eq. J4-3

A_g = L_p*t_p = 8.5[in]*0.313[in] = **2.66**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] Eq. J4-3

Shear rupture	[Kip]	63.89	30.00	DL	0.47		Eq. J4-4

L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

L_e = L - n*L_h = 8.5[in] - 3*0.875[in] = **5.88**[in] DG4 Eq. 3-13

A_{nv} = L_e*t_p = 5.88[in]*0.313[in] = **1.84**[in2] Sec. J4-2

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] Eq. J4-4

Block shear	[Kip]	59.70	30.00	DL	0.50		Eq. J4-5

dh_h = d_h + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.186[in2])) = **59.7**[kip] Eq. J4-5

Resulting tension capacity due prying action	[Kip]	10.57	0.00	DL	0.00		p. 9-13, p. 9-10

f_v = F/(A_b*N_{bolts}) = 30[kip]/(0.442[in2]*6) = **11312.22**[lb/in2] Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/($(1/\Omega)$*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*11312.22[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **74579.19**[lb/in2] Eq. J3-3

$(1/\Omega)R_n$ = $(1/\Omega)$*F'_{nt}*A_b = 0.5*74579.19[lb/in2]*0.442[in2] = **16.48**[kip] Eq. J3-2

f_v = F/(A_b*N_{bolts}) = 30[kip]/(0.442[in2]*6) = **11312.22**[lb/in2] Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/($(1/\Omega)$*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*11312.22[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **74579.19**[lb/in2] Eq. J3-3

$(1/\Omega)R_n$ = $(1/\Omega)$*F'_{nt}*A_b = 0.5*74579.19[lb/in2]*0.442[in2] = **16.48**[kip] Eq. J3-2

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

ρ = b'/a' = 2.34[in]/1.5[in] = **1.56** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/3[in] = **0.729** p. 9-11

t_c = ((3.33*B*b')/($(1/\Omega)$*p*F_u))$^{0.5}$ = ((3.33*16.48[kip]*2.34[in])/(0.5*3[in]*58000[lb/

in2]))$^{0.5}$ = **1.22**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.22[in]/0.313[in])^2 - 1) = **7.57** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.22[in])^2*(1 + 0.729) = **0.114** p. 9-13

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

ρ = b'/a' = 2.34[in]/1.5[in] = **1.56** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/2.75[in] = **0.705** p. 9-11

t_c = ((3.33*B*b')/((1/Ω)*p*F_u))$^{0.5}$ = ((3.33*16.48[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **1.27**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.27[in]/0.313[in])^2 - 1) = **8.59** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.27[in])^2*(1 + 0.705) = **0.103** p. 9-13

HasEqualLengths → **False**

Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.103 + (3 - 2)*0.114)/3 = **0.107** p. 9-13

T_{avail} = 6 * (B*Q) = 6 * (16.48[kip]*0.107) = **10.57**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	52.65	30.00	DL	0.57	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 5.6[in] - 0.813[in]/2) = **5.19**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = $(1/\Omega)$*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*5.19[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.3[in]*65000[lb/in2]*1 = **52.65**[kip] Eq. J3-6

Shear yielding	[Kip]	106.20	30.00	DL	0.28	Eq. J4-3

A_g = L_p*t_p = 17.7[in]*0.3[in] = **5.31**[in2] Sec. D3-1

$(1/\Omega)R_n$ = $(1/\Omega)$*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*5.31[in2] = **106.2**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	315.90	30.00	DL	0.09	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($1/\Omega$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.9[in]*65000[lb/in2]*1) = **315.9**[kip] Eq. J3-6

Global critical strength ratio **0.57**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 9:54 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange3.cnx\

Steel connections

Results

Connection name	**:**	**DA BCF All bolted**
Connection ID	**:**	**SC-01-9F**

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W18x35

Design code: AISC 360-05 ASD

DEMANDS

Description	**Ru** [Kip]	**Pu** [Kip]	**Load type**
DL	60.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
Angle						
Length	[in]	11.50	8.02	16.05	✔	p. 10-8
$L_{min} = T/2 = 16.05[in]/2 = \mathbf{8.02}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 17.7[in] - \max(0.827[in], 0[in]) - \max(0.827[in], 0[in]) = \mathbf{16.05}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.20	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.3[in], 12 [in]) = **7.2**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0.125[in] = **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Support

Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Angle (Beam side)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	84.86	60.00	DL	0.71	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61[kip]) = \mathbf{84.86}[kip]$ — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	116.23	60.00	DL	0.52	Eq. J3-6

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ — Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4* 0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{116.23}[kip]$ — Eq. J3-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Kip]	103.50	60.00	DL	0.58	Eq. J4-3

$A_g = L_p*t_p = 11.5[in]*0.313[in] = \mathbf{3.59}[in2]$ — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = \mathbf{103.5}[kip]$ — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear rupture	[Kip]	87.00	60.00	DL	0.69	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ — Sec. D3-2

$L_e = L - n*L_h = 11.5[in] - 4*0.875[in] = \mathbf{8}[in]$ — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8[in]*0.313[in] = \mathbf{2.5}[in2]$ — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = \mathbf{87}[kip]$ — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear	[Kip]	83.91	60.00	DL	0.72	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ — Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)* 0.875[in])*0.313[in] = \mathbf{0.254}[in2]$ — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (4 - 1)*3[in])*0.313[in] = \mathbf{3.2}[in2]$ — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{2.25}[in2]$ — Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]* 3.2[in2] + 1*58000[lb/in2]*0.254[in2])) = \mathbf{83.91}[kip]$ — Eq. J4-5

Angle (Support side)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	84.86	60.00	DL	0.71	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61[kip]) = \mathbf{84.86}[kip]$ — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	116.23	60.00	DL	0.52	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * ((1/Ω)*(C/(n_c*n))*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(4/(1*4))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = **116.23**[kip] p. 7-18, Sec. J3.10

Shear yielding	[Kip]	103.50	60.00	DL	0.58	Eq. J4-3

A_g = L_p*t_p = 11.5[in]*0.313[in] = **3.59**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ((1/Ω)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = **103.5**[kip] Eq. J4-3

Shear rupture	[Kip]	87.00	60.00	DL	0.69	Eq. J4-4

L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

L_e = L - n*L_h = 11.5[in] - 4*0.875[in] = **8**[in] DG4 Eq. 3-13

A_{nv} = L_e*t_p = 8[in]*0.313[in] = **2.5**[in2] Sec. J4-2

$(1/\Omega)R_n$ = 2 * ((1/Ω)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = **87**[kip] Eq. J4-4

Block shear	[Kip]	79.95	60.00	DL	0.75	Eq. J4-5

dh_h = d_h + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (4 - 1)*3[in])*0.313[in] = **3.2**[in2] Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.25**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n$ = 2 * ((1/Ω)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*3.2[in2] + 1*58000[lb/in2]*0.186[in2])) = **79.95**[kip] Eq. J4-5

Resulting tension capacity due prying action	[Kip]	14.33	0.00	DL	0.00	p. 9-13, p. 9-10

f_v = F/(A_b*N_{bolts}) = 60[kip]/(0.442[in2]*8) = **16968.33**[lb/in2] Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/((1/Ω)*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*16968.33[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **53368.78**[lb/in2] Eq. J3-3

$(1/\Omega)R_n$ = (1/Ω)*F'_{nt}*A_b = 0.5*53368.78[lb/in2]*0.442[in2] = **11.79**[kip] Eq. J3-2

f_v = F/(A_b*N_{bolts}) = 60[kip]/(0.442[in2]*8) = **16968.33**[lb/in2] Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/((1/Ω)*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*16968.33[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **53368.78**[lb/in2] Eq. J3-3

$(1/\Omega)R_n$ = (1/Ω)*F'_{nt}*A_b = 0.5*53368.78[lb/in2]*0.442[in2] = **11.79**[kip] Eq. J3-2

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

ρ = b'/a' = 2.34[in]/1.5[in] = **1.56** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/3[in] = **0.729** p. 9-11

t_c = ((3.33*B*b')/((1/Ω)*p*F_u))$^{0.5}$ = ((3.33*11.79[kip]*2.34[in])/(0.5*3[in]*58000[lb/

in2]))$^{0.5}$ = **1.03**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.03[in]/0.313[in])^2 - 1) = **5.26** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.03[in])^2*(1 + 0.729) = **0.16** p. 9-13

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

ρ = b'/a' = 2.34[in]/1.5[in] = **1.56** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/2.75[in] = **0.705** p. 9-11

t_c = ((3.33*B*b')/(($1/\Omega$)*p*F_u))$^{0.5}$ = ((3.33*11.79[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **1.07**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.07[in]/0.313[in])^2 - 1) = **5.99** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.07[in])^2*(1 + 0.705) = **0.144** p. 9-13

HasEqualLengths → **False**

Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.144 + (4 - 2)*0.16)/4 = **0.152** p. 9-13

T_{avail} = 8 * (B*Q) = 8 * (11.79[kip]*0.152) = **14.33**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	70.20	60.00	DL	0.85	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 4.35[in] - 0.813[in]/2) = **3.94**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = $(1/\Omega)$*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*3.94[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.3[in]*65000[lb/in2]*1 = **70.2**[kip] Eq. J3-6

Shear yielding	[Kip]	106.20	60.00	DL	0.56	Eq. J4-3

A_g = L_p*t_p = 17.7[in]*0.3[in] = **5.31**[in2] Sec. D3-1

$(1/\Omega)R_n$ = $(1/\Omega)$*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*5.31[in2] = **106.2**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	262.08	60.00	DL	0.23	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($1/\Omega$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.56[in]*65000[lb/in2]*1) = **262.08**[kip] Eq. J3-6

Global critical strength ratio **0.85**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 9:27 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange1.cnx\

Steel connections

Results

Connection name : DA BCF All bolted

Connection ID : SC-01-10F

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W18x65

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	75.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	14.50	8.05	16.10	✔	p. 10-8
$L_{min} = T/2 = 16.1[in]/2 = \mathbf{8.05}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 18.4[in] - \max(1.15[in], 0[in]) - \max(1.15[in], 0[in]) = \mathbf{16.1}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in]						Sec. J3.3
IsCorrosionConsidered → **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in]						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8$ [in]						p. 10-9
<u>Angle (Support side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in]						Sec. J3.3
IsCorrosionConsidered → **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in]						Sec. J3.5
<u>Beam</u>						
Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
<u>Support</u>						
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

<u>Angle (Beam side)</u>

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	106.08	75.00	DL	0.71	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = 2 * ($C*(1/\Omega)R_n$) = 2 * (5*10.61[kip]) = **106.08**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	148.85	75.00	DL	0.50	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*(min($k_1*L_{c\text{-}end}$, k_2*d) + min($k_1*L_{c\text{-}spa}$, k_2*d)*(n - 1))*
$t_p*F_u*n_c$) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*
0.75[in])*(5 - 1))*0.313[in]*58000[lb/in2]*1) = **148.85**[kip] — Eq. J3-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Kip]	130.50	75.00	DL	0.57	Eq. J4-3

$A_g = L_p*t_p$ = 14.5[in]*0.313[in] = **4.53**[in2] — Sec. D3-1

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*4.53[in2]) = **130.5**[kip] — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear rupture	[Kip]	110.11	75.00	DL	0.68	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 14.5[in] - 5*0.875[in] = **10.13**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 10.13[in]*0.313[in] = **3.16**[in2] — Sec. J4-2

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*3.16[in2]) = **110.11**[kip] — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear	[Kip]	104.16	75.00	DL	0.72	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*
0.875[in])*0.313[in] = **0.254**[in2] — Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (5 - 1)*3[in])*0.313[in] = **4.14**[in2] — Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (5 - 1)*(3[in] - 0.875[in]) -
0.875[in]/2)*0.313[in] = **2.91**[in2] — Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 — Sec. J4-3

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*min(0.6*F_u*A_{nv} + $U_{bs}*F_u*A_{nt}$, 0.6*F_y*A_{gv} + $U_{bs}*F_u$*
A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*2.91[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*
4.14[in2] + 1*58000[lb/in2]*0.254[in2])) = **104.16**[kip] — Eq. J4-5

<u>Angle (Support side)</u>

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	106.08	75.00	DL	0.71	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = 2 * ($C*(1/\Omega)R_n$) = 2 * (5*10.61[kip]) = **106.08**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	148.85	75.00	DL	0.50	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\text{min}(k_1*L_{c\text{-}end}, k_2*d) + \text{min}(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(5/(1*5))*(\text{min}(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \text{min}(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(5 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{148.85}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 130.50 75.00 DL 0.57 Eq. J4-3

$A_g = L_p*t_p = 14.5\text{[in]}*0.313\text{[in]} = \mathbf{4.53}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*4.53\text{[in2]}) = \mathbf{130.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 110.11 75.00 DL 0.68 Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 14.5\text{[in]} - 5*0.875\text{[in]} = \mathbf{10.13}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 10.13\text{[in]}*0.313\text{[in]} = \mathbf{3.16}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*3.16\text{[in2]}) = \mathbf{110.11}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 100.20 75.00 DL 0.75 Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 1\text{[in]} + 1/16\text{ [in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13\text{[in]} + (1 - 1)*5.5\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.186}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (5 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{4.14}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (5 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{2.91}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\text{min}(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\text{min}(0.6*58000\text{[lb/in2]}*2.91\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]}, 0.6*36000\text{[lb/in2]}*4.14\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]})) = \mathbf{100.2}\text{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 18.10 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 75\text{[kip]}/(0.442\text{[in2]}*10) = \mathbf{16968.33}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \text{min}(\text{max}(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \text{min}(\text{max}(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*16968.33\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{53368.78}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*53368.78\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{11.79}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 75\text{[kip]}/(0.442\text{[in2]}*10) = \mathbf{16968.33}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \text{min}(\text{max}(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \text{min}(\text{max}(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*16968.33\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{53368.78}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*53368.78\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{11.79}\text{[kip]}$ Eq. J3-2

$a' = \text{Min}(a + d/2, 1.25*b + d/2) = \text{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*11.79\text{[kip]}*2.34\text{[in]})/(0.5*3\text{[in]}*58000\text{[lb/}$

in2]))$^{0.5}$ = **1.03**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.03[in]/0.313[in])^2 - 1) = **5.26** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.03[in])^2*(1 + 0.729) = **0.16** p. 9-13

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

ρ = b'/a' = 2.34[in]/1.5[in] = **1.56** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/2.75[in] = **0.705** p. 9-11

t_c = ((3.33*B*b')/(($1/\Omega$)*p*F_u))$^{0.5}$ = ((3.33*11.79[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **1.07**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.07[in]/0.313[in])^2 - 1) = **5.99** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.07[in])^2*(1 + 0.705) = **0.144** p. 9-13

HasEqualLengths → **False**

Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.144 + (5 - 2)*0.16)/5 = **0.153** p. 9-13

T_{avail} = 10 * (B*Q) = 10 * (11.79[kip]*0.153) = **18.1**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	131.63	75.00	DL	0.57	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 3.2[in] - 0.813[in]/2) = **2.79**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

($1/\Omega$)R_n = ($1/\Omega$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*2.79[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.45[in]*65000[lb/in2]*1 = **131.63**[kip] Eq. J3-6

Shear yielding	[Kip]	165.60	75.00	DL	0.45	Eq. J4-3

A_g = L_p*t_p = 18.4[in]*0.45[in] = **8.28**[in2] Sec. D3-1

($1/\Omega$)R_n = ($1/\Omega$)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*8.28[in2] = **165.6**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	526.50	75.00	DL	0.14	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

($1/\Omega$)R_n = 2 * (($1/\Omega$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.9[in]*65000[lb/in2]*1) = **526.5**[kip] Eq. J3-6

Global critical strength ratio **0.75**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-06 3:14 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange2.cnx\

Steel connections

Results

Connection name : DA BCF All bolted

Connection ID : SC-01-11F

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W21x44

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	60.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	11.50	9.40	18.80	✔	p. 10-8
$L_{min} = T/2 = 18.8[in]/2 = \mathbf{9.4}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 20.7[in] - \max(0.95[in], 0[in]) - \max(0.95[in], 0[in]) = \mathbf{18.8}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in]						Sec. J3.3
IsCorrosionConsidered → **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in]$, 12$ [in]$) =$ **7.5**[in]						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8$ [in]						p. 10-9
Angle (Support side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in]						Sec. J3.3
IsCorrosionConsidered → **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in]$, 12$ [in]$) =$ **7.5**[in]						Sec. J3.5
Beam						
Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
Support						
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

<u>Angle (Beam side)</u>

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	84.86	60.00	DL	0.71	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = 2 * ($C*(1/\Omega)R_n$) = 2 * (4*10.61[kip]) = **84.86**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	116.23	60.00	DL	0.52	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*(min($k_1*L_{c\text{-}end}$, k_2*d) + min($k_1*L_{c\text{-}spa}$, k_2*d)*(n - 1))*
$t_p*F_u*n_c$) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*
0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = **116.23**[kip] — Eq. J3-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Kip]	103.50	60.00	DL	0.58	Eq. J4-3

$A_g = L_p*t_p$ = 11.5[in]*0.313[in] = **3.59**[in2] — Sec. D3-1

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = **103.5**[kip] — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear rupture	[Kip]	87.00	60.00	DL	0.69	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 11.5[in] - 4*0.875[in] = **8**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 8[in]*0.313[in] = **2.5**[in2] — Sec. J4-2

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = **87**[kip] — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear	[Kip]	83.91	60.00	DL	0.72	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*
0.875[in])*0.313[in] = **0.254**[in2] — Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (4 - 1)*3[in])*0.313[in] = **3.2**[in2] — Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) -
0.875[in]/2)*0.313[in] = **2.25**[in2] — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

U_{bs} = 1 — Sec. J4-3

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*min(0.6*F_u*A_{nv} + $U_{bs}*F_u*A_{nt}$, 0.6*F_y*A_{gv} + $U_{bs}*F_u*$
A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*
3.2[in2] + 1*58000[lb/in2]*0.254[in2])) = **83.91**[kip] — Eq. J4-5

<u>Angle (Support side)</u>

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	84.86	60.00	DL	0.71	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = 2 * ($C*(1/\Omega)R_n$) = 2 * (4*10.61[kip]) = **84.86**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	116.23	60.00	DL	0.52	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*(C/(n_c*n))*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(4/(1*4))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = **116.23**[kip] p. 7-18, Sec. J3.10

Shear yielding	[Kip]	103.50	60.00	DL	0.58		Eq. J4-3

A_g = L_p*t_p = 11.5[in]*0.313[in] = **3.59**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = **103.5**[kip] Eq. J4-3

Shear rupture	[Kip]	87.00	60.00	DL	0.69		Eq. J4-4

L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

L_e = L - n*L_h = 11.5[in] - 4*0.875[in] = **8**[in] DG4 Eq. 3-13

A_{nv} = L_e*t_p = 8[in]*0.313[in] = **2.5**[in2] Sec. J4-2

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = **87**[kip] Eq. J4-4

Block shear	[Kip]	79.95	60.00	DL	0.75		Eq. J4-5

dh_h = d_h + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (4 - 1)*3[in])*0.313[in] = **3.2**[in2] Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.25**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*3.2[in2] + 1*58000[lb/in2]*0.186[in2])) = **79.95**[kip] Eq. J4-5

Resulting tension capacity due prying action	[Kip]	14.33	0.00	DL	0.00		p. 9-13, p. 9-10

f_v = F/(A_b*N_{bolts}) = 60[kip]/(0.442[in2]*8) = **16968.33**[lb/in2] Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/($(1/\Omega)$*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*16968.33[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **53368.78**[lb/in2] Eq. J3-3

$(1/\Omega)R_n$ = $(1/\Omega)$*F'_{nt}*A_b = 0.5*53368.78[lb/in2]*0.442[in2] = **11.79**[kip] Eq. J3-2

f_v = F/(A_b*N_{bolts}) = 60[kip]/(0.442[in2]*8) = **16968.33**[lb/in2] Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/($(1/\Omega)$*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*16968.33[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **53368.78**[lb/in2] Eq. J3-3

$(1/\Omega)R_n$ = $(1/\Omega)$*F'_{nt}*A_b = 0.5*53368.78[lb/in2]*0.442[in2] = **11.79**[kip] Eq. J3-2

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

ρ = b'/a' = 2.34[in]/1.5[in] = **1.56** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/3[in] = **0.729** p. 9-11

t_c = ((3.33*B*b')/($(1/\Omega)$*p*F_u))$^{0.5}$ = ((3.33*11.79[kip]*2.34[in])/(0.5*3[in]*58000[lb/

in2]))$^{0.5}$ = **1.03**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.03[in]/0.313[in])^2 - 1) = **5.26** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.03[in])^2*(1 + 0.729) = **0.16** p. 9-13

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

ρ = b'/a' = 2.34[in]/1.5[in] = **1.56** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/2.75[in] = **0.705** p. 9-11

t_c = ((3.33*B*b')/(($1/\Omega$)*p*F_u))$^{0.5}$ = ((3.33*11.79[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **1.07**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.07[in]/0.313[in])^2 - 1) = **5.99** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.07[in])^2*(1 + 0.705) = **0.144** p. 9-13

HasEqualLengths → **False**

Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.144 + (4 - 2)*0.16)/4 = **0.152** p. 9-13

T_{avail} = 8 * (B*Q) = 8 * (11.79[kip]*0.152) = **14.33**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	81.90	60.00	DL	0.73	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 5.85[in] - 0.813[in]/2) = **5.44**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = $(1/\Omega)$*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*5.44[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.35[in]*65000[lb/in2]*1 = **81.9**[kip] Eq. J3-6

Shear yielding	[Kip]	144.90	60.00	DL	0.41	Eq. J4-3

A_g = L_p*t_p = 20.7[in]*0.35[in] = **7.25**[in2] Sec. D3-1

$(1/\Omega)R_n$ = $(1/\Omega)$*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*7.25[in2] = **144.9**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	262.08	60.00	DL	0.23	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($1/\Omega$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.56[in]*65000[lb/in2]*1) = **262.08**[kip] Eq. J3-6

Global critical strength ratio **0.75**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 9:53 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange3.cnx\

Steel connections

Results

Connection name : DA BCF All bolted

Connection ID : SC-01-12F

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W21x50

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	20.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	11.50	9.36	18.72	✔	p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

Angle – Length:

$L_{min} = T/2 = 18.72[\text{in}]/2 = \mathbf{9.36}[\text{in}]$ p. 10-8

$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 20.8[\text{in}] - \max(1.04[\text{in}], 0[\text{in}]) - \max(1.04[\text{in}], 0[\text{in}]) = \mathbf{18.72}[\text{in}]$ p. 10-8

Angle (Beam side) – Vertical edge distance:

$L_{emin} = e_{dmin} + C_2 = 1[\text{in}] + 0[\text{in}] = \mathbf{1}[\text{in}]$ Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✓	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✓	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $= \mathbf{2}$[in]						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) = \mathbf{7.5}$[in]						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✓	p. 10-9
$t_{pmax} = 5/8$ [in]						p. 10-9
<u>Angle (Support side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✓	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.25	1.13	--	✓	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $= \mathbf{1.13}$[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✓	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $= \mathbf{2}$[in]						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) = \mathbf{7.5}$[in]						Sec. J3.5
<u>Beam</u>						
Horizontal edge distance	[in]	2.25	1.00	--	✓	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5
<u>Support</u>						
Horizontal edge distance	[in]	1.25	1.00	--	✓	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Angle (Beam side)</u>						
Bolts shear	[Kip]	84.86	20.00	DL	0.24	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$						Eq. J3-1
$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61\text{[kip]}) = \mathbf{84.86}\text{[kip]}$						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	116.23	20.00	DL	0.17	Eq. J3-6
$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$						Sec. J4.10
$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$						Sec. J4.10
$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4* 0.75\text{[in]})*(4 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{116.23}\text{[kip]}$						Eq. J3-6
Shear yielding	[Kip]	103.50	20.00	DL	0.19	Eq. J4-3
$A_g = L_p*t_p = 11.5\text{[in]}*0.313\text{[in]} = \mathbf{3.59}\text{[in2]}$						Sec. D3-1
$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*3.59\text{[in2]}) = \mathbf{103.5}\text{[kip]}$						Eq. J4-3
Shear rupture	[Kip]	87.00	20.00	DL	0.23	Eq. J4-4
$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$						Sec. D3-2
$L_e = L - n*L_h = 11.5\text{[in]} - 4*0.875\text{[in]} = \mathbf{8}\text{[in]}$						DG4 Eq. 3-13
$A_{nv} = L_e*t_p = 8\text{[in]}*0.313\text{[in]} = \mathbf{2.5}\text{[in2]}$						Sec. J4-2
$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*2.5\text{[in2]}) = \mathbf{87}\text{[kip]}$						Eq. J4-4
Block shear	[Kip]	83.91	20.00	DL	0.24	Eq. J4-5
$dh_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$						Sec. D3-2
$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$						Sec. D3-2
$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)* 0.875\text{[in]})*0.313\text{[in]} = \mathbf{0.254}\text{[in2]}$						Sec. J4-3
$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (4 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{3.2}\text{[in2]}$						Sec. J4-3
$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (4 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{2.25}\text{[in2]}$						Sec. J4-3
$IsStressUniform \rightarrow \mathbf{True}$						
$U_{bs} = 1$						Sec. J4-3
$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*2.25\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]}, 0.6*36000\text{[lb/in2]}* 3.2\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]})) = \mathbf{83.91}\text{[kip]}$						Eq. J4-5
<u>Angle (Support side)</u>						
Bolts shear	[Kip]	84.86	20.00	DL	0.24	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$						Eq. J3-1
$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61\text{[kip]}) = \mathbf{84.86}\text{[kip]}$						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	116.23	20.00	DL	0.17	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] | Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] | Sec. J4.10

$(1/\Omega)R_n$ = 2 * ((1/Ω)*(C/(n_c*n))*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(4/(1*4))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = **116.23**[kip] | p. 7-18, Sec. J3.10

Shear yielding	[Kip]	103.50	20.00	DL	0.19		Eq. J4-3

A_g = L_p*t_p = 11.5[in]*0.313[in] = **3.59**[in2] | Sec. D3-1

$(1/\Omega)R_n$ = 2 * ((1/Ω)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = **103.5**[kip] | Eq. J4-3

Shear rupture	[Kip]	87.00	20.00	DL	0.23		Eq. J4-4

L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] | Sec. D3-2

L_e = L - n*L_h = 11.5[in] - 4*0.875[in] = **8**[in] | DG4 Eq. 3-13

A_{nv} = L_e*t_p = 8[in]*0.313[in] = **2.5**[in2] | Sec. J4-2

$(1/\Omega)R_n$ = 2 * ((1/Ω)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = **87**[kip] | Eq. J4-4

Block shear	[Kip]	82.21	20.00	DL	0.24		Eq. J4-5

dh_h = d_h + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] | Sec. D3-2

dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] | Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.225**[in2] | Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (4 - 1)*3[in])*0.313[in] = **3.2**[in2] | Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.25**[in2] | Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 | Sec. J4-3

$(1/\Omega)R_n$ = 2 * ((1/Ω)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.225[in2], 0.6*36000[lb/in2]*3.2[in2] + 1*58000[lb/in2]*0.225[in2])) = **82.21**[kip] | Eq. J4-5

Resulting tension capacity due prying action	[Kip]	15.14	0.00	DL	0.00		p. 9-13, p. 9-10

f_v = F/(A_b*N_{bolts}) = 20[kip]/(0.442[in2]*8) = **5656.11**[lb/in2] | Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/((1/Ω)*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*5656.11[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **90000**[lb/in2] | Eq. J3-3

$(1/\Omega)R_n$ = (1/Ω)*F'_{nt}*A_b = 0.5*90000[lb/in2]*0.442[in2] = **19.89**[kip] | Eq. J3-2

f_v = F/(A_b*N_{bolts}) = 20[kip]/(0.442[in2]*8) = **5656.11**[lb/in2] | Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/((1/Ω)*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*5656.11[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **90000**[lb/in2] | Eq. J3-3

$(1/\Omega)R_n$ = (1/Ω)*F'_{nt}*A_b = 0.5*90000[lb/in2]*0.442[in2] = **19.89**[kip] | Eq. J3-2

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.25[in] + 0.75[in]/2, 1.25*2.59[in] + 0.75[in]/2) = **1.63**[in] | p. 9-12

b' = b - d/2 = 2.59[in] - 0.75[in]/2 = **2.22**[in] | p. 9-12

ρ = b'/a' = 2.22[in]/1.63[in] = **1.37** | p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/3[in] = **0.729** | p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5}$ = ((3.33*19.89[kip]*2.22[in])/(0.5*3[in]*58000[lb/in2]))$^{0.5}$ = **1.3**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1)$ = (1/(0.729*(1 + 1.37)))*((1.3[in]/0.313[in])^2 - 1) = **9.45** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta)$ = (0.313[in]/1.3[in])^2*(1 + 0.729) = **0.1** p. 9-13

a' = Min($a + d/2$, 1.25*$b + d/2$) = Min(1.25[in] + 0.75[in]/2, 1.25*2.59[in] + 0.75[in]/2) = **1.63**[in] p. 9-12

$b' = b - d/2$ = 2.59[in] - 0.75[in]/2 = **2.22**[in] p. 9-12

$\rho = b'/a'$ = 2.22[in]/1.63[in] = **1.37** p. 9-12

$\delta = 1 - d'/p$ = 1 - 0.813[in]/2.75[in] = **0.705** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5}$ = ((3.33*19.89[kip]*2.22[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **1.36**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1)$ = (1/(0.705*(1 + 1.37)))*((1.36[in]/0.313[in])^2 - 1) = **10.72** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta)$ = (0.313[in]/1.36[in])^2*(1 + 0.705) = **0.0903** p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n$ = (2*0.0903 + (4 - 2)*0.1)/4 = **0.0952** p. 9-13

$T_{avail} = 8 * (B*Q)$ = 8 * (19.89[kip]*0.0952) = **15.14**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	88.92	20.00	DL	0.22		Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 5.9[in] - 0.813[in]/2) = **5.49**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(min(1.2*5.49[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.38[in]*65000[lb/in2]*1 = **88.92**[kip] Eq. J3-6

Shear yielding	[Kip]	158.08	20.00	DL	0.13		Eq. J4-3

$A_g = L_p*t_p$ = 20.8[in]*0.38[in] = **7.9**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*7.9[in2] = **158.08**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	262.08	20.00	DL	0.08		Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c)$ = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.56[in]*65000[lb/in2]*1) = **262.08**[kip] Eq. J3-6

Global critical strength ratio **0.24**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

L_{c-spa}: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-06 3:16 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange2.cnx\

Steel connections

Results

Connection name : DA BCF All bolted

Connection ID : SC-01-13F

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W24x55

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	80.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	14.50	10.79	21.58	✔	p. 10-8
$L_{min} = T/2 = 21.58_{[in]}/2 = \mathbf{10.79}_{[in]}$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 23.6_{[in]} - \max(1.01_{[in]}, 0_{[in]}) - \max(1.01_{[in]}, 0_{[in]}) = \mathbf{21.58}_{[in]}$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1_{[in]} + 0_{[in]} = \mathbf{1}_{[in]}$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $= \mathbf{2}$[in] — Sec. J3.3

$IsCorrosionConsidered \rightarrow$ **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in]$, 12$ [in]$) = \mathbf{7.5}$[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $= \mathbf{1.13}$[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $= \mathbf{2}$[in] — Sec. J3.3

$IsCorrosionConsidered \rightarrow$ **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in]$, 12$ [in]$) = \mathbf{7.5}$[in] — Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in] — Tables J3.4, J3.5

Support

Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

<u>Angle (Beam side)</u>

Bolts shear	[Kip]	106.08	80.00	DL	0.75	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = 2 * ($C*(1/\Omega)R_n$) = 2 * (5*10.61[kip]) = **106.08**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	148.85	80.00	DL	0.54	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*(min($k_1*L_{c\text{-}end}$, k_2*d) + min($k_1*L_{c\text{-}spa}$, k_2*d)*(n - 1))*
$t_p*F_u*n_c$) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*
0.75[in])*(5 - 1))*0.313[in]*58000[lb/in2]*1) = **148.85**[kip] — Eq. J3-6

Shear yielding	[Kip]	130.50	80.00	DL	0.61	Eq. J4-3

$A_g = L_p*t_p$ = 14.5[in]*0.313[in] = **4.53**[in2] — Sec. D3-1

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*4.53[in2]) = **130.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	110.11	80.00	DL	0.73	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 14.5[in] - 5*0.875[in] = **10.13**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 10.13[in]*0.313[in] = **3.16**[in2] — Sec. J4-2

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*3.16[in2]) = **110.11**[kip] — Eq. J4-4

Block shear	[Kip]	104.16	80.00	DL	0.77	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*
0.875[in])*0.313[in] = **0.254**[in2] — Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (5 - 1)*3[in])*0.313[in] = **4.14**[in2] — Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (5 - 1)*(3[in] - 0.875[in]) -
0.875[in]/2)*0.313[in] = **2.91**[in2] — Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 — Sec. J4-3

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*min(0.6*F_u*A_{nv} + $U_{bs}*F_u*A_{nt}$, 0.6*F_y*A_{gv} + $U_{bs}*F_u*$
A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*2.91[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*
4.14[in2] + 1*58000[lb/in2]*0.254[in2])) = **104.16**[kip] — Eq. J4-5

<u>Angle (Support side)</u>

Bolts shear	[Kip]	106.08	80.00	DL	0.75	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = 2 * ($C*(1/\Omega)R_n$) = 2 * (5*10.61[kip]) = **106.08**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	148.85	80.00	DL	0.54	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(5/(1*5))*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(5 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{148.85}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	130.50	80.00	DL	0.61		Eq. J4-3

$A_g = L_p*t_p = 14.5\text{[in]}*0.313\text{[in]} = \mathbf{4.53}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*4.53\text{[in2]}) = \mathbf{130.5}\text{[kip]}$ Eq. J4-3

Shear rupture	[Kip]	110.11	80.00	DL	0.73		Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 14.5\text{[in]} - 5*0.875\text{[in]} = \mathbf{10.13}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 10.13\text{[in]}*0.313\text{[in]} = \mathbf{3.16}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*3.16\text{[in2]}) = \mathbf{110.11}\text{[kip]}$ Eq. J4-4

Block shear	[Kip]	100.20	80.00	DL	0.80		Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 1\text{[in]} + 1/16\text{ [in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13\text{[in]} + (1 - 1)*5.5\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.186}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (5 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{4.14}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (5 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{2.91}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*2.91\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]}, 0.6*36000\text{[lb/in2]}*4.14\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]})) = \mathbf{100.2}\text{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action	[Kip]	18.10	0.00	DL	0.00		p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 80\text{[kip]}/(0.442\text{[in2]}*10) = \mathbf{18099.55}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*18099.55\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{49126.7}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*49126.7\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.86}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 80\text{[kip]}/(0.442\text{[in2]}*10) = \mathbf{18099.55}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*18099.55\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{49126.7}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*49126.7\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.86}\text{[kip]}$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*10.86\text{[kip]}*2.34\text{[in]})/(0.5*3\text{[in]}*58000\text{[lb/}$

$in2]))^{0.5} = \mathbf{0.987}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((0.987[in]/0.313[in])^2 - 1) = \mathbf{4.8}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/0.987[in])^2*(1 + 0.729) = \mathbf{0.173}$ p. 9-13

$a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*10.86[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} = \mathbf{1.03}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.03[in]/0.313[in])^2 - 1) = \mathbf{5.47}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.03[in])^2*(1 + 0.705) = \mathbf{0.157}$ p. 9-13

$HasEqualLengths \rightarrow$ **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.157 + (5 - 2)*0.173)/5 = \mathbf{0.167}$ p. 9-13

$T_{avail} = 10 * (B*Q) = 10 * (10.86[kip]*0.167) = \mathbf{18.1}[kip]$ p. 9-10

Beam

Bolt bearing under shear load	[Kip]	115.54	80.00	DL	0.69	Eq. J3-6

$L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 5.8[in] - 0.813[in]/2) = \mathbf{5.39}[in]$ Sec. J4.10

$L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*5.39[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.395[in]*65000[lb/in2]*1 = \mathbf{115.54}[kip]$ Eq. J3-6

Shear yielding	[Kip]	186.44	80.00	DL	0.43	Eq. J4-3

$A_g = L_p*t_p = 23.6[in]*0.395[in] = \mathbf{9.32}[in2]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*9.32[in2] = \mathbf{186.44}[kip]$ Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	397.80	80.00	DL	0.20	Eq. J3-6

$L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = \mathbf{1.20E+31}[in]$ Sec. J4.10

$L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.68[in]*65000[lb/in2]*1) = \mathbf{397.8}[kip]$ Eq. J3-6

Global critical strength ratio **0.80**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 9:56 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange3.cnx\

Steel connections

Results

Connection name : DA BCF All bolted

Connection ID : SC-01-14F

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W24x62

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	100.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	17.50	10.76	21.52	✔	p. 10-8
$L_{min} = T/2 = 21.52$[in]$/2 = \mathbf{10.76}$[in]						p. 10-8
$L_{max} = d$ - max(k, d_{ct}) - max(k, d_{cb}) = 23.7[in] - max(1.09[in], 0[in]) - max(1.09[in], 0[in]) = **21.52**[in]						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in]						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75\text{[in]} = \mathbf{2}\text{[in]}$						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12\ \text{[in]}) = \min(24*0.313\text{[in]}, 12\ \text{[in]}) = \mathbf{7.5}\text{[in]}$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8\ \text{[in]}$						p. 10-9
<u>Angle (Support side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0.125\text{[in]} = \mathbf{1.13}\text{[in]}$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75\text{[in]} = \mathbf{2}\text{[in]}$						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12\ \text{[in]}) = \min(24*0.313\text{[in]}, 12\ \text{[in]}) = \mathbf{7.5}\text{[in]}$						Sec. J3.5
<u>Beam</u>						
Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5
<u>Support</u>						
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Angle (Beam side)</u>						
Bolts shear	[Kip]	127.30	100.00	DL	0.79	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip]						Eq. J3-1
$(1/\Omega)R_n$ = 2 * ($C*(1/\Omega)R_n$) = 2 * (6*10.61[kip]) = **127.3**[kip]						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	181.48	100.00	DL	0.55	Eq. J3-6
$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in]						Sec. J4.10
$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in]						Sec. J4.10
$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*(min($k_1*L_{c\text{-}end}$, k_2*d) + min($k_1*L_{c\text{-}spa}$, k_2*d)*(n - 1))* $t_p*F_u*n_c$) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4* 0.75[in])*(6 - 1))*0.313[in]*58000[lb/in2]*1) = **181.48**[kip]						Eq. J3-6
Shear yielding	[Kip]	157.50	100.00	DL	0.63	Eq. J4-3
$A_g = L_p*t_p$ = 17.5[in]*0.313[in] = **5.47**[in2]						Sec. D3-1
$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*5.47[in2]) = **157.5**[kip]						Eq. J4-3
Shear rupture	[Kip]	133.22	100.00	DL	0.75	Eq. J4-4
$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in]						Sec. D3-2
$L_e = L - n*L_h$ = 17.5[in] - 6*0.875[in] = **12.25**[in]						DG4 Eq. 3-13
$A_{nv} = L_e*t_p$ = 12.25[in]*0.313[in] = **3.83**[in2]						Sec. J4-2
$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*3.83[in2]) = **133.22**[kip]						Eq. J4-4
Block shear	[Kip]	124.41	100.00	DL	0.80	Eq. J4-5
$dh_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in]						Sec. D3-2
$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in]						Sec. D3-2
A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)* 0.875[in])*0.313[in] = **0.254**[in2]						Sec. J4-3
A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (6 - 1)*3[in])*0.313[in] = **5.08**[in2]						Sec. J4-3
A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (6 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **3.57**[in2]						Sec. J4-3
IsStressUniform → **True**						
U_{bs} = 1						Sec. J4-3
$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$)*min(0.6*F_u*A_{nv} + $U_{bs}*F_u*A_{nt}$, 0.6*F_y*A_{gv} + $U_{bs}*F_u*$ A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*3.57[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]* 5.08[in2] + 1*58000[lb/in2]*0.254[in2])) = **124.41**[kip]						Eq. J4-5
<u>Angle (Support side)</u>						
Bolts shear	[Kip]	127.30	100.00	DL	0.79	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip]						Eq. J3-1
$(1/\Omega)R_n$ = 2 * ($C*(1/\Omega)R_n$) = 2 * (6*10.61[kip]) = **127.3**[kip]						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	181.48	100.00	DL	0.55	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[\text{in}] - 0.813[\text{in}]/2) = \mathbf{0.844}[\text{in}]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[\text{in}] - 0.813[\text{in}]) = \mathbf{2.19}[\text{in}]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(6/(1*6))*(\min(1.2*0.844[\text{in}], 2.4*0.75[\text{in}]) + \min(1.2*2.19[\text{in}], 2.4*0.75[\text{in}])*(6 - 1))*0.313[\text{in}]*58000[\text{lb/in2}]*1) = \mathbf{181.48}[\text{kip}]$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	157.50	100.00	DL	0.63	Eq. J4-3

$A_g = L_p*t_p = 17.5[\text{in}]*0.313[\text{in}] = \mathbf{5.47}[\text{in2}]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[\text{lb/in2}]*5.47[\text{in2}]) = \mathbf{157.5}[\text{kip}]$ Eq. J4-3

Shear rupture	[Kip]	133.22	100.00	DL	0.75	Eq. J4-4

$L_h = d_h + 1/16\ [\text{in}] = 0.813[\text{in}] + 1/16\ [\text{in}] = \mathbf{0.875}[\text{in}]$ Sec. D3-2

$L_e = L - n*L_h = 17.5[\text{in}] - 6*0.875[\text{in}] = \mathbf{12.25}[\text{in}]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 12.25[\text{in}]*0.313[\text{in}] = \mathbf{3.83}[\text{in2}]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[\text{lb/in2}]*3.83[\text{in2}]) = \mathbf{133.22}[\text{kip}]$ Eq. J4-4

Block shear	[Kip]	120.45	100.00	DL	0.83	Eq. J4-5

$dh_h = d_h + 1/16\ [\text{in}] = 1[\text{in}] + 1/16\ [\text{in}] = \mathbf{1.06}[\text{in}]$ Sec. D3-2

$dh_v = d_h + 1/16\ [\text{in}] = 0.813[\text{in}] + 1/16\ [\text{in}] = \mathbf{0.875}[\text{in}]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[\text{in}] + (1 - 1)*5.5[\text{in}] - (1 - 0.5)*1.06[\text{in}])*0.313[\text{in}] = \mathbf{0.186}[\text{in2}]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[\text{in}] + (6 - 1)*3[\text{in}])*0.313[\text{in}] = \mathbf{5.08}[\text{in2}]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[\text{in}] + (6 - 1)*(3[\text{in}] - 0.875[\text{in}]) - 0.875[\text{in}]/2)*0.313[\text{in}] = \mathbf{3.57}[\text{in2}]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[\text{lb/in2}]*3.57[\text{in2}] + 1*58000[\text{lb/in2}]*0.186[\text{in2}], 0.6*36000[\text{lb/in2}]*5.08[\text{in2}] + 1*58000[\text{lb/in2}]*0.186[\text{in2}])) = \mathbf{120.45}[\text{kip}]$ Eq. J4-5

Resulting tension capacity due prying action	[Kip]	21.86	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 100[\text{kip}]/(0.442[\text{in2}]*12) = \mathbf{18853.7}[\text{lb/in2}]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[\text{lb/in2}] - 90000[\text{lb/in2}]*18853.7[\text{lb/in2}]/(0.5*48000[\text{lb/in2}]), 0.0), 90000[\text{lb/in2}]) = \mathbf{46298.64}[\text{lb/in2}]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*46298.64[\text{lb/in2}]*0.442[\text{in2}] = \mathbf{10.23}[\text{kip}]$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 100[\text{kip}]/(0.442[\text{in2}]*12) = \mathbf{18853.7}[\text{lb/in2}]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[\text{lb/in2}] - 90000[\text{lb/in2}]*18853.7[\text{lb/in2}]/(0.5*48000[\text{lb/in2}]), 0.0), 90000[\text{lb/in2}]) = \mathbf{46298.64}[\text{lb/in2}]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*46298.64[\text{lb/in2}]*0.442[\text{in2}] = \mathbf{10.23}[\text{kip}]$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[\text{in}] + 0.75[\text{in}]/2, 1.25*2.72[\text{in}] + 0.75[\text{in}]/2) = \mathbf{1.5}[\text{in}]$ p. 9-12

$b' = b - d/2 = 2.72[\text{in}] - 0.75[\text{in}]/2 = \mathbf{2.34}[\text{in}]$ p. 9-12

$\rho = b'/a' = 2.34[\text{in}]/1.5[\text{in}] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[\text{in}]/3[\text{in}] = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*10.23[\text{kip}]*2.34[\text{in}])/(0.5*3[\text{in}]*58000[\text{lb/}$

in2]))$^{0.5}$ = **0.958**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((0.958[in]/0.313[in])^2 - 1) = **4.5** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/0.958[in])^2*(1 + 0.729) = **0.184** p. 9-13

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

ρ = b'/a' = 2.34[in]/1.5[in] = **1.56** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/2.75[in] = **0.705** p. 9-11

t_c = ((3.33*B*b')/(($1/\Omega$)*p*F_u))$^{0.5}$ = ((3.33*10.23[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **1**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1[in]/0.313[in])^2 - 1) = **5.13** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1[in])^2*(1 + 0.705) = **0.166** p. 9-13

HasEqualLengths → **False**

Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.166 + (6 - 2)*0.184)/6 = **0.178** p. 9-13

T_{avail} = 12 * (B*Q) = 12 * (10.23[kip]*0.178) = **21.86**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	150.93	100.00	DL	0.66	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 4.35[in] - 0.813[in]/2) = **3.94**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

($1/\Omega$)R_n = ($1/\Omega$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*3.94[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(6 - 1))*0.43[in]*65000[lb/in2]*1 = **150.93**[kip] Eq. J3-6

Shear yielding	[Kip]	203.82	100.00	DL	0.49	Eq. J4-3

A_g = L_p*t_p = 23.7[in]*0.43[in] = **10.19**[in2] Sec. D3-1

($1/\Omega$)R_n = ($1/\Omega$)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*10.19[in2] = **203.82**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	393.12	100.00	DL	0.25	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

($1/\Omega$)R_n = 2 * (($1/\Omega$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(6 - 1))*0.56[in]*65000[lb/in2]*1) = **393.12**[kip] Eq. J3-6

Global critical strength ratio **0.83**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 9:46 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange2.cnx\

Steel connections

Results

Connection name : DA BCF All bolted
Connection ID : SC-01-15F

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W24x68

Design code: AISC 360-05 ASD

DEMANDS

Description	**Ru** [Kip]	**Pu** [Kip]	**Load type**
DL	90.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
Angle						
Length	[in]	14.50	10.76	21.52	✔	p. 10-8
$L_{min} = T/2 = 21.52[in]/2 = \mathbf{10.76}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 23.7[in] - \max(1.09[in], 0[in]) - \max(1.09[in], 0[in]) = \mathbf{21.52}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in]						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in]						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8$ [in]						p. 10-9

<u>Angle (Support side)</u>

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in]						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in]						Sec. J3.5

<u>Beam</u>

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5

<u>Support</u>

Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Angle (Beam side)</u>						
Bolts shear	[Kip]	106.08	90.00	DL	0.85	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$						Eq. J3-1
$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (5*10.61[kip]) = \mathbf{106.08}[kip]$						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	148.85	90.00	DL	0.60	Eq. J3-6
$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$						Sec. J4.10
$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$						Sec. J4.10
$(1/\Omega)R_n = 2 * ((1/\Omega)*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4* 0.75[in])*(5 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{148.85}[kip]$						Eq. J3-6
Shear yielding	[Kip]	130.50	90.00	DL	0.69	Eq. J4-3
$A_g = L_p*t_p = 14.5[in]*0.313[in] = \mathbf{4.53}[in2]$						Sec. D3-1
$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*4.53[in2]) = \mathbf{130.5}[kip]$						Eq. J4-3
Shear rupture	[Kip]	110.11	90.00	DL	0.82	Eq. J4-4
$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$						Sec. D3-2
$L_e = L - n*L_h = 14.5[in] - 5*0.875[in] = \mathbf{10.13}[in]$						DG4 Eq. 3-13
$A_{nv} = L_e*t_p = 10.13[in]*0.313[in] = \mathbf{3.16}[in2]$						Sec. J4-2
$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*3.16[in2]) = \mathbf{110.11}[kip]$						Eq. J4-4
Block shear	[Kip]	104.16	90.00	DL	0.86	Eq. J4-5
$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$						Sec. D3-2
$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$						Sec. D3-2
$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)* 0.875[in])*0.313[in] = \mathbf{0.254}[in2]$						Sec. J4-3
$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (5 - 1)*3[in])*0.313[in] = \mathbf{4.14}[in2]$						Sec. J4-3
$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (5 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{2.91}[in2]$						Sec. J4-3
$IsStressUniform \rightarrow \mathbf{True}$						
$U_{bs} = 1$						Sec. J4-3
$(1/\Omega)R_n = 2 * ((1/\Omega)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*2.91[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]* 4.14[in2] + 1*58000[lb/in2]*0.254[in2])) = \mathbf{104.16}[kip]$						Eq. J4-5
<u>Angle (Support side)</u>						
Bolts shear	[Kip]	106.08	90.00	DL	0.85	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$						Eq. J3-1
$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (5*10.61[kip]) = \mathbf{106.08}[kip]$						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	148.85	90.00	DL	0.60	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * ((1/Ω)*(C/(n_c*n))*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(5/(1*5))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.313[in]*58000[lb/in2]*1) = **148.85**[kip] p. 7-18, Sec. J3.10

Shear yielding	[Kip]	130.50	90.00	DL	0.69		Eq. J4-3

A_g = L_p*t_p = 14.5[in]*0.313[in] = **4.53**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ((1/Ω)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*4.53[in2]) = **130.5**[kip] Eq. J4-3

Shear rupture	[Kip]	110.11	90.00	DL	0.82		Eq. J4-4

L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

L_e = L - n*L_h = 14.5[in] - 5*0.875[in] = **10.13**[in] DG4 Eq. 3-13

A_{nv} = L_e*t_p = 10.13[in]*0.313[in] = **3.16**[in2] Sec. J4-2

$(1/\Omega)R_n$ = 2 * ((1/Ω)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*3.16[in2]) = **110.11**[kip] Eq. J4-4

Block shear	[Kip]	100.20	90.00	DL	0.90		Eq. J4-5

dh_h = d_h + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (5 - 1)*3[in])*0.313[in] = **4.14**[in2] Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (5 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.91**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n$ = 2 * ((1/Ω)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*2.91[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*4.14[in2] + 1*58000[lb/in2]*0.186[in2])) = **100.2**[kip] Eq. J4-5

Resulting tension capacity due prying action	[Kip]	23.01	0.00	DL	0.00		p. 9-13, p. 9-10

f_v = F/(A_b*N_{bolts}) = 90[kip]/(0.442[in2]*10) = **20361.99**[lb/in2] Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/((1/Ω)*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*20361.99[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **40642.53**[lb/in2] Eq. J3-3

$(1/\Omega)R_n$ = (1/Ω)*F'_{nt}*A_b = 0.5*40642.53[lb/in2]*0.442[in2] = **8.98**[kip] Eq. J3-2

f_v = F/(A_b*N_{bolts}) = 90[kip]/(0.442[in2]*10) = **20361.99**[lb/in2] Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/((1/Ω)*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*20361.99[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **40642.53**[lb/in2] Eq. J3-3

$(1/\Omega)R_n$ = (1/Ω)*F'_{nt}*A_b = 0.5*40642.53[lb/in2]*0.442[in2] = **8.98**[kip] Eq. J3-2

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.22[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.22[in] - 0.75[in]/2 = **1.84**[in] p. 9-12

ρ = b'/a' = 1.84[in]/1.5[in] = **1.23** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/3[in] = **0.729** p. 9-11

t_c = ((3.33*B*b')/((1/Ω)*p*F_u))$^{0.5}$ = ((3.33*8.98[kip]*1.84[in])/(0.5*3[in]*58000[lb/

in2]))$^{0.5}$ = **0.796**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.23)))*((0.796[in]/0.313[in])^2 - 1) = **3.38** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/0.796[in])^2*(1 + 0.729) = **0.266** p. 9-13

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.22[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.22[in] - 0.75[in]/2 = **1.84**[in] p. 9-12

ρ = b'/a' = 1.84[in]/1.5[in] = **1.23** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/2.75[in] = **0.705** p. 9-11

t_c = ((3.33*B*b')/((1/Ω)*p*F_u))$^{0.5}$ = ((3.33*8.98[kip]*1.84[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **0.832**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.23)))*((0.832[in]/0.313[in])^2 - 1) = **3.87** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/0.832[in])^2*(1 + 0.705) = **0.241** p. 9-13

HasEqualLengths → **False**

Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.241 + (5 - 2)*0.266)/5 = **0.256** p. 9-13

T_{avail} = 10 * (B*Q) = 10 * (8.98[kip]*0.256) = **23.01**[kip] p. 9-10

<u>Beam</u>

Bolt bearing under shear load [Kip] 121.39 90.00 DL 0.74 Eq. J3-6

L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 5.85[in] - 0.813[in]/2) = **5.44**[in] Sec. J4.10

L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = $(1/\Omega)$*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*5.44[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.415[in]*65000[lb/in2]*1 = **121.39**[kip] Eq. J3-6

Shear yielding [Kip] 196.71 90.00 DL 0.46 Eq. J4-3

A_g = L_p*t_p = 23.7[in]*0.415[in] = **9.84**[in2] Sec. D3-1

$(1/\Omega)R_n$ = $(1/\Omega)$*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*9.84[in2] = **196.71**[kip] Eq. J4-3

<u>Support</u>

Bolt bearing under shear load [Kip] 362.70 90.00 DL 0.25 Eq. J3-6

L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.62[in]*65000[lb/in2]*1) = **362.7**[kip] Eq. J3-6

Global critical strength ratio **0.90**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 9:49 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange2.cnx\

Steel connections

Results

Connection name	:	**DA BCF All bolted**
Connection ID	:	**SC-01-16F**

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W24x84

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	110.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	17.50	10.78	21.56	✔	p. 10-8

$L_{min} = T/2 = 21.56[\text{in}]/2 = \mathbf{10.78}[\text{in}]$ p. 10-8

$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 24.1[\text{in}] - \max(1.27[\text{in}], 0[\text{in}]) - \max(1.27[\text{in}], 0[\text{in}]) = \mathbf{21.56}[\text{in}]$ p. 10-8

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[\text{in}] + 0[\text{in}] = \mathbf{1}[\text{in}]$ Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3{*}d = 8/3{*}0.75\text{[in]} = \mathbf{2}\text{[in]}$						Sec. J3.3
$IsCorrosionConsidered \rightarrow \mathbf{False}$						
$s_{max} = \min(24{*}t_p, 12\ \text{[in]}) = \min(24{*}0.313\text{[in]}, 12\ \text{[in]}) = \mathbf{7.5}\text{[in]}$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8\ \text{[in]}$						p. 10-9
<u>Angle (Support side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3{*}d = 8/3{*}0.75\text{[in]} = \mathbf{2}\text{[in]}$						Sec. J3.3
$IsCorrosionConsidered \rightarrow \mathbf{False}$						
$s_{max} = \min(24{*}t_p, 12\ \text{[in]}) = \min(24{*}0.313\text{[in]}, 12\ \text{[in]}) = \mathbf{7.5}\text{[in]}$						Sec. J3.5
<u>Beam</u>						
Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5
<u>Support</u>						
Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Angle (Beam side)</u>						
Bolts shear	[Kip]	127.30	110.00	DL	0.86	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$						Eq. J3-1
$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (6*10.61\text{[kip]}) = \mathbf{127.3}\text{[kip]}$						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	181.48	110.00	DL	0.61	Eq. J3-6
$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$						Sec. J4.10
$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$						Sec. J4.10
$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4* 0.75\text{[in]})*(6 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{181.48}\text{[kip]}$						Eq. J3-6
Shear yielding	[Kip]	157.50	110.00	DL	0.70	Eq. J4-3
$A_g = L_p*t_p = 17.5\text{[in]}*0.313\text{[in]} = \mathbf{5.47}\text{[in2]}$						Sec. D3-1
$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*5.47\text{[in2]}) = \mathbf{157.5}\text{[kip]}$						Eq. J4-3
Shear rupture	[Kip]	133.22	110.00	DL	0.83	Eq. J4-4
$L_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$						Sec. D3-2
$L_e = L - n*L_h = 17.5\text{[in]} - 6*0.875\text{[in]} = \mathbf{12.25}\text{[in]}$						DG4 Eq. 3-13
$A_{nv} = L_e*t_p = 12.25\text{[in]}*0.313\text{[in]} = \mathbf{3.83}\text{[in2]}$						Sec. J4-2
$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*3.83\text{[in2]}) = \mathbf{133.22}\text{[kip]}$						Eq. J4-4
Block shear	[Kip]	124.41	110.00	DL	0.88	Eq. J4-5
$dh_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$						Sec. D3-2
$dh_v = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$						Sec. D3-2
$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)* 0.875\text{[in]})*0.313\text{[in]} = \mathbf{0.254}\text{[in2]}$						Sec. J4-3
$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (6 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{5.08}\text{[in2]}$						Sec. J4-3
$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (6 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{3.57}\text{[in2]}$						Sec. J4-3
$IsStressUniform \rightarrow \mathbf{True}$						
$U_{bs} = 1$						Sec. J4-3
$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*3.57\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]}, 0.6*36000\text{[lb/in2]}* 5.08\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]})) = \mathbf{124.41}\text{[kip]}$						Eq. J4-5
<u>Angle (Support side)</u>						
Bolts shear	[Kip]	127.30	110.00	DL	0.86	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$						Eq. J3-1
$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (6*10.61\text{[kip]}) = \mathbf{127.3}\text{[kip]}$						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	181.48	110.00	DL	0.61	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(6/(1*6))*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(6 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{181.48}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 157.50 110.00 DL 0.70 Eq. J4-3

$A_g = L_p*t_p = 17.5\text{[in]}*0.313\text{[in]} = \mathbf{5.47}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*5.47\text{[in2]}) = \mathbf{157.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 133.22 110.00 DL 0.83 Eq. J4-4

$L_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 17.5\text{[in]} - 6*0.875\text{[in]} = \mathbf{12.25}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 12.25\text{[in]}*0.313\text{[in]} = \mathbf{3.83}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*3.83\text{[in2]}) = \mathbf{133.22}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 124.41 110.00 DL 0.88 Eq. J4-5

$dh_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25\text{[in]} + (1 - 1)*5.5\text{[in]} - (1 - 0.5)*0.875\text{[in]})*0.313\text{[in]} = \mathbf{0.254}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (6 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{5.08}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (6 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{3.57}\text{[in2]}$ Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*3.57\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]}, 0.6*36000\text{[lb/in2]}*5.08\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]})) = \mathbf{124.41}\text{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 29.81 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 110\text{[kip]}/(0.442\text{[in2]}*12) = \mathbf{20739.06}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*20739.06\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{39228.51}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*39228.51\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{8.67}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 110\text{[kip]}/(0.442\text{[in2]}*12) = \mathbf{20739.06}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*20739.06\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{39228.51}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*39228.51\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{8.67}\text{[kip]}$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.25\text{[in]} + 0.75\text{[in]}/2, 1.25*2.09\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.63}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.09\text{[in]} - 0.75\text{[in]}/2 = \mathbf{1.72}\text{[in]}$ p. 9-12

$\rho = b'/a' = 1.72\text{[in]}/1.63\text{[in]} = \mathbf{1.06}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*8.67$[kip]$*1.72$[in]$)/(0.5*3$[in]$*58000$[lb/in2]$))^{0.5} = \mathbf{0.755}$[in] p. 9-12

$\alpha' = (1/(\delta*(1+\rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1+1.06)))*((0.755$[in]$/0.313$[in]$)^2 - 1) = \mathbf{3.23}$ p. 9-13

$Q = (t_p/t_c)^2*(1+\delta) = (0.313$[in]$/0.755$[in]$)^2*(1+0.729) = \mathbf{0.296}$ p. 9-13

$a' = \text{Min}(a + d/2, 1.25*b + d/2) = \text{Min}(1.25$[in] $+ 0.75$[in]$/2, 1.25*2.09$[in] $+ 0.75$[in]$/2) = \mathbf{1.63}$[in] p. 9-12

$b' = b - d/2 = 2.09$[in] $- 0.75$[in]$/2 = \mathbf{1.72}$[in] p. 9-12

$\rho = b'/a' = 1.72$[in]$/1.63$[in] $= \mathbf{1.06}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813$[in]$/2.75$[in] $= \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*8.67$[kip]$*1.72$[in]$)/(0.5*2.75$[in]$*58000$[lb/in2]$))^{0.5} = \mathbf{0.789}$[in] p. 9-12

$\alpha' = (1/(\delta*(1+\rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1+1.06)))*((0.789$[in]$/0.313$[in]$)^2 - 1) = \mathbf{3.7}$ p. 9-13

$Q = (t_p/t_c)^2*(1+\delta) = (0.313$[in]$/0.789$[in]$)^2*(1+0.705) = \mathbf{0.268}$ p. 9-13

$HasEqualLengths \rightarrow$ **False**

$Q = (2*Q_{ext} + (n-2)*Q_{int})/n = (2*0.268 + (6-2)*0.296)/6 = \mathbf{0.287}$ p. 9-13

$T_{avail} = 12 * (B*Q) = 12 * (8.67$[kip]$*0.287) = \mathbf{29.81}$[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	164.97	110.00	DL	0.67	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 4.55$[in] $- 0.813$[in]$/2) = \mathbf{4.14}$[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in] $- 0.813$[in]$) = \mathbf{2.19}$[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n-1))*t_p*F_u*n_c = 0.5*(\min(1.2*4.14$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(6-1))*0.47$[in]$*65000$[lb/in2]$*1 = \mathbf{164.97}$[kip] Eq. J3-6

Shear yielding	[Kip]	226.54	110.00	DL	0.49	Eq. J4-3

$A_g = L_p*t_p = 24.1$[in]$*0.47$[in] $= \mathbf{11.33}$[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000$[lb/in2]$*11.33$[in2] $= \mathbf{226.54}$[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	435.24	110.00	DL	0.25	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.20E+31$[in] $- 0.813$[in]$/2) = \mathbf{1.20E+31}$[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in] $- 0.813$[in]$) = \mathbf{2.19}$[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n-1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(6-1))*0.62$[in]$*65000$[lb/in2]$*1) = \mathbf{435.24}$[kip] Eq. J3-6

Global critical strength ratio **0.88**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}:Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}:Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}:Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}:Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}:Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 9:57 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01F Beam to Column Flange Shear Double Angle All Bolted\B2C Flange3.cnx\

Steel connections

Results

Connection name : DA BCF All bolted

Connection ID : SC-01-17F

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W27x84

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	80.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	14.50	12.11	24.22	✔	p. 10-8

$L_{min} = T/2 = 24.22[in]/2 = \mathbf{12.11}[in]$ — p. 10-8

$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 26.7[in] - \max(1.24[in], 0[in]) - \max(1.24[in], 0[in]) = \mathbf{24.22}[in]$ — p. 10-8

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75\text{[in]} = \mathbf{2}\text{[in]}$						Sec. J3.3
$IsCorrosionConsidered \rightarrow \mathbf{False}$						
$s_{max} = \min(24*t_p, 12\ \text{[in]}) = \min(24*0.313\text{[in]}, 12\ \text{[in]}) = \mathbf{7.5}\text{[in]}$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8\ \text{[in]}$						p. 10-9
<u>Angle (Support side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0.125\text{[in]} = \mathbf{1.13}\text{[in]}$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75\text{[in]} = \mathbf{2}\text{[in]}$						Sec. J3.3
$IsCorrosionConsidered \rightarrow \mathbf{False}$						
$s_{max} = \min(24*t_p, 12\ \text{[in]}) = \min(24*0.313\text{[in]}, 12\ \text{[in]}) = \mathbf{7.5}\text{[in]}$						Sec. J3.5
<u>Beam</u>						
Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5
<u>Support</u>						
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Angle (Beam side)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	106.08	80.00	DL	0.75	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n)$ = 2 * (5*10.61[kip]) = **106.08**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	148.85	80.00	DL	0.54	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c)$ = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.313[in]*58000[lb/in2]*1) = **148.85**[kip] — Eq. J3-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Kip]	130.50	80.00	DL	0.61	Eq. J4-3

$A_g = L_p*t_p$ = 14.5[in]*0.313[in] = **4.53**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g)$ = 2 * (0.667*0.60*36000[lb/in2]*4.53[in2]) = **130.5**[kip] — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear rupture	[Kip]	110.11	80.00	DL	0.73	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 14.5[in] - 5*0.875[in] = **10.13**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 10.13[in]*0.313[in] = **3.16**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv})$ = 2 * (0.5*0.60*58000[lb/in2]*3.16[in2]) = **110.11**[kip] — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear	[Kip]	104.16	80.00	DL	0.77	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.313[in] = **0.254**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (5 - 1)*3[in])*0.313[in] = **4.14**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (5 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.91**[in2] — Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}))$ = 2 * (0.5*min(0.6*58000[lb/in2]*2.91[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*4.14[in2] + 1*58000[lb/in2]*0.254[in2])) = **104.16**[kip] — Eq. J4-5

Angle (Support side)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	106.08	80.00	DL	0.75	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n)$ = 2 * (5*10.61[kip]) = **106.08**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	148.85	80.00	DL	0.54	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($1/\Omega$)*(C/(n_c*n))*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(5/(1*5))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.313[in]*58000[lb/in2]*1) = **148.85**[kip] — p. 7-18, Sec. J3.10

Shear yielding [Kip] 130.50 80.00 DL 0.61 — Eq. J4-3

A_g = L_p*t_p = 14.5[in]*0.313[in] = **4.53**[in2] — Sec. D3-1

$(1/\Omega)R_n$ = 2 * (($1/\Omega$)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*4.53[in2]) = **130.5**[kip] — Eq. J4-3

Shear rupture [Kip] 110.11 80.00 DL 0.73 — Eq. J4-4

L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

L_e = L - n*L_h = 14.5[in] - 5*0.875[in] = **10.13**[in] — DG4 Eq. 3-13

A_{nv} = L_e*t_p = 10.13[in]*0.313[in] = **3.16**[in2] — Sec. J4-2

$(1/\Omega)R_n$ = 2 * (($1/\Omega$)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*3.16[in2]) = **110.11**[kip] — Eq. J4-4

Block shear [Kip] 100.20 80.00 DL 0.80 — Eq. J4-5

dh_h = d_h + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] — Sec. D3-2

dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] — Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (5 - 1)*3[in])*0.313[in] = **4.14**[in2] — Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (5 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.91**[in2] — Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 — Sec. J4-3

$(1/\Omega)R_n$ = 2 * (($1/\Omega$)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*2.91[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*4.14[in2] + 1*58000[lb/in2]*0.186[in2])) = **100.2**[kip] — Eq. J4-5

Resulting tension capacity due prying action [Kip] 18.10 0.00 DL 0.00 — p. 9-13, p. 9-10

f_v = F/(A_b*N_{bolts}) = 80[kip]/(0.442[in2]*10) = **18099.55**[lb/in2] — Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/(($1/\Omega$)*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*18099.55[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **49126.7**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n$ = $(1/\Omega)$*F'_{nt}*A_b = 0.5*49126.7[lb/in2]*0.442[in2] = **10.86**[kip] — Eq. J3-2

f_v = F/(A_b*N_{bolts}) = 80[kip]/(0.442[in2]*10) = **18099.55**[lb/in2] — Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/(($1/\Omega$)*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*18099.55[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **49126.7**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n$ = $(1/\Omega)$*F'_{nt}*A_b = 0.5*49126.7[lb/in2]*0.442[in2] = **10.86**[kip] — Eq. J3-2

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] — p. 9-12

b' = b - d/2 = 2.72[in] - 0.75[in]/2 = **2.34**[in] — p. 9-12

ρ = b'/a' = 2.34[in]/1.5[in] = **1.56** — p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/3[in] = **0.729** — p. 9-11

t_c = ((3.33*B*b')/(($1/\Omega$)*p*F_u))$^{0.5}$ = ((3.33*10.86[kip]*2.34[in])/(0.5*3[in]*58000[lb/

$in2]))^{0.5} = \mathbf{0.987}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((0.987[in]/0.313[in])^2 - 1) = \mathbf{4.8}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/0.987[in])^2*(1 + 0.729) = \mathbf{0.173}$ p. 9-13

$a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*10.86[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} = \mathbf{1.03}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.03[in]/0.313[in])^2 - 1) = \mathbf{5.47}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.03[in])^2*(1 + 0.705) = \mathbf{0.157}$ p. 9-13

$HasEqualLengths \rightarrow$ **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.157 + (5 - 2)*0.173)/5 = \mathbf{0.167}$ p. 9-13

$T_{avail} = 10 * (B*Q) = 10 * (10.86[kip]*0.167) = \mathbf{18.1}[kip]$ p. 9-10

Beam

Bolt bearing under shear load	[Kip]	134.55	80.00	DL	0.59	Eq. J3-6

$L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 7.35[in] - 0.813[in]/2) = \mathbf{6.94}[in]$ Sec. J4.10

$L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*6.94[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.46[in]*65000[lb/in2]*1 = \mathbf{134.55}[kip]$ Eq. J3-6

Shear yielding	[Kip]	245.64	80.00	DL	0.33	Eq. J4-3

$A_g = L_p*t_p = 26.7[in]*0.46[in] = \mathbf{12.28}[in2]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*12.28[in2] = \mathbf{245.64}[kip]$ Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	353.93	80.00	DL	0.23	Eq. J3-6

$L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = \mathbf{1.20E+31}[in]$ Sec. J4.10

$L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.605[in]*65000[lb/in2]*1) = \mathbf{353.93}[kip]$ Eq. J3-6

Global critical strength ratio **0.80**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L_{c-end}: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

L_{c-spa}: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

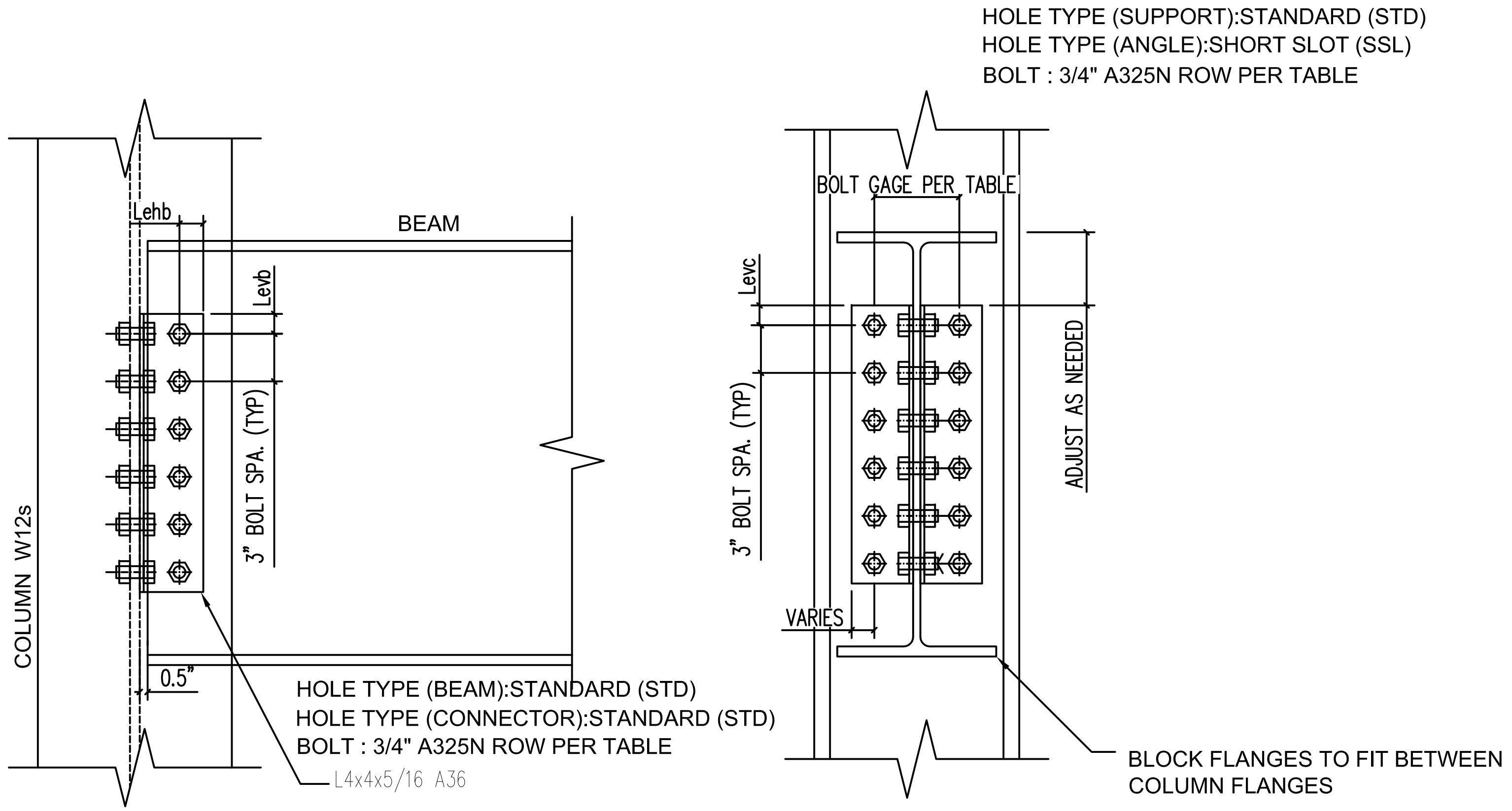
U_{bs}: Stress index

SC-01(W) BEAM TO W-SHAPE COLUMN WEB DOUBLE ANGLE CONNECTION (ALL BOLTED)

Connection ID	Beam Size	Beam Web Thickness (inch)	Design Reaction (kip) "R"	Double Angle Size**	3/4" Dia. A325N Bolt Rows	Bolt Spacing (inch) "Spa."	Bolt Gage on Column (inch) "Ga"**	Beam Side Bolt Edge Distance (inch)		Column Side Bolt Edge Distance (inch)	
								Vertical "Levb"	Horizontal "Lehb"	Vertical "Levc"	Horizontal "Lehc"
SC-01-1W	W10x17	1/4"	≤20	L4x4x5/16	2	3	6	1.25	1.25	1.25	Varies⩾ 1.125"
SC-01-2W		1/4"	≤35		3						
SC-01-3W	W14x22	1/4"	≤20	L4x4x5/16	3	3	6	1.25	1.25	1.25	
SC-01-4W	W14X26	1/4"	≤30	L4x4x5/16	3	3	6	1.25	1.25	1.25	
SC-01-5W	W16x26	1/4"	≤20	L4x4x5/16	3	3	6	1.25	1.25	1.25	
			≤40								
SC-01-6W	W16x31	1/4"	≤20	L4x4x5/16	3	3	6	1.25	1.25	1.25	
			≤40								
SC-01-7W	W18x35	5/16"	≤20	L4x4x5/16	3	3	6	1.25	1.25	1.25	
			≤40								
SC-01-8W	W18x40	5/16"	≤20	L4x4x5/16	3	3	6	1.25	1.25	1.25	
			≤40								
SC-01-9W			≤60		4						
SC-01-10W	W18X60	7/16"	≤50	L4x4x5/16	3	3	6.25	1.25	1.25	1.25	
SC-01-11W	W18X65	7/16"	≤65	L4x4x5/16	4	3	6.25	1.25	1.25	1.25	
SC-01-12W	W21X44	3/8"	≤60	L4x4x5/16	4	3	6	1.25	1.25	1.25	
SC-01-13W	W24x55	3/8"	≤20	L4x4x5/16	4	3	6	1.25	1.25	1.25	
			≤40								
			≤60								
SC-01-14W			≤80		5						
SC-01-15W	W27x94	1/2"	≤90	L4x4x5/16	6	3	6.25	1.25	1.25	1.25	
SC-01-16W	W33x118	9/16"	≤140	L4x4x5/16	8	3	6.25	1.25	1.25	1.25	
SC-01-17W	W36X247	13/16"	≤80	L4x4x5/16	6	3	6.5	1.25	1.25	1.25	
SC-01-18W	W36X282	7/8"	≤80	L4x4x5/16	6	3	6.5	1.25	1.25	1.25	
SC-01-19W	W36X302	15/16"	≤80	L4x4x5/16	6	3	6.75	1.25	1.25	1.25	

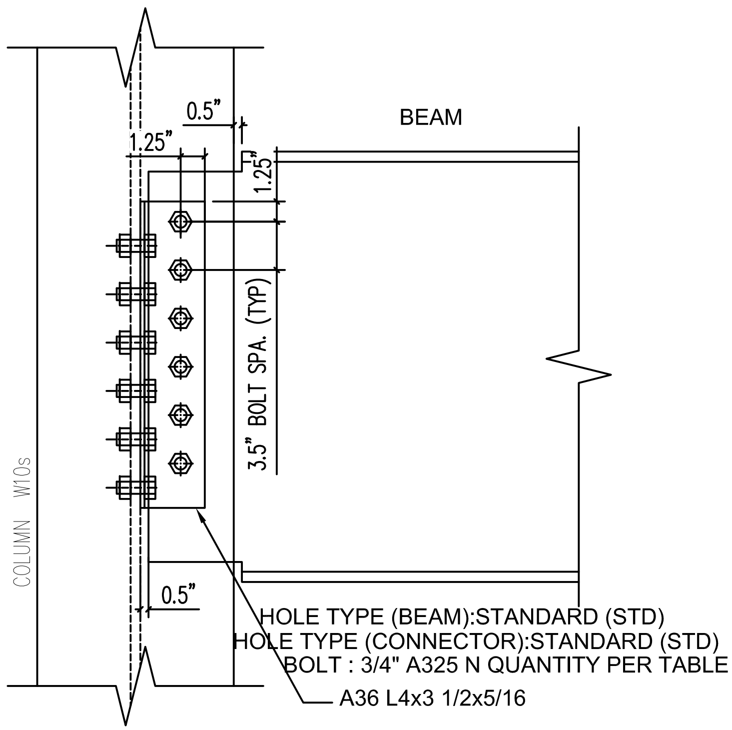
1. Short Slotted Hole on angle leg attached to supporting column
2. Blocking (Narrow down) beam flanges only to fit between column flanges
3. **Use L4x3 1/2x5/16 at W10s Column Web Connection for narrow space (7.5-8 inch wide). Short leg against column web. Gage= 5 inch. Stagger the bolt with P=1.75 inch.
4. See SC-03 connection details if beam depth is not enough for stagger pattern.
5. When beam with Ga1=6" frames into column web with beam Ga2=6.25" from the other side of column. Use Ga.=min (Ga1. Ga2)
Use stagger bolts. P=1.5 inch. For Column W10s web framing, see item 3 above.

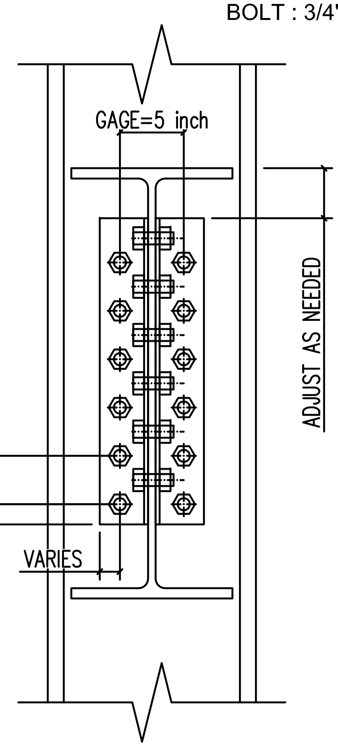
SC-01W	Beam to WF Column Web Double Angle Connection (ALL BOLTED)



SC-01W	Beam to WF Column Web Double Angle Connection (ALL BOLTED)

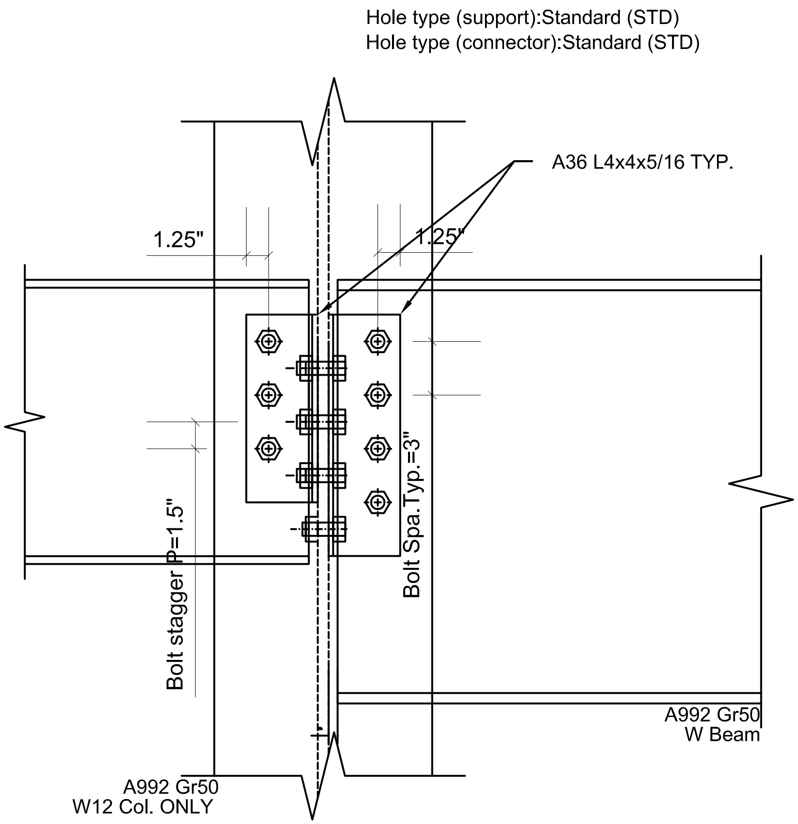
HOLE TYPE (SUPPORT):STANDARD (STD)
HOLE TYPE (CONNECTOR):SHORT SLOT (SSL)
BOLT : 3/4" A325 N QUANTITY PER TABLE

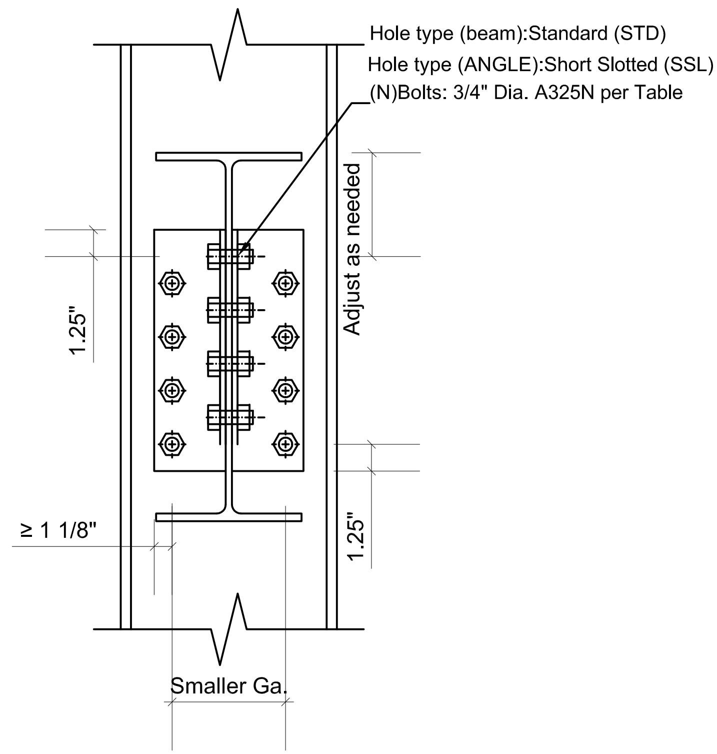




STAGGER PATTERN FOR W10s COL. NARROW WEB

SC-01W Beam to WF Column Web Double Angle Connection (ALL BOLTED)





Current Date: 2016-05-05 10:54 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB1.cnx\

Steel connections

Results

Connection name : DA BCW All bolted

Connection ID : SC-01-1W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W10x17

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	20.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	5.50	4.42	8.84	✔	p. 10-8
$L_{min} = T/2 = 8.84[in]/2 = \mathbf{4.42}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 10.1[in] - \max(0.63[in], 0[in]) - \max(0.63[in], 0[in]) = \mathbf{8.84}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.76	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.24$[in], 12 [in]$) =$ **5.76**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	42.43	20.00	DL	0.47	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (2*10.61$[kip]$) = \mathbf{42.43}$[kip] Tables (7-1..14)

Bolt bearing under shear load [Kip] 50.98 20.00 DL 0.39 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) = \mathbf{0.844}$[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) = \mathbf{2.19}$[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(2 - 1))*0.313$[in]$*58000$[lb/in2]$*1) = \mathbf{50.98}$[kip] Eq. J3-6

Shear yielding [Kip] 49.50 20.00 DL 0.40 Eq. J4-3

$A_g = L_p*t_p = 5.5$[in]$*0.313$[in] $= \mathbf{1.72}$[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*1.72$[in2]$) = \mathbf{49.5}$[kip] Eq. J4-3

Shear rupture [Kip] 40.78 20.00 DL 0.49 Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $= \mathbf{0.875}$[in] Sec. D3-2

$L_e = L - n*L_h = 5.5$[in] $- 2*0.875$[in] $= \mathbf{3.75}$[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 3.75$[in]$*0.313$[in] $= \mathbf{1.17}$[in2] Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*1.17$[in2]$) = \mathbf{40.78}$[kip] Eq. J4-4

Block shear [Kip] 43.41 20.00 DL 0.46 Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $= \mathbf{0.875}$[in] Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $= \mathbf{0.875}$[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25$[in] $+ (1 - 1)*3$[in] $- (1 - 0.5)*0.875$[in]$)*0.313$[in] $= \mathbf{0.254}$[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] $+ (2 - 1)*3$[in]$)*0.313$[in] $= \mathbf{1.33}$[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25$[in] $+ (2 - 1)*(3$[in] $- 0.875$[in]$) - 0.875$[in]$/2)*0.313$[in] $= \mathbf{0.918}$[in2] Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000$[lb/in2]$*0.918$[in2] $+ 1*58000$[lb/in2]$*0.254$[in2]$, 0.6*36000$[lb/in2]$*1.33$[in2] $+ 1*58000$[lb/in2]$*0.254$[in2]$)) = \mathbf{43.41}$[kip] Eq. J4-5

Angle (Support side)

Bolts shear [Kip] 42.43 20.00 DL 0.47 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $= \mathbf{10.61}$[kip] Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (2*10.61$[kip]$) = \mathbf{42.43}$[kip] Tables (7-1..14)

Bolt bearing under shear load [Kip] 50.98 20.00 DL 0.39 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) = \mathbf{0.844}$[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) = \mathbf{2.19}$[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(2/(1*2))*(\min(1.2*0.844$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(2 - 1))*0.313$[in]$*58000$[lb/in2]$*1) = \mathbf{50.98}$[kip] p. 7-18, Sec. J3.10

Shear yielding [Kip] 49.50 20.00 DL 0.40 Eq. J4-3

$A_g = L_p*t_p$ = 5.5[in]*0.313[in] = **1.72**[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g)$ = 2 * (0.667*0.60*36000[lb/in2]*1.72[in2]) = **49.5**[kip] Eq. J4-3

Shear rupture [Kip] 40.78 20.00 DL 0.49 Eq. J4-4

$L_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$L_e = L - n*L_h$ = 5.5[in] - 2*0.875[in] = **3.75**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 3.75[in]*0.313[in] = **1.17**[in2] Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv})$ = 2 * (0.5*0.60*58000[lb/in2]*1.17[in2]) = **40.78**[kip] Eq. J4-4

Block shear [Kip] 39.45 20.00 DL 0.51 Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (2 - 1)*3[in])*0.313[in] = **1.33**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (2 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **0.918**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}))$ = 2 * (0.5*min(0.6*58000[lb/in2]*0.918[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*1.33[in2] + 1*58000[lb/in2]*0.186[in2])) = **39.45**[kip] Eq. J4-5

Resulting tension capacity due prying action [Kip] 6.80 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts})$ = 20[kip]/(0.442[in2]*4) = **11312.22**[lb/in2] Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*11312.22[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **74579.19**[lb/in2] Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*74579.19[lb/in2]*0.442[in2] = **16.48**[kip] Eq. J3-2

$f_v = F/(A_b*N_{bolts})$ = 20[kip]/(0.442[in2]*4) = **11312.22**[lb/in2] Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*11312.22[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **74579.19**[lb/in2] Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*74579.19[lb/in2]*0.442[in2] = **16.48**[kip] Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2)$ = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

$\rho = b'/a'$ = 2.34[in]/1.5[in] = **1.56** p. 9-12

$\delta = 1 - d'/p$ = 1 - 0.813[in]/3[in] = **0.729** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5}$ = ((3.33*16.48[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))$^{0.5}$ = **1.22**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1)$ = (1/(0.729*(1 + 1.56)))*((1.22[in]/0.313[in])^2 - 1) = **7.57** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta)$ = (0.313[in]/1.22[in])^2*(1 + 0.729) = **0.114** p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2)$ = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*16.48[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} = \mathbf{1.27}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.27[in]/0.313[in])^2 - 1) = \mathbf{8.59}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.27[in])^2*(1 + 0.705) = \mathbf{0.103}$ p. 9-13

$HasEqualLengths \rightarrow$ **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.103 + (2 - 2)*0.114)/2 = \mathbf{0.103}$ p. 9-13

$T_{avail} = 4 * (B*Q) = 4 * (16.48[kip]*0.103) = \mathbf{6.8}[kip]$ p. 9-10

Beam

Bolt bearing under shear load	[Kip]	28.08	20.00	DL	0.71	Eq. J3-6

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 3.55[in] - 0.813[in]/2) = \mathbf{3.14}[in]$ Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*3.14[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(2 - 1))*0.24[in]*65000[lb/in2]*1 = \mathbf{28.08}[kip]$ Eq. J3-6

Shear yielding	[Kip]	48.48	20.00	DL	0.41	Eq. J4-3

$A_g = L_p*t_p = 10.1[in]*0.24[in] = \mathbf{2.42}[in2]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*2.42[in2] = \mathbf{48.48}[kip]$ Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	100.62	20.00	DL	0.20	Eq. J3-6

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = \mathbf{1.20E+31}[in]$ Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(2 - 1))*0.43[in]*65000[lb/in2]*1) = \mathbf{100.62}[kip]$ Eq. J3-6

Global critical strength ratio **0.71**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 11:09 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB2.cnx\

Steel connections

Results

Connection name : DA BCW All bolted

Connection ID : SC-01-2W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:10x17

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	35.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	8.50	4.42	8.84	✔	p. 10-8
$L_{min} = T/2 = 8.84[in]/2 = \mathbf{4.42}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 10.1[in] - \max(0.63[in], 0[in]) - \max(0.63[in], 0[in]) = \mathbf{8.84}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.76	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $= \mathbf{2}$[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.24$[in], 12 [in]$) = \mathbf{5.76}$[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $= \mathbf{1.13}$[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $= \mathbf{2}$[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) = \mathbf{7.5}$[in] — Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	63.65	35.00	DL	0.55	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $= \mathbf{10.61}$[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61\text{[kip]}) = \mathbf{63.65}\text{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load	[Kip]	104.50	35.00	DL	0.33	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.5*0.844\text{[in]}, 3*0.75\text{[in]}) + \min(1.5*2.19\text{[in]}, 3*0.75\text{[in]})*(3 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{104.5}\text{[kip]}$ Eq. J3-6

Shear yielding	[Kip]	76.50	35.00	DL	0.46	Eq. J4-3

$A_g = L_p*t_p = 8.5\text{[in]}*0.313\text{[in]} = \mathbf{2.66}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*2.66\text{[in2]}) = \mathbf{76.5}\text{[kip]}$ Eq. J4-3

Shear rupture	[Kip]	63.89	35.00	DL	0.55	Eq. J4-4

$L_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 8.5\text{[in]} - 3*0.875\text{[in]} = \mathbf{5.88}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88\text{[in]}*0.313\text{[in]} = \mathbf{1.84}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*1.84\text{[in2]}) = \mathbf{63.89}\text{[kip]}$ Eq. J4-4

Block shear	[Kip]	63.66	35.00	DL	0.55	Eq. J4-5

$dh_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)*0.875\text{[in]})*0.313\text{[in]} = \mathbf{0.254}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (3 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{2.27}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (3 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{1.58}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*1.58\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]}, 0.6*36000\text{[lb/in2]}*2.27\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]})) = \mathbf{63.66}\text{[kip]}$ Eq. J4-5

Angle (Support side)

Bolts shear	[Kip]	63.65	35.00	DL	0.55	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61\text{[kip]}) = \mathbf{63.65}\text{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load	[Kip]	104.50	35.00	DL	0.33	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(\min(1.5*0.844\text{[in]}, 3*0.75\text{[in]}) + \min(1.5*2.19\text{[in]}, 3*0.75\text{[in]})*(3 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{104.5}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	76.50	35.00	DL	0.46	Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] — Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	63.89	35.00	DL	0.55	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 8.5[in] - 3*0.875[in] = **5.88**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 5.88[in]*0.313[in] = **1.84**[in2] — Sec. J4-2

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] — Eq. J4-4

Block shear	[Kip]	59.70	35.00	DL	0.59	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] — Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 — Sec. J4-3

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.186[in2])) = **59.7**[kip] — Eq. J4-5

Resulting tension capacity due prying action	[Kip]	10.57	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts})$ = 35[kip]/(0.442[in2]*6) = **13197.59**[lb/in2] — Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/($(1/\Omega)$*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*13197.59[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **67509.05**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*67509.05[lb/in2]*0.442[in2] = **14.92**[kip] — Eq. J3-2

$f_v = F/(A_b*N_{bolts})$ = 35[kip]/(0.442[in2]*6) = **13197.59**[lb/in2] — Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/($(1/\Omega)$*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*13197.59[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **67509.05**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*67509.05[lb/in2]*0.442[in2] = **14.92**[kip] — Eq. J3-2

a' = Min($a + d/2$, 1.25*$b + d/2$) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] — p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] — p. 9-12

$\rho = b'/a'$ = 2.34[in]/1.5[in] = **1.56** — p. 9-12

$\delta = 1 - d'/p$ = 1 - 0.813[in]/3[in] = **0.729** — p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5}$ = ((3.33*14.92[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))$^{0.5}$ = **1.16**[in] — p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1)$ = (1/(0.729*(1 + 1.56)))*((1.16[in]/0.313[in])^2 - 1) = **6.8** — p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta)$ = (0.313[in]/1.16[in])^2*(1 + 0.729) = **0.126** — p. 9-13

a' = Min($a + d/2$, 1.25*$b + d/2$) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] — p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] — p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/2.75\text{[in]} = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*14.92\text{[kip]}*2.34\text{[in]})/(0.5*2.75\text{[in]}*58000\text{[lb/in2]}))^{0.5} = \mathbf{1.21}\text{[in]}$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.21\text{[in]}/0.313\text{[in]})^2 - 1) = \mathbf{7.73}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313\text{[in]}/1.21\text{[in]})^2*(1 + 0.705) = \mathbf{0.114}$ p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.114 + (3 - 2)*0.126)/3 = \mathbf{0.118}$ p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (14.92\text{[kip]}*0.118) = \mathbf{10.57}\text{[kip]}$ p. 9-10

Beam

Bolt bearing under shear load [Kip] 52.65 35.00 DL 0.66 Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 2.05\text{[in]} - 0.813\text{[in]}/2) = \mathbf{1.64}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.5*1.64\text{[in]}, 3*0.75\text{[in]}) + \min(1.5*2.19\text{[in]}, 3*0.75\text{[in]})*(3 - 1))*0.24\text{[in]}*65000\text{[lb/in2]}*1 = \mathbf{52.65}\text{[kip]}$ Eq. J3-6

Shear yielding [Kip] 48.48 35.00 DL 0.72 Eq. J4-3

$A_g = L_p*t_p = 10.1\text{[in]}*0.24\text{[in]} = \mathbf{2.42}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000\text{[lb/in2]}*2.42\text{[in2]} = \mathbf{48.48}\text{[kip]}$ Eq. J4-3

Support

Bolt bearing under shear load [Kip] 188.66 35.00 DL 0.19 Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.20E+31\text{[in]} - 0.813\text{[in]}/2) = \mathbf{1.20E+31}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.5*1.20E+31\text{[in]}, 3*0.75\text{[in]}) + \min(1.5*2.19\text{[in]}, 3*0.75\text{[in]})*(3 - 1))*0.43\text{[in]}*65000\text{[lb/in2]}*1) = \mathbf{188.66}\text{[kip]}$ Eq. J3-6

Global critical strength ratio **0.72**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}:Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 11:16 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB2.cnx\

Steel connections

Results

Connection name : DA BCW All bolted

Connection ID : SC-01-3W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W14x22

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	20.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	9.50	6.11	12.23	✔	p. 10-8
$L_{min} = T/2 = 12.23[\text{in}]/2 = \mathbf{6.12}[\text{in}]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 13.7[\text{in}] - \max(0.735[\text{in}], 0[\text{in}]) - \max(0.735[\text{in}], 0[\text{in}]) = \mathbf{12.23}[\text{in}]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[\text{in}] + 0[\text{in}] = \mathbf{1}[\text{in}]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.50	2.00	5.52	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.23[in], 12\ [in]) = \mathbf{5.52}[in]$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8\ [in]$						p. 10-9
<u>Angle (Support side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0.125[in] = \mathbf{1.13}[in]$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.50	2.00	6.96	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.29[in], 12\ [in]) = \mathbf{6.96}[in]$						Sec. J3.5
<u>Beam</u>						
Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Angle (Beam side)</u>						
Bolts shear	[Kip]	63.65	20.00	DL	0.31	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$						Eq. J3-1

$(1/\Omega)R_n$ = 2 * (C*$(1/\Omega)R_n$) = 2 * (3*10.61[kip]) = **63.65**[kip] Tables (7-1..14)

Bolt bearing under shear load [Kip] 83.60 20.00 DL 0.24 Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3.5[in] - 0.813[in]) = **2.69**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.69[in], 2.4*0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] Eq. J3-6

Shear yielding [Kip] 85.50 20.00 DL 0.23 Eq. J4-3

A_g = L_p*t_p = 9.5[in]*0.313[in] = **2.97**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.97[in2]) = **85.5**[kip] Eq. J4-3

Shear rupture [Kip] 74.77 20.00 DL 0.27 Eq. J4-4

L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

L_e = L - n*L_h = 9.5[in] - 3*0.875[in] = **6.88**[in] DG4 Eq. 3-13

A_{nv} = L_e*t_p = 6.88[in]*0.313[in] = **2.15**[in2] Sec. J4-2

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.15[in2]) = **74.77**[kip] Eq. J4-4

Block shear [Kip] 70.41 20.00 DL 0.28 Eq. J4-5

dh_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.313[in] = **0.254**[in2] Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (3 - 1)*3.5[in])*0.313[in] = **2.58**[in2] Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (3 - 1)*(3.5[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.89**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*1.89[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*2.58[in2] + 1*58000[lb/in2]*0.254[in2])) = **70.41**[kip] Eq. J4-5

Angle (Support side)

Bolts shear [Kip] 63.65 20.00 DL 0.31 Tables (7-1..14)

$(1/\Omega)R_n$ = $(1/\Omega)$*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] Eq. J3-1

$(1/\Omega)R_n$ = 2 * (C*$(1/\Omega)R_n$) = 2 * (3*10.61[kip]) = **63.65**[kip] Tables (7-1..14)

Bolt bearing under shear load [Kip] 83.60 20.00 DL 0.24 p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3.5[in] - 0.813[in]) = **2.69**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*(C/(n_c*n))*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.69[in], 2.4*0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] p. 7-18, Sec. J3.10

Shear yielding [Kip] 85.50 20.00 DL 0.23 Eq. J4-3

$A_g = L_p*t_p = 9.5[in]*0.313[in] = \mathbf{2.97}[in2]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.97[in2]) = \mathbf{85.5}[kip]$ Eq. J4-3

Shear rupture [Kip] 74.77 20.00 DL 0.27 Eq. J4-4

$L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 9.5[in] - 3*0.875[in] = \mathbf{6.88}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 6.88[in]*0.313[in] = \mathbf{2.15}[in2]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.15[in2]) = \mathbf{74.77}[kip]$ Eq. J4-4

Block shear [Kip] 66.45 20.00 DL 0.30 Eq. J4-5

$dh_h = d_h + 1/16 [in] = 1[in] + 1/16 [in] = \mathbf{1.06}[in]$ Sec. D3-2

$dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = \mathbf{0.186}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (3 - 1)*3.5[in])*0.313[in] = \mathbf{2.58}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (3 - 1)*(3.5[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{1.89}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*1.89[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*2.58[in2] + 1*58000[lb/in2]*0.186[in2])) = \mathbf{66.45}[kip]$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 15.28 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 20[kip]/(0.442[in2]*6) = \mathbf{7541.48}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*7541.48[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{88719.46}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*88719.46[lb/in2]*0.442[in2] = \mathbf{19.61}[kip]$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 20[kip]/(0.442[in2]*6) = \mathbf{7541.48}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*7541.48[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{88719.46}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*88719.46[lb/in2]*0.442[in2] = \mathbf{19.61}[kip]$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[in] + 0.75[in]/2, 1.25*2.22[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.22[in] - 0.75[in]/2 = \mathbf{1.84}[in]$ p. 9-12

$\rho = b'/a' = 1.84[in]/1.5[in] = \mathbf{1.23}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/3.5[in] = \mathbf{0.768}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*19.61[kip]*1.84[in])/(0.5*3.5[in]*58000[lb/in2]))^{0.5} = \mathbf{1.09}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.768*(1 + 1.23)))*((1.09[in]/0.313[in])^2 - 1) = \mathbf{6.51}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.09[in])^2*(1 + 0.768) = \mathbf{0.146}$ p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[in] + 0.75[in]/2, 1.25*2.22[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.22[in] - 0.75[in]/2 = \mathbf{1.84}[in]$ p. 9-12

$\rho = b'/a' = 1.84$[in]$/1.5$[in] $=$ **1.23** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813$[in]$/3$[in] $=$ **0.729** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*19.61$[kip]$*1.84$[in]$)/(0.5*3$[in]$*58000$[lb/in2]$))^{0.5}$ = **1.18**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.23)))*((1.18$[in]$/0.313$[in]$)^2 - 1)$ = **8.1** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313$[in]$/1.18$[in]$)^2*(1 + 0.729)$ = **0.122** p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.122 + (3 - 2)*0.146)/3$ = **0.13** p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (19.61$[kip]$*0.13)$ = **15.28**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	40.37	20.00	DL	0.50	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 3.35$[in] $- 0.813$[in]$/2)$ = **2.94**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3.5$[in] $- 0.813$[in]$)$ = **2.69**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*2.94$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.69$[in]$, 2.4*0.75$[in]$)*(3 - 1))*0.23$[in]$*65000$[lb/in2]$*1$ = **40.37**[kip] Eq. J3-6

Shear yielding	[Kip]	63.02	20.00	DL	0.32	Eq. J4-3

$A_g = L_p*t_p = 13.7$[in]$*0.23$[in] = **3.15**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000$[lb/in2]$*3.15$[in2] = **63.02**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	101.79	20.00	DL	0.20	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.20E+31$[in] $- 0.813$[in]$/2)$ = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3.5$[in] $- 0.813$[in]$)$ = **2.69**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.69$[in]$, 2.4*0.75$[in]$)*(3 - 1))*0.29$[in]$*65000$[lb/in2]$*1)$ = **101.79**[kip] Eq. J3-6

Global critical strength ratio **0.50**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 10:57 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB1.cnx\

Steel connections

Results

Connection name : DA BCW All bolted

Connection ID : SC-01-4W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W14x26

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	30.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	8.50	6.13	12.26	✔	p. 10-8
$L_{min} = T/2 = 12.26$[in]$/2 = \mathbf{6.13}$[in]						p. 10-8
$L_{max} = d$ - max(k, d_{ct}) - max(k, d_{cb}) = 13.9[in] - max(0.82[in], 0[in]) - max(0.82[in], 0[in]) = **12.26**[in]						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in]						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.12	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.255$[in], 12 [in]$) =$ **6.12**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	63.65	30.00	DL	0.47	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = 2 * (C*$(1/\Omega)R_n$) = 2 * (3*10.61[kip]) = **63.65**[kip] Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	30.00	DL	0.36	Eq. J3-6

L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] Eq. J3-6

Shear yielding	[Kip]	76.50	30.00	DL	0.39	Eq. J4-3

A_g = L_p*t_p = 8.5[in]*0.313[in] = **2.66**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] Eq. J4-3

Shear rupture	[Kip]	63.89	30.00	DL	0.47	Eq. J4-4

L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

L_e = L - n*L_h = 8.5[in] - 3*0.875[in] = **5.88**[in] DG4 Eq. 3-13

A_{nv} = L_e*t_p = 5.88[in]*0.313[in] = **1.84**[in2] Sec. J4-2

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] Eq. J4-4

Block shear	[Kip]	63.66	30.00	DL	0.47	Eq. J4-5

dh_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.313[in] = **0.254**[in2] Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.254[in2])) = **63.66**[kip] Eq. J4-5

<u>Angle (Support side)</u>

Bolts shear	[Kip]	63.65	30.00	DL	0.47	Tables (7-1..14)

$(1/\Omega)R_n$ = $(1/\Omega)$*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] Eq. J3-1

$(1/\Omega)R_n$ = 2 * (C*$(1/\Omega)R_n$) = 2 * (3*10.61[kip]) = **63.65**[kip] Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	30.00	DL	0.36	p. 7-18, Sec. J3.10

L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*(C/(n_c*n))*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] p. 7-18, Sec. J3.10

Shear yielding	[Kip]	76.50	30.00	DL	0.39		Eq. J4-3

$A_g = L_p*t_p = 8.5$[in]$*0.313$[in] $=$ **2.66**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*2.66$[in2]$) =$ **76.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	63.89	30.00	DL	0.47		Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h = 8.5$[in] $- 3*0.875$[in] $=$ **5.88**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ $= 5.88$[in]$*0.313$[in] $=$ **1.84**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*1.84$[in2]$) =$ **63.89**[kip] — Eq. J4-4

Block shear	[Kip]	59.70	30.00	DL	0.50		Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 1$[in] $+ 1/16$ [in] $=$ **1.06**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13$[in] $+ (1 - 1)*5.5$[in] $- (1 - 0.5)*$
1.06[in]$)*0.313$[in] $=$ **0.186**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] $+ (3 - 1)*3$[in]$)*0.313$[in] $=$ **2.27**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25$[in] $+ (3 - 1)*(3$[in] $- 0.875$[in]$) -$
0.875[in]$/2)*0.313$[in] $=$ **1.58**[in2] — Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*$
$A_{nt})) = 2 * (0.5*\min(0.6*58000$[lb/in2]$*1.58$[in2] $+ 1*58000$[lb/in2]$*0.186$[in2]$, 0.6*36000$[lb/in2]$*$
2.27[in2] $+ 1*58000$[lb/in2]$*0.186$[in2]$)) =$ **59.7**[kip] — Eq. J4-5

Resulting tension capacity due prying action	[Kip]	10.57	0.00	DL	0.00		p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 30$[kip]$/(0.442$[in2]$*6) =$ **11312.22**[lb/in2] — Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000$[lb/in2] $-$
90000[lb/in2]$*11312.22$[lb/in2]$/(0.5*48000$[lb/in2]$), 0.0), 90000$[lb/in2]$) =$ **74579.19**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*74579.19$[lb/in2]$*0.442$[in2] $=$ **16.48**[kip] — Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 30$[kip]$/(0.442$[in2]$*6) =$ **11312.22**[lb/in2] — Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000$[lb/in2] $-$
90000[lb/in2]$*11312.22$[lb/in2]$/(0.5*48000$[lb/in2]$), 0.0), 90000$[lb/in2]$) =$ **74579.19**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*74579.19$[lb/in2]$*0.442$[in2] $=$ **16.48**[kip] — Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13$[in] $+ 0.75$[in]$/2, 1.25*2.72$[in] $+ 0.75$[in]$/2) =$ **1.5**[in] — p. 9-12

$b' = b - d/2 = 2.72$[in] $- 0.75$[in]$/2 =$ **2.34**[in] — p. 9-12

$\rho = b'/a' = 2.34$[in]$/1.5$[in] $=$ **1.56** — p. 9-12

$\delta = 1 - d'/p = 1 - 0.813$[in]$/3$[in] $=$ **0.729** — p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*16.48$[kip]$*2.34$[in]$)/(0.5*3$[in]$*58000$[lb/in2]$))^{0.5} =$ **1.22**[in] — p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.22$[in]$/0.313$[in]$)^2 - 1) =$
7.57 — p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313$[in]$/1.22$[in]$)^2*(1 + 0.729) =$ **0.114** — p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13$[in] $+ 0.75$[in]$/2, 1.25*2.72$[in] $+ 0.75$[in]$/2) =$ **1.5**[in] — p. 9-12

$b' = b - d/2 = 2.72$[in] $- 0.75$[in]$/2 =$ **2.34**[in] — p. 9-12

$\rho = b'/a' = 2.34$[in]$/1.5$[in] $=$ **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813$[in]$/2.75$[in] $=$ **0.705** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*16.48$[kip]$*2.34$[in]$)/(0.5*2.75$[in]$*58000$[lb/in2]$))^{0.5} =$ **1.27**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.27$[in]$/0.313$[in]$)^2 - 1) =$ **8.59** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313$[in]$/1.27$[in]$)^2*(1 + 0.705) =$ **0.103** p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.103 + (3 - 2)*0.114)/3 =$ **0.107** p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (16.48$[kip]$*0.107) =$ **10.57**[kip] p. 9-10

Beam

Bolt bearing under shear load [Kip] 44.75 30.00 DL 0.67 Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 3.95$[in] $- 0.813$[in]$/2) =$ **3.54**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*3.54$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(3 - 1))*0.255$[in]$*65000$[lb/in2]$*1 =$ **44.75**[kip] Eq. J3-6

Shear yielding [Kip] 70.89 30.00 DL 0.42 Eq. J4-3

$A_g = L_p*t_p = 13.9$[in]$*0.255$[in] $=$ **3.54**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000$[lb/in2]$*3.54$[in2] $=$ **70.89**[kip] Eq. J4-3

Support

Bolt bearing under shear load [Kip] 180.77 30.00 DL 0.17 Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.20E+31$[in] $- 0.813$[in]$/2) =$ **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(3 - 1))*0.515$[in]$*65000$[lb/in2]$*1) =$ **180.77**[kip] Eq. J3-6

Global critical strength ratio **0.67**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

L_{c-spa}: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-06 3:43 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB2.cnx\

Steel connections

Results

Connection name : DA BCW All bolted

Connection ID : SC-01-5W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W16x26

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	40.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	8.50	7.10	14.21	✔	p. 10-8
$L_{min} = T/2 = 14.21[\text{in}]/2 = \mathbf{7.1}[\text{in}]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 15.7[\text{in}] - \max(0.747[\text{in}], 0[\text{in}]) - \max(0.747[\text{in}], 0[\text{in}]) = \mathbf{14.21}[\text{in}]$						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[\text{in}] + 0[\text{in}] = \mathbf{1}[\text{in}]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.00	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in]						Sec. J3.3
IsCorrosionConsidered → **False**						
$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.25[in], 12 [in]) = **6**[in]						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8$ [in]						p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0.125[in] = **1.13**[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in]						Sec. J3.3
IsCorrosionConsidered → **False**						
$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in]						Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in]						Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	63.65	40.00	DL	0.63	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]*0.442[in2] = **10.61**[kip]						Eq. J3-1

$(1/\Omega)R_n$ = 2 * (C*$(1/\Omega)R_n$) = 2 * (3*10.61[kip]) = **63.65**[kip] Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	40.00	DL	0.48	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4* 0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] Eq. J3-6

Shear yielding	[Kip]	76.50	40.00	DL	0.52	Eq. J4-3

A_g = L_p*t_p = 8.5[in]*0.313[in] = **2.66**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] Eq. J4-3

Shear rupture	[Kip]	63.89	40.00	DL	0.63	Eq. J4-4

L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

L_e = L - n*L_h = 8.5[in] - 3*0.875[in] = **5.88**[in] DG4 Eq. 3-13

A_{nv} = L_e*t_p = 5.88[in]*0.313[in] = **1.84**[in2] Sec. J4-2

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] Eq. J4-4

Block shear	[Kip]	63.66	40.00	DL	0.63	Eq. J4-5

dh_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)* 0.875[in])*0.313[in] = **0.254**[in2] Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]* 2.27[in2] + 1*58000[lb/in2]*0.254[in2])) = **63.66**[kip] Eq. J4-5

Angle (Support side)

Bolts shear	[Kip]	63.65	40.00	DL	0.63	Tables (7-1..14)

$(1/\Omega)R_n$ = $(1/\Omega)$*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] Eq. J3-1

$(1/\Omega)R_n$ = 2 * (C*$(1/\Omega)R_n$) = 2 * (3*10.61[kip]) = **63.65**[kip] Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	40.00	DL	0.48	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*(C/(n_c*n))*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2* d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2* 2.19[in], 2.4*0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] p. 7-18, Sec. J3.10

Shear yielding	[Kip]	76.50	40.00	DL	0.52		Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] — Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	63.89	40.00	DL	0.63		Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 8.5[in] - 3*0.875[in] = **5.88**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 5.88[in]*0.313[in] = **1.84**[in2] — Sec. J4-2

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] — Eq. J4-4

Block shear	[Kip]	59.70	40.00	DL	0.67		Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] — Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 — Sec. J4-3

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.186[in2])) = **59.7**[kip] — Eq. J4-5

Resulting tension capacity due prying action	[Kip]	10.57	0.00	DL	0.00		p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts})$ = 40[kip]/(0.442[in2]*6) = **15082.96**[lb/in2] — Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/($(1/\Omega)$*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*15082.96[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **60438.91**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*60438.91[lb/in2]*0.442[in2] = **13.36**[kip] — Eq. J3-2

$f_v = F/(A_b*N_{bolts})$ = 40[kip]/(0.442[in2]*6) = **15082.96**[lb/in2] — Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/($(1/\Omega)$*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*15082.96[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **60438.91**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*60438.91[lb/in2]*0.442[in2] = **13.36**[kip] — Eq. J3-2

a' = Min($a + d/2$, 1.25*$b + d/2$) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] — p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] — p. 9-12

$\rho = b'/a'$ = 2.34[in]/1.5[in] = **1.56** — p. 9-12

$\delta = 1 - d'/p$ = 1 - 0.813[in]/3[in] = **0.729** — p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5}$ = ((3.33*13.36[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))$^{0.5}$ = **1.09**[in] — p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1)$ = (1/(0.729*(1 + 1.56)))*((1.09[in]/0.313[in])^2 - 1) = **6.03** — p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta)$ = (0.313[in]/1.09[in])^2*(1 + 0.729) = **0.141** — p. 9-13

a' = Min($a + d/2$, 1.25*$b + d/2$) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] — p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] — p. 9-12

$\rho = b'/a' = 2.34_{[in]}/1.5_{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813_{[in]}/2.75_{[in]} = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*13.36_{[kip]}*2.34_{[in]})/(0.5*2.75_{[in]}*58000_{[lb/in2]}))^{0.5} = \mathbf{1.14}_{[in]}$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.14_{[in]}/0.313_{[in]})^2 - 1) = \mathbf{6.86}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313_{[in]}/1.14_{[in]})^2*(1 + 0.705) = \mathbf{0.127}$ p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.127 + (3 - 2)*0.141)/3 = \mathbf{0.132}$ p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (13.36_{[kip]}*0.132) = \mathbf{10.57}_{[kip]}$ p. 9-10

Beam

Bolt bearing under shear load	[Kip]	43.88	40.00	DL	0.91	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 4.85_{[in]} - 0.813_{[in]}/2) = \mathbf{4.44}_{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3_{[in]} - 0.813_{[in]}) = \mathbf{2.19}_{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*4.44_{[in]}, 2.4*0.75_{[in]}) + \min(1.2*2.19_{[in]}, 2.4*0.75_{[in]})*(3 - 1))*0.25_{[in]}*65000_{[lb/in2]}*1 = \mathbf{43.88}_{[kip]}$ Eq. J3-6

Shear yielding	[Kip]	78.50	40.00	DL	0.51	Eq. J4-3

$A_g = L_p*t_p = 15.7_{[in]}*0.25_{[in]} = \mathbf{3.93}_{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000_{[lb/in2]}*3.93_{[in2]} = \mathbf{78.5}_{[kip]}$ Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	121.10	40.00	DL	0.33	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.20E+31_{[in]} - 0.813_{[in]}/2) = \mathbf{1.20E+31}_{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3_{[in]} - 0.813_{[in]}) = \mathbf{2.19}_{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31_{[in]}, 2.4*0.75_{[in]}) + \min(1.2*2.19_{[in]}, 2.4*0.75_{[in]})*(3 - 1))*0.345_{[in]}*65000_{[lb/in2]}*1) = \mathbf{121.1}_{[kip]}$ Eq. J3-6

Global critical strength ratio **0.91**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 1:12 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB4.cnx\

Steel connections

Results

Connection name : DA BCW All bolted

Connection ID : SC-01-6W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W16x31

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	40.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	8.50	7.11	14.22	✔	p. 10-8
$L_{min} = T/2 = 14.22[in]/2 = \mathbf{7.11}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 15.9[in] - \max(0.842[in], 0[in]) - \max(0.842[in], 0[in]) = \mathbf{14.22}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--		Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.60		Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d$ = 8/3*0.75[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12\text{ [in]})$ = min(24*0.275[in], 12 [in]) = **6.6**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63		p. 10-9

t_{pmax} = 5/8 [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--		Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--		Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1[in] + 0.125[in] = **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50		Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d$ = 8/3*0.75[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12\text{ [in]})$ = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--		Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	63.65	40.00	DL	0.63	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = 2 * (C*$(1/\Omega)R_n$) = 2 * (3*10.61[kip]) = **63.65**[kip] Tables (7-1..14)

Bolt bearing under shear load [Kip] 83.60 40.00 DL 0.48 Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($1/\Omega$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] Eq. J3-6

Shear yielding [Kip] 76.50 40.00 DL 0.52 Eq. J4-3

A_g = L_p*t_p = 8.5[in]*0.313[in] = **2.66**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * (($1/\Omega$)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] Eq. J4-3

Shear rupture [Kip] 63.89 40.00 DL 0.63 Eq. J4-4

L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

L_e = L - n*L_h = 8.5[in] - 3*0.875[in] = **5.88**[in] DG4 Eq. 3-13

A_{nv} = L_e*t_p = 5.88[in]*0.313[in] = **1.84**[in2] Sec. J4-2

$(1/\Omega)R_n$ = 2 * (($1/\Omega$)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] Eq. J4-4

Block shear [Kip] 63.66 40.00 DL 0.63 Eq. J4-5

dh_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.313[in] = **0.254**[in2] Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n$ = 2 * (($1/\Omega$)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.254[in2])) = **63.66**[kip] Eq. J4-5

Angle (Support side)

Bolts shear [Kip] 63.65 40.00 DL 0.63 Tables (7-1..14)

$(1/\Omega)R_n$ = $(1/\Omega)$*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] Eq. J3-1

$(1/\Omega)R_n$ = 2 * (C*$(1/\Omega)R_n$) = 2 * (3*10.61[kip]) = **63.65**[kip] Tables (7-1..14)

Bolt bearing under shear load [Kip] 83.60 40.00 DL 0.48 p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($1/\Omega$)*(C/(n_c*n))*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] p. 7-18, Sec. J3.10

Shear yielding	[Kip]	76.50	40.00	DL	0.52	Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] — Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)*0.60*F_y*A_g$) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	63.89	40.00	DL	0.63	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 8.5[in] - 3*0.875[in] = **5.88**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 5.88[in]*0.313[in] = **1.84**[in2] — Sec. J4-2

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)*0.60*F_u*A_{nv}$) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] — Eq. J4-4

Block shear	[Kip]	59.70	40.00	DL	0.67	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] — Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 — Sec. J4-3

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*min($0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}$, $0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}$)) = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.186[in2])) = **59.7**[kip] — Eq. J4-5

Resulting tension capacity due prying action	[Kip]	10.57	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts})$ = 40[kip]/(0.442[in2]*6) = **15082.96**[lb/in2] — Sec. J3.7

F'_{nt} = min(max($1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv})$, 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*15082.96[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **60438.91**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*60438.91[lb/in2]*0.442[in2] = **13.36**[kip] — Eq. J3-2

$f_v = F/(A_b*N_{bolts})$ = 40[kip]/(0.442[in2]*6) = **15082.96**[lb/in2] — Sec. J3.7

F'_{nt} = min(max($1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv})$, 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*15082.96[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **60438.91**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*60438.91[lb/in2]*0.442[in2] = **13.36**[kip] — Eq. J3-2

a' = Min($a + d/2$, $1.25*b + d/2$) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] — p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] — p. 9-12

$\rho = b'/a'$ = 2.34[in]/1.5[in] = **1.56** — p. 9-12

$\delta = 1 - d'/p$ = 1 - 0.813[in]/3[in] = **0.729** — p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5}$ = ((3.33*13.36[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))$^{0.5}$ = **1.09**[in] — p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1)$ = (1/(0.729*(1 + 1.56)))*((1.09[in]/0.313[in])^2 - 1) = **6.03** — p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta)$ = (0.313[in]/1.09[in])^2*(1 + 0.729) = **0.141** — p. 9-13

a' = Min($a + d/2$, $1.25*b + d/2$) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] — p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] — p. 9-12

$\rho = b'/a' = 2.34$[in]$/1.5$[in] $=$ **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813$[in]$/2.75$[in] $=$ **0.705** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*13.36$[kip]$*2.34$[in]$)/(0.5*2.75$[in]$*58000$[lb/in2]$))^{0.5} =$ **1.14**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.14$[in]$/0.313$[in]$)^2 - 1) =$ **6.86** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313$[in]$/1.14$[in]$)^2*(1 + 0.705) =$ **0.127** p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.127 + (3 - 2)*0.141)/3 =$ **0.132** p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (13.36$[kip]$*0.132) =$ **10.57**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	48.26	40.00	DL	0.83	Eq. J3-6

$L_{c-end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 4.95$[in] $- 0.813$[in]$/2) =$ **4.54**[in] Sec. J4.10

$L_{c-spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*4.54$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(3 - 1))*0.275$[in]$*65000$[lb/in2]$*1 =$ **48.26**[kip] Eq. J3-6

Shear yielding	[Kip]	87.45	40.00	DL	0.46	Eq. J4-3

$A_g = L_p*t_p = 15.9$[in]$*0.275$[in] $=$ **4.37**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000$[lb/in2]$*4.37$[in2] $=$ **87.45**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	136.89	40.00	DL	0.29	Eq. J3-6

$L_{c-end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.20E+31$[in] $- 0.813$[in]$/2) =$ **1.20E+31**[in] Sec. J4.10

$L_{c-spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(3 - 1))*0.39$[in]$*65000$[lb/in2]$*1) =$ **136.89**[kip] Eq. J3-6

Global critical strength ratio **0.83**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 11:08 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB2.cnx\

Steel connections

Results

Connection name : DA BCW All bolted

Connection ID : SC-01-7W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W18x35

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	40.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	8.50	8.02	16.05	✔	p. 10-8

$L_{min} = T/2 = 16.05[\text{in}]/2 = \mathbf{8.02}[\text{in}]$ p. 10-8

$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 17.7[\text{in}] - \max(0.827[\text{in}], 0[\text{in}]) - \max(0.827[\text{in}], 0[\text{in}]) = \mathbf{16.05}[\text{in}]$ p. 10-8

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[\text{in}] + 0[\text{in}] = \mathbf{1}[\text{in}]$ Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--		Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.20		Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in]						Sec. J3.3
IsCorrosionConsidered → **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.3$[in], 12 [in]$) =$ **7.2**[in]						Sec. J3.5
Thickness	[in]	0.31	--	0.63		p. 10-9
$t_{pmax} = 5/8$ [in]						p. 10-9

<u>Angle (Support side)</u>

Vertical edge distance	[in]	1.25	1.00	--		Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--		Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50		Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in]						Sec. J3.3
IsCorrosionConsidered → **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in]						Sec. J3.5

<u>Beam</u>

Horizontal edge distance	[in]	2.25	1.00	--		Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Angle (Beam side)</u>						
Bolts shear	[Kip]	63.65	40.00	DL	0.63	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip]						Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61[kip]) = \mathbf{63.65}[kip]$ Tables (7-1..14)

Bolt bearing under shear load	[Kip]	104.50	40.00	DL	0.38	Eq. J3-6

$L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ Sec. J4.10

$L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(min(1.5*0.844[in], 3*0.75[in]) + min(1.5*2.19[in], 3*0.75[in])* (3 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{104.5}[kip]$ Eq. J3-6

Shear yielding	[Kip]	76.50	40.00	DL	0.52	Eq. J4-3

$A_g = L_p*t_p = 8.5[in]*0.313[in] = \mathbf{2.66}[in2]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = \mathbf{76.5}[kip]$ Eq. J4-3

Shear rupture	[Kip]	63.89	40.00	DL	0.63	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 8.5[in] - 3*0.875[in] = \mathbf{5.88}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88[in]*0.313[in] = \mathbf{1.84}[in2]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = \mathbf{63.89}[kip]$ Eq. J4-4

Block shear	[Kip]	63.66	40.00	DL	0.63	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)* 0.875[in])*0.313[in] = \mathbf{0.254}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (3 - 1)*3[in])*0.313[in] = \mathbf{2.27}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{1.58}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]* 2.27[in2] + 1*58000[lb/in2]*0.254[in2])) = \mathbf{63.66}[kip]$ Eq. J4-5

<u>Angle (Support side)</u>

Bolts shear	[Kip]	63.65	40.00	DL	0.63	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61[kip]) = \mathbf{63.65}[kip]$ Tables (7-1..14)

Bolt bearing under shear load	[Kip]	104.50	40.00	DL	0.38	p. 7-18, Sec. J3.10

$L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ Sec. J4.10

$L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2* d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(min(1.5*0.844[in], 3*0.75[in]) + min(1.5* 2.19[in], 3*0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{104.5}[kip]$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	76.50	40.00	DL	0.52	Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] — Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	63.89	40.00	DL	0.63	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 8.5[in] - 3*0.875[in] = **5.88**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 5.88[in]*0.313[in] = **1.84**[in2] — Sec. J4-2

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] — Eq. J4-4

Block shear	[Kip]	59.70	40.00	DL	0.67	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] — Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 — Sec. J4-3

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.186[in2])) = **59.7**[kip] — Eq. J4-5

Resulting tension capacity due prying action	[Kip]	10.57	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts})$ = 40[kip]/(0.442[in2]*6) = **15082.96**[lb/in2] — Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/($(1/\Omega)$*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*15082.96[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **60438.91**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*60438.91[lb/in2]*0.442[in2] = **13.36**[kip] — Eq. J3-2

$f_v = F/(A_b*N_{bolts})$ = 40[kip]/(0.442[in2]*6) = **15082.96**[lb/in2] — Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/($(1/\Omega)$*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*15082.96[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **60438.91**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*60438.91[lb/in2]*0.442[in2] = **13.36**[kip] — Eq. J3-2

a' = Min($a + d/2$, 1.25*$b + d/2$) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] — p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] — p. 9-12

$\rho = b'/a'$ = 2.34[in]/1.5[in] = **1.56** — p. 9-12

$\delta = 1 - d'/p$ = 1 - 0.813[in]/3[in] = **0.729** — p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5}$ = ((3.33*13.36[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))$^{0.5}$ = **1.09**[in] — p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1)$ = (1/(0.729*(1 + 1.56)))*((1.09[in]/0.313[in])^2 - 1) = **6.03** — p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta)$ = (0.313[in]/1.09[in])^2*(1 + 0.729) = **0.141** — p. 9-13

a' = Min($a + d/2$, 1.25*$b + d/2$) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] — p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] — p. 9-12

$\rho = b'/a' = 2.34$[in]$/1.5$[in] = **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813$[in]$/2.75$[in] = **0.705** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*13.36$[kip]$*2.34$[in]$)/(0.5*2.75$[in]$*58000$[lb/in2]$))^{0.5}$ = **1.14**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.14$[in]$/0.313$[in]$)^2 - 1)$ = **6.86** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313$[in]$/1.14$[in]$)^2*(1 + 0.705)$ = **0.127** p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.127 + (3 - 2)*0.141)/3$ = **0.132** p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (13.36$[kip]$*0.132)$ = **10.57**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	65.81	40.00	DL	0.61		Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 5.85$[in]$ - 0.813$[in]$/2)$ = **5.44**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in]$ - 0.813$[in]$)$ = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.5*5.44$[in]$, 3*0.75$[in]$) + \min(1.5*2.19$[in]$, 3*0.75$[in]$)*(3 - 1))*0.3$[in]$*65000$[lb/in2]$*1$ = **65.81**[kip] Eq. J3-6

Shear yielding	[Kip]	106.20	40.00	DL	0.38		Eq. J4-3

$A_g = L_p*t_p = 17.7$[in]$*0.3$[in] = **5.31**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000$[lb/in2]$*5.31$[in2] = **106.2**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	188.66	40.00	DL	0.21		Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.20E+31$[in]$ - 0.813$[in]$/2)$ = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in]$ - 0.813$[in]$)$ = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.5*1.20E+31$[in]$, 3*0.75$[in]$) + \min(1.5*2.19$[in]$, 3*0.75$[in]$)*(3 - 1))*0.43$[in]$*65000$[lb/in2]$*1)$ = **188.66**[kip] Eq. J3-6

Global critical strength ratio **0.67**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 10:55 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB1.cnx\

Steel connections

Results

Connection name : DA BCW All bolted

Connection ID : SC-01-8W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:18x40

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	40.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	8.50	8.02	16.05	✔	p. 10-8
$L_{min} = T/2 = 16.05[in]/2 = \mathbf{8.02}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 17.9[in] - \max(0.927[in], 0[in]) - \max(0.927[in], 0[in]) = \mathbf{16.05}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0.125[in] = **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	63.65	40.00	DL	0.63	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61\text{[kip]}) = \mathbf{63.65}\text{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 83.60 40.00 DL 0.48 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(3 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{83.6}\text{[kip]}$ Eq. J3-6

Shear yielding [Kip] 76.50 40.00 DL 0.52 Eq. J4-3

$A_g = L_p*t_p = 8.5\text{[in]}*0.313\text{[in]} = \mathbf{2.66}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*2.66\text{[in2]}) = \mathbf{76.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 63.89 40.00 DL 0.63 Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 8.5\text{[in]} - 3*0.875\text{[in]} = \mathbf{5.88}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88\text{[in]}*0.313\text{[in]} = \mathbf{1.84}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*1.84\text{[in2]}) = \mathbf{63.89}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 63.66 40.00 DL 0.63 Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)* 0.875\text{[in]})*0.313\text{[in]} = \mathbf{0.254}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (3 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{2.27}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (3 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{1.58}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*1.58\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]}, 0.6*36000\text{[lb/in2]}* 2.27\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]})) = \mathbf{63.66}\text{[kip]}$ Eq. J4-5

Angle (Support side)

Bolts shear [Kip] 63.65 40.00 DL 0.63 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61\text{[kip]}) = \mathbf{63.65}\text{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 83.60 40.00 DL 0.48 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2* d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2* 2.19\text{[in]}, 2.4*0.75\text{[in]})*(3 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{83.6}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	76.50	40.00	DL	0.52	Eq. J4-3

$A_g = L_p * t_p = 8.5[\mathrm{in}]*0.313[\mathrm{in}] = \mathbf{2.66}[\mathrm{in2}]$ — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[\mathrm{lb/in2}]*2.66[\mathrm{in2}]) = \mathbf{76.5}[\mathrm{kip}]$ — Eq. J4-3

Shear rupture	[Kip]	63.89	40.00	DL	0.63	Eq. J4-4

$L_h = d_h + 1/16\,[\mathrm{in}] = 0.813[\mathrm{in}] + 1/16\,[\mathrm{in}] = \mathbf{0.875}[\mathrm{in}]$ — Sec. D3-2

$L_e = L - n*L_h = 8.5[\mathrm{in}] - 3*0.875[\mathrm{in}] = \mathbf{5.88}[\mathrm{in}]$ — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88[\mathrm{in}]*0.313[\mathrm{in}] = \mathbf{1.84}[\mathrm{in2}]$ — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[\mathrm{lb/in2}]*1.84[\mathrm{in2}]) = \mathbf{63.89}[\mathrm{kip}]$ — Eq. J4-4

Block shear	[Kip]	59.70	40.00	DL	0.67	Eq. J4-5

$dh_h = d_h + 1/16\,[\mathrm{in}] = 1[\mathrm{in}] + 1/16\,[\mathrm{in}] = \mathbf{1.06}[\mathrm{in}]$ — Sec. D3-2

$dh_v = d_h + 1/16\,[\mathrm{in}] = 0.813[\mathrm{in}] + 1/16\,[\mathrm{in}] = \mathbf{0.875}[\mathrm{in}]$ — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[\mathrm{in}] + (1 - 1)*5.5[\mathrm{in}] - (1 - 0.5)*1.06[\mathrm{in}])*0.313[\mathrm{in}] = \mathbf{0.186}[\mathrm{in2}]$ — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[\mathrm{in}] + (3 - 1)*3[\mathrm{in}])*0.313[\mathrm{in}] = \mathbf{2.27}[\mathrm{in2}]$ — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[\mathrm{in}] + (3 - 1)*(3[\mathrm{in}] - 0.875[\mathrm{in}]) - 0.875[\mathrm{in}]/2)*0.313[\mathrm{in}] = \mathbf{1.58}[\mathrm{in2}]$ — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[\mathrm{lb/in2}]*1.58[\mathrm{in2}] + 1*58000[\mathrm{lb/in2}]*0.186[\mathrm{in2}], 0.6*36000[\mathrm{lb/in2}]*2.27[\mathrm{in2}] + 1*58000[\mathrm{lb/in2}]*0.186[\mathrm{in2}])) = \mathbf{59.7}[\mathrm{kip}]$ — Eq. J4-5

Resulting tension capacity due prying action	[Kip]	10.57	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 40[\mathrm{kip}]/(0.442[\mathrm{in2}]*6) = \mathbf{15082.96}[\mathrm{lb/in2}]$ — Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[\mathrm{lb/in2}] - 90000[\mathrm{lb/in2}]*15082.96[\mathrm{lb/in2}]/(0.5*48000[\mathrm{lb/in2}]), 0.0), 90000[\mathrm{lb/in2}]) = \mathbf{60438.91}[\mathrm{lb/in2}]$ — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*60438.91[\mathrm{lb/in2}]*0.442[\mathrm{in2}] = \mathbf{13.36}[\mathrm{kip}]$ — Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 40[\mathrm{kip}]/(0.442[\mathrm{in2}]*6) = \mathbf{15082.96}[\mathrm{lb/in2}]$ — Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[\mathrm{lb/in2}] - 90000[\mathrm{lb/in2}]*15082.96[\mathrm{lb/in2}]/(0.5*48000[\mathrm{lb/in2}]), 0.0), 90000[\mathrm{lb/in2}]) = \mathbf{60438.91}[\mathrm{lb/in2}]$ — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*60438.91[\mathrm{lb/in2}]*0.442[\mathrm{in2}] = \mathbf{13.36}[\mathrm{kip}]$ — Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[\mathrm{in}] + 0.75[\mathrm{in}]/2, 1.25*2.72[\mathrm{in}] + 0.75[\mathrm{in}]/2) = \mathbf{1.5}[\mathrm{in}]$ — p. 9-12

$b' = b - d/2 = 2.72[\mathrm{in}] - 0.75[\mathrm{in}]/2 = \mathbf{2.34}[\mathrm{in}]$ — p. 9-12

$\rho = b'/a' = 2.34[\mathrm{in}]/1.5[\mathrm{in}] = \mathbf{1.56}$ — p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[\mathrm{in}]/3[\mathrm{in}] = \mathbf{0.729}$ — p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*13.36[\mathrm{kip}]*2.34[\mathrm{in}])/(0.5*3[\mathrm{in}]*58000[\mathrm{lb/in2}]))^{0.5} = \mathbf{1.09}[\mathrm{in}]$ — p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.09[\mathrm{in}]/0.313[\mathrm{in}])^2 - 1) = \mathbf{6.03}$ — p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[\mathrm{in}]/1.09[\mathrm{in}])^2*(1 + 0.729) = \mathbf{0.141}$ — p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[\mathrm{in}] + 0.75[\mathrm{in}]/2, 1.25*2.72[\mathrm{in}] + 0.75[\mathrm{in}]/2) = \mathbf{1.5}[\mathrm{in}]$ — p. 9-12

$b' = b - d/2 = 2.72[\mathrm{in}] - 0.75[\mathrm{in}]/2 = \mathbf{2.34}[\mathrm{in}]$ — p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*13.36[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} = \mathbf{1.14}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.14[in]/0.313[in])^2 - 1) = \mathbf{6.86}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.14[in])^2*(1 + 0.705) = \mathbf{0.127}$ p. 9-13

$HasEqualLengths \rightarrow$ **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.127 + (3 - 2)*0.141)/3 = \mathbf{0.132}$ p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (13.36[kip]*0.132) = \mathbf{10.57}[kip]$ p. 9-10

Beam

Bolt bearing under shear load	[Kip]	55.28	40.00	DL	0.72	Eq. J3-6

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 5.95[in] - 0.813[in]/2) = \mathbf{5.54}[in]$ Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*5.54[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.315[in]*65000[lb/in2]*1 = \mathbf{55.28}[kip]$ Eq. J3-6

Shear yielding	[Kip]	112.77	40.00	DL	0.35	Eq. J4-3

$A_g = L_p*t_p = 17.9[in]*0.315[in] = \mathbf{5.64}[in2]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*5.64[in2] = \mathbf{112.77}[kip]$ Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	164.97	40.00	DL	0.24	Eq. J3-6

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = \mathbf{1.20E+31}[in]$ Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.47[in]*65000[lb/in2]*1) = \mathbf{164.97}[kip]$ Eq. J3-6

Global critical strength ratio **0.72**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}:Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 1:05 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB4.cnx\

Steel connections

Results

Connection name : DA BCW All bolted
Connection ID : SC-01-9W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W18x40

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	60.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	11.50	8.02	16.05	✔	p. 10-8

$L_{min} = T/2 = 16.05\text{[in]}/2 = \mathbf{8.02}\text{[in]}$ — p. 10-8

$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 17.9\text{[in]} - \max(0.927\text{[in]}, 0\text{[in]}) - \max(0.927\text{[in]}, 0\text{[in]}) = \mathbf{16.05}\text{[in]}$ — p. 10-8

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$ — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

$IsCorrosionConsidered \rightarrow$ **False**

$s_{max} = \min(24*t_p,\ 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

$IsCorrosionConsidered \rightarrow$ **False**

$s_{max} = \min(24*t_p,\ 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	84.86	60.00	DL	0.71	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = 2 * (C*$(1/\Omega)R_n$) = 2 * (4*10.61[kip]) = **84.86**[kip] Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	60.00	DL	0.52	Eq. J3-6

L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = **116.23**[kip] Eq. J3-6

Shear yielding	[Kip]	103.50	60.00	DL	0.58	Eq. J4-3

A_g = L_p*t_p = 11.5[in]*0.313[in] = **3.59**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = **103.5**[kip] Eq. J4-3

Shear rupture	[Kip]	87.00	60.00	DL	0.69	Eq. J4-4

L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

L_e = L - n*L_h = 11.5[in] - 4*0.875[in] = **8**[in] DG4 Eq. 3-13

A_{nv} = L_e*t_p = 8[in]*0.313[in] = **2.5**[in2] Sec. J4-2

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = **87**[kip] Eq. J4-4

Block shear	[Kip]	83.91	60.00	DL	0.72	Eq. J4-5

dh_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.313[in] = **0.254**[in2] Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (4 - 1)*3[in])*0.313[in] = **3.2**[in2] Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.25**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*3.2[in2] + 1*58000[lb/in2]*0.254[in2])) = **83.91**[kip] Eq. J4-5

Angle (Support side)

Bolts shear	[Kip]	84.86	60.00	DL	0.71	Tables (7-1..14)

$(1/\Omega)R_n$ = $(1/\Omega)$*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] Eq. J3-1

$(1/\Omega)R_n$ = 2 * (C*$(1/\Omega)R_n$) = 2 * (4*10.61[kip]) = **84.86**[kip] Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	60.00	DL	0.52	p. 7-18, Sec. J3.10

L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($(1/\Omega)$*(C/(n_c*n))*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(4/(1*4))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = **116.23**[kip] p. 7-18, Sec. J3.10

Shear yielding	[Kip]	103.50	60.00	DL	0.58	Eq. J4-3

$A_g = L_p * t_p$ = 11.5[in]*0.313[in] = **3.59**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g)$ = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = **103.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	87.00	60.00	DL	0.69	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 11.5[in] - 4*0.875[in] = **8**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 8[in]*0.313[in] = **2.5**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv})$ = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = **87**[kip] — Eq. J4-4

Block shear	[Kip]	79.95	60.00	DL	0.75	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (4 - 1)*3[in])*0.313[in] = **3.2**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.25**[in2] — Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 — Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}))$ = 2 * (0.5*min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*3.2[in2] + 1*58000[lb/in2]*0.186[in2])) = **79.95**[kip] — Eq. J4-5

Resulting tension capacity due prying action	[Kip]	14.33	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts})$ = 60[kip]/(0.442[in2]*8) = **16968.33**[lb/in2] — Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*16968.33[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **53368.78**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*53368.78[lb/in2]*0.442[in2] = **11.79**[kip] — Eq. J3-2

$f_v = F/(A_b*N_{bolts})$ = 60[kip]/(0.442[in2]*8) = **16968.33**[lb/in2] — Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*16968.33[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **53368.78**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*53368.78[lb/in2]*0.442[in2] = **11.79**[kip] — Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2)$ = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] — p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] — p. 9-12

$\rho = b'/a'$ = 2.34[in]/1.5[in] = **1.56** — p. 9-12

$\delta = 1 - d'/p$ = 1 - 0.813[in]/3[in] = **0.729** — p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5}$ = ((3.33*11.79[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))$^{0.5}$ = **1.03**[in] — p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1)$ = (1/(0.729*(1 + 1.56)))*((1.03[in]/0.313[in])^2 - 1) = **5.26** — p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta)$ = (0.313[in]/1.03[in])^2*(1 + 0.729) = **0.16** — p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2)$ = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] — p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] — p. 9-12

$\rho = b'/a' = 2.34$[in]$/1.5$[in] $= \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813$[in]$/2.75$[in] $= \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*11.79$[kip]$*2.34$[in]$)/(0.5*2.75$[in]$*58000$[lb/in2]$))^{0.5} = \mathbf{1.07}$[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.07$[in]$/0.313$[in]$)^2 - 1) = \mathbf{5.99}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313$[in]$/1.07$[in]$)^2*(1 + 0.705) = \mathbf{0.144}$ p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.144 + (4 - 2)*0.16)/4 = \mathbf{0.152}$ p. 9-13

$T_{avail} = 8 * (B*Q) = 8 * (11.79$[kip]$*0.152) = \mathbf{14.33}$[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	73.71	60.00	DL	0.81	Eq. J3-6

$L_{c-end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 4.45$[in] $- 0.813$[in]$/2) = \mathbf{4.04}$[in] Sec. J4.10

$L_{c-spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in] $- 0.813$[in]$) = \mathbf{2.19}$[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*4.04$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(4 - 1))*0.315$[in]$*65000$[lb/in2]$*1 = \mathbf{73.71}$[kip] Eq. J3-6

Shear yielding	[Kip]	112.77	60.00	DL	0.53	Eq. J4-3

$A_g = L_p*t_p = 17.9$[in]$*0.315$[in] $= \mathbf{5.64}$[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000$[lb/in2]$*5.64$[in2] $= \mathbf{112.77}$[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	182.52	60.00	DL	0.33	Eq. J3-6

$L_{c-end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.20E+31$[in] $- 0.813$[in]$/2) = \mathbf{1.20E+31}$[in] Sec. J4.10

$L_{c-spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in] $- 0.813$[in]$) = \mathbf{2.19}$[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(4 - 1))*0.39$[in]$*65000$[lb/in2]$*1) = \mathbf{182.52}$[kip] Eq. J3-6

Global critical strength ratio **0.81**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L_{c-end}: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 10:51 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB1.cnx\

Steel connections

Results

Connection name : DA BCW All bolted
Connection ID : SC-01-10W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W18x60

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	50.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	8.50	8.00	16.00	✔	p. 10-8
$L_{min} = T/2 = 16[\text{in}]/2 = \mathbf{8}[\text{in}]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 18.2[\text{in}] - \max(1.1[\text{in}], 0[\text{in}]) - \max(1.1[\text{in}], 0[\text{in}]) = \mathbf{16}[\text{in}]$						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[\text{in}] + 0[\text{in}] = \mathbf{1}[\text{in}]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0.125[in] = **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio		References
Angle (Beam side)							
Bolts shear	[Kip]	63.65	50.00	DL	0.79	●	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61\text{[kip]}) = \mathbf{63.65}\text{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 83.60 50.00 DL 0.60 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4* 0.75\text{[in]})*(3 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{83.6}\text{[kip]}$ Eq. J3-6

Shear yielding [Kip] 76.50 50.00 DL 0.65 Eq. J4-3

$A_g = L_p*t_p = 8.5\text{[in]}*0.313\text{[in]} = \mathbf{2.66}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*2.66\text{[in2]}) = \mathbf{76.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 63.89 50.00 DL 0.78 Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 8.5\text{[in]} - 3*0.875\text{[in]} = \mathbf{5.88}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88\text{[in]}*0.313\text{[in]} = \mathbf{1.84}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*1.84\text{[in2]}) = \mathbf{63.89}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 63.66 50.00 DL 0.79 Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)* 0.875\text{[in]})*0.313\text{[in]} = \mathbf{0.254}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (3 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{2.27}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (3 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{1.58}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*1.58\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]}, 0.6*36000\text{[lb/in2]}* 2.27\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]})) = \mathbf{63.66}\text{[kip]}$ Eq. J4-5

Angle (Support side)

Bolts shear [Kip] 63.65 50.00 DL 0.79 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61\text{[kip]}) = \mathbf{63.65}\text{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 83.60 50.00 DL 0.60 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2* d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2* 2.19\text{[in]}, 2.4*0.75\text{[in]})*(3 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{83.6}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 76.50 50.00 DL 0.65 Eq. J4-3

$A_g = L_p*t_p = 8.5[in]*0.313[in] = \mathbf{2.66}[in2]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = \mathbf{76.5}[kip]$ Eq. J4-3

Shear rupture [Kip] 63.89 50.00 DL 0.78 Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 8.5[in] - 3*0.875[in] = \mathbf{5.88}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88[in]*0.313[in] = \mathbf{1.84}[in2]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = \mathbf{63.89}[kip]$ Eq. J4-4

Block shear [Kip] 59.70 50.00 DL 0.84 Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 1[in] + 1/16\ [in] = \mathbf{1.06}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = \mathbf{0.186}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (3 - 1)*3[in])*0.313[in] = \mathbf{2.27}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{1.58}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.186[in2])) = \mathbf{59.7}[kip]$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 10.57 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 50[kip]/(0.442[in2]*6) = \mathbf{18853.7}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*18853.7[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{46298.64}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*46298.64[lb/in2]*0.442[in2] = \mathbf{10.23}[kip]$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 50[kip]/(0.442[in2]*6) = \mathbf{18853.7}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*18853.7[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{46298.64}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*46298.64[lb/in2]*0.442[in2] = \mathbf{10.23}[kip]$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/3[in] = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*10.23[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))^{0.5} = \mathbf{0.958}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((0.958[in]/0.313[in])^2 - 1) = \mathbf{4.5}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/0.958[in])^2*(1 + 0.729) = \mathbf{0.184}$ p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*10.23[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} = \mathbf{1}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1[in]/0.313[in])^2 - 1) = \mathbf{5.13}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1[in])^2*(1 + 0.705) = \mathbf{0.166}$ p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.166 + (3 - 2)*0.184)/3 = \mathbf{0.172}$ p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (10.23[kip]*0.172) = \mathbf{10.57}[kip]$ p. 9-10

Beam

Bolt bearing under shear load	[Kip]	72.83	50.00	DL	0.69	Eq. J3-6

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 6.1[in] - 0.813[in]/2) = \mathbf{5.69}[in]$ Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*5.69[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.415[in]*65000[lb/in2]*1 = \mathbf{72.83}[kip]$ Eq. J3-6

Shear yielding	[Kip]	151.06	50.00	DL	0.33	Eq. J4-3

$A_g = L_p*t_p = 18.2[in]*0.415[in] = \mathbf{7.55}[in2]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*7.55[in2] = \mathbf{151.06}[kip]$ Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	193.05	50.00	DL	0.26	Eq. J3-6

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = \mathbf{1.20E+31}[in]$ Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.55[in]*65000[lb/in2]*1) = \mathbf{193.05}[kip]$ Eq. J3-6

Global critical strength ratio **0.84**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 11:03 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB1.cnx\

Steel connections

Results

Connection name : DA BCW All bolted

Connection ID : SC-01-11W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W18x65

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	65.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	11.50	8.05	16.10	✔	p. 10-8
$L_{min} = T/2 = 16.1[in]/2 = \mathbf{8.05}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 18.4[in] - \max(1.15[in], 0[in]) - \max(1.15[in], 0[in]) = \mathbf{16.1}[in]$						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	84.86	65.00	DL	0.77	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61\mathrm{[kip]}) = \mathbf{84.86}\mathrm{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 116.23 65.00 DL 0.56 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\mathrm{[in]} - 0.813\mathrm{[in]}/2) = \mathbf{0.844}\mathrm{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\mathrm{[in]} - 0.813\mathrm{[in]}) = \mathbf{2.19}\mathrm{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844\mathrm{[in]}, 2.4*0.75\mathrm{[in]}) + \min(1.2*2.19\mathrm{[in]}, 2.4* 0.75\mathrm{[in]})*(4 - 1))*0.313\mathrm{[in]}*58000\mathrm{[lb/in2]}*1) = \mathbf{116.23}\mathrm{[kip]}$ Eq. J3-6

Shear yielding [Kip] 103.50 65.00 DL 0.63 Eq. J4-3

$A_g = L_p*t_p = 11.5\mathrm{[in]}*0.313\mathrm{[in]} = \mathbf{3.59}\mathrm{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\mathrm{[lb/in2]}*3.59\mathrm{[in2]}) = \mathbf{103.5}\mathrm{[kip]}$ Eq. J4-3

Shear rupture [Kip] 87.00 65.00 DL 0.75 Eq. J4-4

$L_h = d_h + 1/16\ \mathrm{[in]} = 0.813\mathrm{[in]} + 1/16\ \mathrm{[in]} = \mathbf{0.875}\mathrm{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 11.5\mathrm{[in]} - 4*0.875\mathrm{[in]} = \mathbf{8}\mathrm{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8\mathrm{[in]}*0.313\mathrm{[in]} = \mathbf{2.5}\mathrm{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\mathrm{[lb/in2]}*2.5\mathrm{[in2]}) = \mathbf{87}\mathrm{[kip]}$ Eq. J4-4

Block shear [Kip] 83.91 65.00 DL 0.77 Eq. J4-5

$dh_h = d_h + 1/16\ \mathrm{[in]} = 0.813\mathrm{[in]} + 1/16\ \mathrm{[in]} = \mathbf{0.875}\mathrm{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \mathrm{[in]} = 0.813\mathrm{[in]} + 1/16\ \mathrm{[in]} = \mathbf{0.875}\mathrm{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25\mathrm{[in]} + (1 - 1)*3\mathrm{[in]} - (1 - 0.5)* 0.875\mathrm{[in]})*0.313\mathrm{[in]} = \mathbf{0.254}\mathrm{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\mathrm{[in]} + (4 - 1)*3\mathrm{[in]})*0.313\mathrm{[in]} = \mathbf{3.2}\mathrm{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\mathrm{[in]} + (4 - 1)*(3\mathrm{[in]} - 0.875\mathrm{[in]}) - 0.875\mathrm{[in]}/2)*0.313\mathrm{[in]} = \mathbf{2.25}\mathrm{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt})) = 2 * (0.5*\min(0.6*58000\mathrm{[lb/in2]}*2.25\mathrm{[in2]} + 1*58000\mathrm{[lb/in2]}*0.254\mathrm{[in2]}, 0.6*36000\mathrm{[lb/in2]}* 3.2\mathrm{[in2]} + 1*58000\mathrm{[lb/in2]}*0.254\mathrm{[in2]})) = \mathbf{83.91}\mathrm{[kip]}$ Eq. J4-5

<u>Angle (Support side)</u>

Bolts shear [Kip] 84.86 65.00 DL 0.77 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\mathrm{[lb/in2]}*0.442\mathrm{[in2]} = \mathbf{10.61}\mathrm{[kip]}$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61\mathrm{[kip]}) = \mathbf{84.86}\mathrm{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 116.23 65.00 DL 0.56 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\mathrm{[in]} - 0.813\mathrm{[in]}/2) = \mathbf{0.844}\mathrm{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\mathrm{[in]} - 0.813\mathrm{[in]}) = \mathbf{2.19}\mathrm{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2* d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(4/(1*4))*(\min(1.2*0.844\mathrm{[in]}, 2.4*0.75\mathrm{[in]}) + \min(1.2* 2.19\mathrm{[in]}, 2.4*0.75\mathrm{[in]})*(4 - 1))*0.313\mathrm{[in]}*58000\mathrm{[lb/in2]}*1) = \mathbf{116.23}\mathrm{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	103.50	65.00	DL	0.63	Eq. J4-3

$A_g = L_p*t_p$ = 11.5[in]*0.313[in] = **3.59**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g)$ = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = **103.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	87.00	65.00	DL	0.75	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 11.5[in] - 4*0.875[in] = **8**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 8[in]*0.313[in] = **2.5**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv})$ = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = **87**[kip] — Eq. J4-4

Block shear	[Kip]	79.95	65.00	DL	0.81	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (4 - 1)*3[in])*0.313[in] = **3.2**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.25**[in2] — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}))$ = 2 * (0.5*min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*3.2[in2] + 1*58000[lb/in2]*0.186[in2])) = **79.95**[kip] — Eq. J4-5

Resulting tension capacity due prying action	[Kip]	14.33	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts})$ = 65[kip]/(0.442[in2]*8) = **18382.35**[lb/in2] — Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*18382.35[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **48066.18**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*48066.18[lb/in2]*0.442[in2] = **10.62**[kip] — Eq. J3-2

$f_v = F/(A_b*N_{bolts})$ = 65[kip]/(0.442[in2]*8) = **18382.35**[lb/in2] — Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*18382.35[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **48066.18**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*48066.18[lb/in2]*0.442[in2] = **10.62**[kip] — Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2)$ = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] — p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] — p. 9-12

$\rho = b'/a'$ = 2.34[in]/1.5[in] = **1.56** — p. 9-12

$\delta = 1 - d'/p$ = 1 - 0.813[in]/3[in] = **0.729** — p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5}$ = ((3.33*10.62[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))$^{0.5}$ = **0.976**[in] — p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1)$ = (1/(0.729*(1 + 1.56)))*((0.976[in]/0.313[in])^2 - 1) = **4.69** — p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta)$ = (0.313[in]/0.976[in])^2*(1 + 0.729) = **0.177** — p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2)$ = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] — p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] — p. 9-12

$\rho = b'/a' = 2.34$[in]$/1.5$[in] = **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813$[in]$/2.75$[in] = **0.705** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*10.62$[kip]$*2.34$[in]$)/(0.5*2.75$[in]$*58000$[lb/in2]$))^{0.5}$ = **1.02**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.02$[in]$/0.313$[in]$)^2 - 1)$ = **5.34** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313$[in]$/1.02$[in]$)^2*(1 + 0.705)$ = **0.16** p. 9-13

$HasEqualLengths \rightarrow$ **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.16 + (4 - 2)*0.177)/4$ = **0.169** p. 9-13

$T_{avail} = 8 * (B*Q) = 8 * (10.62$[kip]$*0.169)$ = **14.33**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	105.30	65.00	DL	0.62	Eq. J3-6

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 4.7$[in]$ - 0.813$[in]$/2)$ = **4.29**[in] Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3$[in]$ - 0.813$[in]$)$ = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*4.29$[in]$, 2.4*0.75$[in]$) + min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(4 - 1))*0.45$[in]$*65000$[lb/in2]$*1$ = **105.3**[kip] Eq. J3-6

Shear yielding	[Kip]	165.60	65.00	DL	0.39	Eq. J4-3

$A_g = L_p*t_p = 18.4$[in]$*0.45$[in] = **8.28**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000$[lb/in2]$*8.28$[in2] = **165.6**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	241.02	65.00	DL	0.27	Eq. J3-6

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31$[in]$ - 0.813$[in]$/2)$ = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3$[in]$ - 0.813$[in]$)$ = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31$[in]$, 2.4*0.75$[in]$) + min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(4 - 1))*0.515$[in]$*65000$[lb/in2]$*1)$ = **241.02**[kip] Eq. J3-6

Global critical strength ratio **0.81**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 11:13 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB2.cnx\

Steel connections

Results

Connection name : DA BCW All bolted

Connection ID : SC-01-12W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W21x44

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	60.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	11.50	9.40	18.80	✔	p. 10-8
$L_{min} = T/2 = 18.8$[in]$/2 = \mathbf{9.4}$[in]						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 20.7$[in] $- \max(0.95$[in], 0[in]$) - \max(0.95$[in], 0[in]$) = \mathbf{18.8}$[in]						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3 * d = 8/3 * 0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24 * t_p, 12$ [in]$) = \min(24 * 0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3 * d = 8/3 * 0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24 * t_p, 12$ [in]$) = \min(24 * 0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	84.86	60.00	DL	0.71	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega) * F_{nv} * A_b = 0.5 * 48000$[lb/in2]$* 0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61[kip]) = \mathbf{84.86}[kip]$ Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	60.00	DL	0.52	Eq. J3-6

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4* 0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{116.23}[kip]$ Eq. J3-6

Shear yielding	[Kip]	103.50	60.00	DL	0.58	Eq. J4-3

$A_g = L_p*t_p = 11.5[in]*0.313[in] = \mathbf{3.59}[in2]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = \mathbf{103.5}[kip]$ Eq. J4-3

Shear rupture	[Kip]	87.00	60.00	DL	0.69	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 11.5[in] - 4*0.875[in] = \mathbf{8}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8[in]*0.313[in] = \mathbf{2.5}[in2]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = \mathbf{87}[kip]$ Eq. J4-4

Block shear	[Kip]	83.91	60.00	DL	0.72	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)* 0.875[in])*0.313[in] = \mathbf{0.254}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (4 - 1)*3[in])*0.313[in] = \mathbf{3.2}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{2.25}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]* 3.2[in2] + 1*58000[lb/in2]*0.254[in2])) = \mathbf{83.91}[kip]$ Eq. J4-5

<u>Angle (Support side)</u>

Bolts shear	[Kip]	84.86	60.00	DL	0.71	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61[kip]) = \mathbf{84.86}[kip]$ Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	60.00	DL	0.52	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2* d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(4/(1*4))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2* 2.19[in], 2.4*0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{116.23}[kip]$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	103.50	60.00	DL	0.58	Eq. J4-3

$A_g = L_p*t_p = 11.5\text{[in]}*0.313\text{[in]} = \mathbf{3.59}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*3.59\text{[in2]}) = \mathbf{103.5}\text{[kip]}$ Eq. J4-3

Shear rupture	[Kip]	87.00	60.00	DL	0.69	Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 11.5\text{[in]} - 4*0.875\text{[in]} = \mathbf{8}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8\text{[in]}*0.313\text{[in]} = \mathbf{2.5}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*2.5\text{[in2]}) = \mathbf{87}\text{[kip]}$ Eq. J4-4

Block shear	[Kip]	79.95	60.00	DL	0.75	Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 1\text{[in]} + 1/16\text{ [in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13\text{[in]} + (1 - 1)*5.5\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.186}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (4 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{3.2}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (4 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{2.25}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*2.25\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]}, 0.6*36000\text{[lb/in2]}*3.2\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]})) = \mathbf{79.95}\text{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action	[Kip]	14.33	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 60\text{[kip]}/(0.442\text{[in2]}*8) = \mathbf{16968.33}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*16968.33\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{53368.78}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*53368.78\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{11.79}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 60\text{[kip]}/(0.442\text{[in2]}*8) = \mathbf{16968.33}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*16968.33\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{53368.78}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*53368.78\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{11.79}\text{[kip]}$ Eq. J3-2

$a' = \text{Min}(a + d/2, 1.25*b + d/2) = \text{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*11.79\text{[kip]}*2.34\text{[in]})/(0.5*3\text{[in]}*58000\text{[lb/in2]}))^{0.5} = \mathbf{1.03}\text{[in]}$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.03\text{[in]}/0.313\text{[in]})^2 - 1) = \mathbf{5.26}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313\text{[in]}/1.03\text{[in]})^2*(1 + 0.729) = \mathbf{0.16}$ p. 9-13

$a' = \text{Min}(a + d/2, 1.25*b + d/2) = \text{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34$[in]$/1.5$[in] $=$ **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813$[in]$/2.75$[in] $=$ **0.705** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*11.79$[kip]$*2.34$[in]$)/(0.5*2.75$[in]$*58000$[lb/in2]$))^{0.5} =$ **1.07**[in] p. 9-12

$\alpha' = (1/(\delta*(1+\rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.07$[in]$/0.313$[in]$)^2 - 1) =$ **5.99** p. 9-13

$Q = (t_p/t_c)^2*(1+\delta) = (0.313$[in]$/1.07$[in]$)^2*(1 + 0.705) =$ **0.144** p. 9-13

HasEqualLengths $\rightarrow$ **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.144 + (4 - 2)*0.16)/4 =$ **0.152** p. 9-13

$T_{avail} = 8 * (B*Q) = 8 * (11.79$[kip]$*0.152) =$ **14.33**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	81.90	60.00	DL	0.73	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 5.85$[in]$ - 0.813$[in]$/2) =$ **5.44**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in]$ - 0.813$[in]$) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n-1))*t_p*F_u*n_c = 0.5*(\min(1.2*5.44$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(4 - 1))*0.35$[in]$*65000$[lb/in2]$*1 =$ **81.9**[kip] Eq. J3-6

Shear yielding	[Kip]	144.90	60.00	DL	0.41	Eq. J4-3

$A_g = L_p*t_p = 20.7$[in]$*0.35$[in] $=$ **7.25**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000$[lb/in2]$*7.25$[in2] $=$ **144.9**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	182.52	60.00	DL	0.33	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.20E+31$[in]$ - 0.813$[in]$/2) =$ **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in]$ - 0.813$[in]$) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n-1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(4 - 1))*0.39$[in]$*65000$[lb/in2]$*1) =$ **182.52**[kip] Eq. J3-6

Global critical strength ratio **0.75**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-06 3:54 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB4.cnx\

Steel connections

Results

Connection name : DA BCW All bolted

Connection ID : SC-01-13W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W24x55

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	60.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	11.50	10.79	21.58	✔	p. 10-8

$L_{min} = T/2 = 21.58_{[in]}/2 = \mathbf{10.79}_{[in]}$ p. 10-8

$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 23.6_{[in]} - \max(1.01_{[in]}, 0_{[in]}) - \max(1.01_{[in]}, 0_{[in]}) = \mathbf{21.58}_{[in]}$ p. 10-8

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1_{[in]} + 0_{[in]} = \mathbf{1}_{[in]}$ Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	84.86	60.00	DL	0.71 ●	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61[kip]) = \mathbf{84.86}[kip]$ Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	60.00	DL	0.52		Eq. J3-6

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4* 0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{116.23}[kip]$ Eq. J3-6

Shear yielding	[Kip]	103.50	60.00	DL	0.58		Eq. J4-3

$A_g = L_p*t_p = 11.5[in]*0.313[in] = \mathbf{3.59}[in2]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = \mathbf{103.5}[kip]$ Eq. J4-3

Shear rupture	[Kip]	87.00	60.00	DL	0.69		Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 11.5[in] - 4*0.875[in] = \mathbf{8}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8[in]*0.313[in] = \mathbf{2.5}[in2]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = \mathbf{87}[kip]$ Eq. J4-4

Block shear	[Kip]	83.91	60.00	DL	0.72		Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)* 0.875[in])*0.313[in] = \mathbf{0.254}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (4 - 1)*3[in])*0.313[in] = \mathbf{3.2}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{2.25}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u* A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]* 3.2[in2] + 1*58000[lb/in2]*0.254[in2])) = \mathbf{83.91}[kip]$ Eq. J4-5

<u>Angle (Support side)</u>

Bolts shear	[Kip]	84.86	60.00	DL	0.71		Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61[kip]) = \mathbf{84.86}[kip]$ Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	60.00	DL	0.52		p. 7-18, Sec. J3.10

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(min(k_1*L_{c\text{-}end}, k_2*d) + min(k_1*L_{c\text{-}spa}, k_2* d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(4/(1*4))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2* 2.19[in], 2.4*0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{116.23}[kip]$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	103.50	60.00	DL	0.58		Eq. J4-3

$A_g = L_p*t_p = 11.5$[in]$*0.313$[in] = **3.59**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*3.59$[in2]) = **103.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	87.00	60.00	DL	0.69		Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h = 11.5$[in] - 4*0.875[in] = **8**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8$[in]*0.313[in] = **2.5**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]*2.5[in2]) = **87**[kip] — Eq. J4-4

Block shear	[Kip]	79.95	60.00	DL	0.75		Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 1[in] + 1/16 [in] = **1.06**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (4 - 1)*3[in])*0.313[in] = **3.2**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.25**[in2] — Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}))$ = 2 * (0.5*min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*3.2[in2] + 1*58000[lb/in2]*0.186[in2])) = **79.95**[kip] — Eq. J4-5

Resulting tension capacity due prying action	[Kip]	14.33	0.00	DL	0.00		p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts})$ = 60[kip]/(0.442[in2]*8) = **16968.33**[lb/in2] — Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*16968.33[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **53368.78**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*53368.78[lb/in2]*0.442[in2] = **11.79**[kip] — Eq. J3-2

$f_v = F/(A_b*N_{bolts})$ = 60[kip]/(0.442[in2]*8) = **16968.33**[lb/in2] — Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*16968.33[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **53368.78**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*53368.78[lb/in2]*0.442[in2] = **11.79**[kip] — Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2)$ = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] — p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] — p. 9-12

$\rho = b'/a'$ = 2.34[in]/1.5[in] = **1.56** — p. 9-12

$\delta = 1 - d'/p$ = 1 - 0.813[in]/3[in] = **0.729** — p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5}$ = ((3.33*11.79[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))$^{0.5}$ = **1.03**[in] — p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1)$ = (1/(0.729*(1 + 1.56)))*((1.03[in]/0.313[in])^2 - 1) = **5.26** — p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta)$ = (0.313[in]/1.03[in])^2*(1 + 0.729) = **0.16** — p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2)$ = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] — p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] — p. 9-12

$\rho = b'/a' = 2.34$[in]$/1.5$[in] = **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813$[in]$/2.75$[in] = **0.705** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*11.79$[kip]$*2.34$[in]$)/(0.5*2.75$[in]$*58000$[lb/in2]$))^{0.5}$ = **1.07**[in] p. 9-12

$\alpha' = (1/(\delta*(1+\rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.07$[in]$/0.313$[in]$)^2 - 1)$ = **5.99** p. 9-13

$Q = (t_p/t_c)^2*(1+\delta) = (0.313$[in]$/1.07$[in]$)^2*(1 + 0.705)$ = **0.144** p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.144 + (4 - 2)*0.16)/4$ = **0.152** p. 9-13

$T_{avail} = 8 * (B*Q) = 8 * (11.79$[kip]$*0.152)$ = **14.33**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	92.43	60.00	DL	0.65	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 7.3$[in]$ - 0.813$[in]$/2)$ = **6.89**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in]$ - 0.813$[in]$)$ = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*6.89$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(4 - 1))*0.395$[in]$*65000$[lb/in2]$*1$ = **92.43**[kip] Eq. J3-6

Shear yielding	[Kip]	186.44	60.00	DL	0.32	Eq. J4-3

$A_g = L_p*t_p = 23.6$[in]$*0.395$[in] = **9.32**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000$[lb/in2]$*9.32$[in2] = **186.44**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	168.48	60.00	DL	0.36	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.20E+31$[in]$ - 0.813$[in]$/2)$ = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in]$ - 0.813$[in]$)$ = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(4 - 1))*0.36$[in]$*65000$[lb/in2]$*1)$ = **168.48**[kip] Eq. J3-6

Global critical strength ratio **0.75**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 11:25 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB2.cnx\

Steel connections

Results

Connection name : DA BCW All bolted

Connection ID : SC-01-14W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W24x55

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	80.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	14.50	10.79	21.58	✔	p. 10-8
$L_{min} = T/2 = 21.58[in]/2 = \mathbf{10.79}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 23.6[in] - \max(1.01[in], 0[in]) - \max(1.01[in], 0[in]) = \mathbf{21.58}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	106.08	80.00	DL	0.75	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = 2 * (C*$(1/\Omega)R_n$) = 2 * (5*10.61[kip]) = **106.08**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	148.85	80.00	DL	0.54	Eq. J3-6

L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.313[in]*58000[lb/in2]*1) = **148.85**[kip] — Eq. J3-6

Shear yielding	[Kip]	130.50	80.00	DL	0.61	Eq. J4-3

A_g = L_p*t_p = 14.5[in]*0.313[in] = **4.53**[in2] — Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*4.53[in2]) = **130.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	110.11	80.00	DL	0.73	Eq. J4-4

L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

L_e = L - n*L_h = 14.5[in] - 5*0.875[in] = **10.13**[in] — DG4 Eq. 3-13

A_{nv} = L_e*t_p = 10.13[in]*0.313[in] = **3.16**[in2] — Sec. J4-2

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*3.16[in2]) = **110.11**[kip] — Eq. J4-4

Block shear	[Kip]	104.16	80.00	DL	0.77	Eq. J4-5

dh_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.313[in] = **0.254**[in2] — Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (5 - 1)*3[in])*0.313[in] = **4.14**[in2] — Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (5 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.91**[in2] — Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 — Sec. J4-3

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*2.91[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*4.14[in2] + 1*58000[lb/in2]*0.254[in2])) = **104.16**[kip] — Eq. J4-5

<u>Angle (Support side)</u>

Bolts shear	[Kip]	106.08	80.00	DL	0.75	Tables (7-1..14)

$(1/\Omega)R_n$ = $(1/\Omega)$*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = 2 * (C*$(1/\Omega)R_n$) = 2 * (5*10.61[kip]) = **106.08**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	148.85	80.00	DL	0.54	p. 7-18, Sec. J3.10

L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*(C/(n_c*n))*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(5/(1*5))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.313[in]*58000[lb/in2]*1) = **148.85**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	130.50	80.00	DL	0.61	Eq. J4-3

$A_g = L_p * t_p = 14.5[in]*0.313[in] = \mathbf{4.53}[in2]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*4.53[in2]) = \mathbf{130.5}[kip]$ Eq. J4-3

Shear rupture	[Kip]	110.11	80.00	DL	0.73	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 14.5[in] - 5*0.875[in] = \mathbf{10.13}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 10.13[in]*0.313[in] = \mathbf{3.16}[in2]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*3.16[in2]) = \mathbf{110.11}[kip]$ Eq. J4-4

Block shear	[Kip]	100.20	80.00	DL	0.80	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 1[in] + 1/16\ [in] = \mathbf{1.06}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = \mathbf{0.186}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (5 - 1)*3[in])*0.313[in] = \mathbf{4.14}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (5 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{2.91}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*2.91[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*4.14[in2] + 1*58000[lb/in2]*0.186[in2])) = \mathbf{100.2}[kip]$ Eq. J4-5

Resulting tension capacity due prying action	[Kip]	18.10	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 80[kip]/(0.442[in2]*10) = \mathbf{18099.55}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*18099.55[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{49126.7}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*49126.7[lb/in2]*0.442[in2] = \mathbf{10.86}[kip]$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 80[kip]/(0.442[in2]*10) = \mathbf{18099.55}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*18099.55[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{49126.7}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*49126.7[lb/in2]*0.442[in2] = \mathbf{10.86}[kip]$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/3[in] = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*10.86[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))^{0.5} = \mathbf{0.987}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((0.987[in]/0.313[in])^2 - 1) = \mathbf{4.8}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/0.987[in])^2*(1 + 0.729) = \mathbf{0.173}$ p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34$[in]$/1.5$[in] $=$ **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813$[in]$/2.75$[in] $=$ **0.705** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*10.86$[kip]$*2.34$[in]$)/(0.5*2.75$[in]$*58000$[lb/in2]$))^{0.5} =$ **1.03**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.03$[in]$/0.313$[in]$)^2 - 1) =$ **5.47** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313$[in]$/1.03$[in]$)^2*(1 + 0.705) =$ **0.157** p. 9-13

HasEqualLengths $\rightarrow$ **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.157 + (5 - 2)*0.173)/5 =$ **0.167** p. 9-13

$T_{avail} = 10 * (B*Q) = 10 * (10.86$[kip]$*0.167) =$ **18.1**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	115.54	80.00	DL	0.69	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 5.8$[in] $- 0.813$[in]$/2) =$ **5.39**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*5.39$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(5 - 1))*0.395$[in]$*65000$[lb/in2]$*1 =$ **115.54**[kip] Eq. J3-6

Shear yielding	[Kip]	186.44	80.00	DL	0.43	Eq. J4-3

$A_g = L_p*t_p = 23.6$[in]$*0.395$[in] $=$ **9.32**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000$[lb/in2]$*9.32$[in2] $=$ **186.44**[kip] Eq. J4-3

Support

Bolt bearing under shear load	[Kip]	274.95	80.00	DL	0.29	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.20E+31$[in] $- 0.813$[in]$/2) =$ **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(5 - 1))*0.47$[in]$*65000$[lb/in2]$*1) =$ **274.95**[kip] Eq. J3-6

Global critical strength ratio **0.80**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}:Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

F: Required shear force for combined tension and shear

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

L_{c-spa}: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

Current Date: 2016-05-05 11:10 AM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB2.cnx\

Steel connections

Results

Connection name : DA BCW All bolted
Connection ID : SC-01-15W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W27x94

Design code: AISC 360-05 ASD

DEMANDS

Description	**Ru** [Kip]	**Pu** [Kip]	**Load type**
DL	90.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
Angle						
Length	[in]	17.50	12.11	24.22	✔	p. 10-8
$L_{min} = T/2 = 24.22[in]/2 = \mathbf{12.11}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 26.9[in] - \max(1.34[in], 1.34[in]) - \max(1.34[in], 1.34[in]) = \mathbf{24.22}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✓	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✓	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in]$, 12$ [in]$) =$ **7.5**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✓	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✓	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✓	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.08	✓	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.295$[in]$, 12$ [in]$) =$ **7.08**[in] — Sec. J3.5

Beam

Top cope length	[in]	3.86	--	53.80	✓

$c_{max} = 2*d = 2*26.9$[in] $=$ **53.8**[in]

Bottom cope length	[in]	3.86	--	53.80	✓

$c_{max} = 2*d = 2*26.9$[in] $=$ **53.8**[in]

Top cope depth	[in]	1.34	--	4.70	✓

$d_{ctmax} = \min(d/2, d_{top} - w) = \min(26.9$[in]$/2, 4.7$[in] $- 0$[in]$) =$ **4.7**[in]

Bottom cope depth	[in]	1.34	--	4.70	✓

$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(26.9$[in]$/2, 26.9$[in] $- 17.5$[in] $- 4.7$[in] $- 0$[in]$) =$ **4.7**[in]

Vertical edge distance	[in]	4.61	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	127.30	90.00	DL	0.71	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip]						Eq. J3-1
$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (6*10.61$[kip]$)$ $=$ **127.3**[kip]						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	181.48	90.00	DL	0.50	Eq. J3-6
$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2)$ $=$ **0.844**[in]						Sec. J4.10
$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$)$ $=$ **2.19**[in]						Sec. J4.10
$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(6 - 1))*0.313$[in]$*58000$[lb/in2]$*1)$ $=$ **181.48**[kip]						Eq. J3-6
Shear yielding	[Kip]	157.50	90.00	DL	0.57	Eq. J4-3
$A_g = L_p*t_p = 17.5$[in]$*0.313$[in] $=$ **5.47**[in2]						Sec. D3-1
$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*5.47$[in2]$)$ $=$ **157.5**[kip]						Eq. J4-3
Shear rupture	[Kip]	133.22	90.00	DL	0.68	Eq. J4-4
$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in]						Sec. D3-2
$L_e = L - n*L_h = 17.5$[in] $- 6*0.875$[in] $=$ **12.25**[in]						DG4 Eq. 3-13
$A_{nv} = L_e*t_p = 12.25$[in]$*0.313$[in] $=$ **3.83**[in2]						Sec. J4-2
$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*3.83$[in2]$)$ $=$ **133.22**[kip]						Eq. J4-4
Block shear	[Kip]	124.41	90.00	DL	0.72	Eq. J4-5
$dh_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in]						Sec. D3-2
$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in]						Sec. D3-2
$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25$[in] $+ (1 - 1)*3$[in] $- (1 - 0.5)*0.875$[in]$)*0.313$[in] $=$ **0.254**[in2]						Sec. J4-3
$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] $+ (6 - 1)*3$[in]$)*0.313$[in] $=$ **5.08**[in2]						Sec. J4-3
$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25$[in] $+ (6 - 1)*(3$[in] $- 0.875$[in]$) - 0.875$[in]$/2)*0.313$[in] $=$ **3.57**[in2]						Sec. J4-3
$IsStressUniform \rightarrow$ **True**						

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*3.57[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*5.08[in2] + 1*58000[lb/in2]*0.254[in2])) = \mathbf{124.41}[kip]$ Eq. J4-5

Angle (Support side)

Bolts shear	[Kip]	127.30	90.00	DL	0.71	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (6*10.61[kip]) = \mathbf{127.3}[kip]$ Tables (7-1..14)

Bolt bearing under shear load	[Kip]	181.48	90.00	DL	0.50	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(6/(1*6))*(\min(1.2*0.844[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(6 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{181.48}[kip]$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	157.50	90.00	DL	0.57	Eq. J4-3

$A_g = L_p*t_p = 17.5[in]*0.313[in] = \mathbf{5.47}[in2]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*5.47[in2]) = \mathbf{157.5}[kip]$ Eq. J4-3

Shear rupture	[Kip]	133.22	90.00	DL	0.68	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 17.5[in] - 6*0.875[in] = \mathbf{12.25}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 12.25[in]*0.313[in] = \mathbf{3.83}[in2]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*3.83[in2]) = \mathbf{133.22}[kip]$ Eq. J4-4

Block shear	[Kip]	120.45	90.00	DL	0.75	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 1[in] + 1/16\ [in] = \mathbf{1.06}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = \mathbf{0.186}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (6 - 1)*3[in])*0.313[in] = \mathbf{5.08}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (6 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{3.57}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*3.57[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*5.08[in2] + 1*58000[lb/in2]*0.186[in2])) = \mathbf{120.45}[kip]$ Eq. J4-5

Resulting tension capacity due prying action	[Kip]	21.86	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 90[kip]/(0.442[in2]*12) = \mathbf{16968.33}[lb/in2]$ Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/(($1/\Omega$)*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*16968.33[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **53368.78**[lb/in2] Eq. J3-3

$(1/\Omega)R_n$ = $(1/\Omega)$*F'_{nt}*A_b = 0.5*53368.78[lb/in2]*0.442[in2] = **11.79**[kip] Eq. J3-2

f_v = F/(A_b*N_{bolts}) = 90[kip]/(0.442[in2]*12) = **16968.33**[lb/in2] Sec. J3.7

F'_{nt} = min(max(1.3*F_{nt} - F_{nt}*f_v/(($1/\Omega$)*F_{nv}), 0.0), F_{nt}) = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*16968.33[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **53368.78**[lb/in2] Eq. J3-3

$(1/\Omega)R_n$ = $(1/\Omega)$*F'_{nt}*A_b = 0.5*53368.78[lb/in2]*0.442[in2] = **11.79**[kip] Eq. J3-2

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

ρ = b'/a' = 2.34[in]/1.5[in] = **1.56** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/3[in] = **0.729** p. 9-11

t_c = ((3.33*B*b')/(($1/\Omega$)*p*F_u))$^{0.5}$ = ((3.33*11.79[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))$^{0.5}$ = **1.03**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.03[in]/0.313[in])^2 - 1) = **5.26** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.03[in])^2*(1 + 0.729) = **0.16** p. 9-13

a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

b' = b - d/2 = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

ρ = b'/a' = 2.34[in]/1.5[in] = **1.56** p. 9-12

δ = 1 - d'/p = 1 - 0.813[in]/2.75[in] = **0.705** p. 9-11

t_c = ((3.33*B*b')/(($1/\Omega$)*p*F_u))$^{0.5}$ = ((3.33*11.79[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **1.07**[in] p. 9-12

α' = (1/(δ*(1 + ρ)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.07[in]/0.313[in])^2 - 1) = **5.99** p. 9-13

Q = (t_p/t_c)^2*(1 + δ) = (0.313[in]/1.07[in])^2*(1 + 0.705) = **0.144** p. 9-13

HasEqualLengths → **False**

Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.144 + (6 - 2)*0.16)/6 = **0.154** p. 9-13

T_{avail} = 12 * (B*Q) = 12 * (11.79[kip]*0.154) = **21.86**[kip] p. 9-10

Beam

Bolt bearing under shear load [Kip] 171.99 90.00 DL 0.52 Eq. J3-6

L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 4.61[in] - 0.813[in]/2) = **4.2**[in] Sec. J4.10

L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = $(1/\Omega)$*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*4.2[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(6 - 1))*0.49[in]*65000[lb/in2]*1 = **171.99**[kip] Eq. J3-6

Shear yielding [Kip] 237.36 90.00 DL 0.38 Eq. J4-3

A_g = L_p*t_p = 24.22[in]*0.49[in] = **11.87**[in2] Sec. D3-1

$(1/\Omega)R_n$ = $(1/\Omega)$*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*11.87[in2] = **237.36**[kip] Eq. J4-3

Shear rupture [Kip] 181.26 90.00 DL 0.50 Eq. J4-4

L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

L_e = L - n*L_h = 24.22[in] - 6*0.875[in] = **18.97**[in] DG4 Eq. 3-13

A_{nv} = L_e*t_p = 18.97[in]*0.49[in] = **9.3**[in2] Sec. J4-2

$(1/\Omega)R_n$ = $(1/\Omega)$*0.60*F_u*A_{nv} = 0.5*0.60*65000[lb/in2]*9.3[in2] = **181.26**[kip] Eq. J4-4

Block shear	[Kip]	170.25	90.00	DL	0.53		Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (2.25[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.49[in] = **0.888**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (4.61[in] + (6 - 1)*3[in])*0.49[in] = **9.61**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (4.61[in] + (6 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.49[in] = **7.25**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$ = 0.5*min(0.6*65000[lb/in2]*7.25[in2] + 1*65000[lb/in2]*0.888[in2], 0.6*50000[lb/in2]*9.61[in2] + 1*65000[lb/in2]*0.888[in2]) = **170.25**[kip] Eq. J4-5

Flexural yielding	[Kip]	329.16	90.00	DL	0.27		p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e$ = 0.599*50000[lb/in2]*47.91[in3]/4.36[in] = **329.16**[kip] p. 9-6

Flexural rupture	[Kip]	357.30	90.00	DL	0.25		p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e$ = 0.5*65000[lb/in2]*47.91[in3]/4.36[in] = **357.3**[kip] p. 9-6

Local web buckling	[Kip]	329.16	90.00	DL	0.27		p. 9-8, p. 9-7

$h_o = d - d_c$ = 26.9[in] - 2.68[in] = **24.22**[in] p. 9-7

IsBeamCopedAtBothFlanges = $(c_t<=2*d)$ and $(d_{ct}<=0.2*d)$ and $(c_b<=2*d)$ and $(d_{cb}<=0.2*d)$ = (3.86[in]<=2*26.9[in]) and (1.34[in]<=0.2*26.9[in]) and (3.86[in]<=2*26.9[in]) and (1.34[in]<=0.2*26.9[in]) = **True** p. 9-8

$f_d = 3.5 - 7.5*(d_c/d)$ = 3.5 - 7.5*(1.34[in]/26.9[in]) = **3.13** p. 9-8

$F_{cr} = 0.62*\pi*E*t_w^2/(c*h_o)*f_d$ = 0.62*π*2.90E+07[lb/in2]*0.49[in]^2/(3.86[in]*24.22[in])*3.13 = **4.54E+05**[lb/in2] p. 9-8

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e$ = 0.599*min(50000[lb/in2], 4.54E+05[lb/in2])*47.91[in3]/4.36[in] = **329.16**[kip] p. 9-7

Support

Bolt bearing under shear load	[Kip]	207.09	90.00	DL	0.43		Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c)$ = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(6 - 1))*0.295[in]*65000[lb/in2]*1) = **207.09**[kip] Eq. J3-6

Global critical strength ratio **0.75**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}:Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

c: Coped length

C_2: Edge distance increment

c_b: Bottom cope length

c_t: Top cope length

c_{max}: Maximum coped length

d: Nominal bolt diameter

d_c: Coped depth

d_{cb}: Bottom cope depth

d_{cbmax}: Maximum bottom coped depth

d_{ct}: Top cope depth

d_{ctmax}: Maximum top coped depth

d_h: Nominal hole dimension

d_{top}: Beam top edge distance

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

d: Beam depth

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

e: Load eccentricity

E: Elastic modulus

F: Required shear force for combined tension and shear

F_{cr}: Critical stress, flexural stress buckling

f_d: Plate buckling model adjustment factor for beam coped at both flanges

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

h_o: Reduced beam depth

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsBeamCopedAtBothFlanges: Is beam coped at both flanges

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

S_{net}: Net section modulus

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

t_w: Web thickness

U_{bs}: Stress index

w: Weld size

Z_{net}: Net plastic section modulus

Current Date: 2016-05-05 12:58 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB4.cnx\

Steel connections

Results

Connection name : DA BCW All bolted

Connection ID : SC-01-16W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W33x118

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	140.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	23.50	15.01	30.02	✔	p. 10-8

$L_{min} = T/2 = 30.02[\text{in}]/2 = \mathbf{15.01}[\text{in}]$ p. 10-8

$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 32.9[\text{in}] - \max(1.44[\text{in}], 1.44[\text{in}]) - \max(1.44[\text{in}], 1.44[\text{in}]) = \mathbf{30.02}[\text{in}]$ p. 10-8

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[\text{in}] + 0[\text{in}] = \mathbf{1}[\text{in}]$ Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0.125[in] = **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Beam

Top cope length	[in]	5.81	--	65.80	✔

$c_{max} = 2*d = 2*32.9$[in] = **65.8**[in]

Bottom cope length	[in]	5.81	--	65.80	✔

$c_{max} = 2*d = 2*32.9$[in] = **65.8**[in]

Top cope depth	[in]	1.44	--	4.70	✔

$d_{ctmax} = \min(d/2, d_{top} - w)$ = min(32.9[in]/2, 4.7[in] - 0[in]) = **4.7**[in]

Bottom cope depth	[in]	1.44	--	4.70	✔

$d_{cbmax} = \min(d/2, d - L - d_{top} - w)$ = min(32.9[in]/2, 32.9[in] - 23.5[in] - 4.7[in] - 0[in]) = **4.7**[in]

Vertical edge distance	[in]	4.51	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Angle (Beam side)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	169.73	140.00	DL	0.82	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (8*10.61$[kip]) = **169.73**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	246.73	140.00	DL	0.57	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25$[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(8 - 1))*0.313[in]*58000[lb/in2]*1) = **246.73**[kip] — Eq. J3-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Kip]	211.50	140.00	DL	0.66	Eq. J4-3

$A_g = L_p*t_p = 23.5$[in]$*0.313$[in] = **7.34**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*7.34$[in2]) = **211.5**[kip] — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear rupture	[Kip]	179.44	140.00	DL	0.78	Eq. J4-4

$L_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h = 23.5$[in] - 8*0.875[in] = **16.5**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 16.5$[in]$*0.313$[in] = **5.16**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*5.16$[in2]) = **179.44**[kip] — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear	[Kip]	164.91	140.00	DL	0.85	Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25$[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.313[in] = **0.254**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] + (8 - 1)*3[in])*0.313[in] = **6.95**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25$[in] + (8 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **4.9**[in2] — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*4.9[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*6.95[in2] + 1*58000[lb/in2]*0.254[in2])) = \mathbf{164.91}[kip]$ Eq. J4-5

Angle (Support side)

Bolts shear	[Kip]	169.73	140.00	DL	0.82	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (8*10.61[kip]) = \mathbf{169.73}[kip]$ Tables (7-1..14)

Bolt bearing under shear load	[Kip]	246.73	140.00	DL	0.57	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(8/(1*8))*(\min(1.2*0.844[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(8 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{246.73}[kip]$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	211.50	140.00	DL	0.66	Eq. J4-3

$A_g = L_p*t_p = 23.5[in]*0.313[in] = \mathbf{7.34}[in2]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*7.34[in2]) = \mathbf{211.5}[kip]$ Eq. J4-3

Shear rupture	[Kip]	179.44	140.00	DL	0.78	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 23.5[in] - 8*0.875[in] = \mathbf{16.5}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 16.5[in]*0.313[in] = \mathbf{5.16}[in2]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*5.16[in2]) = \mathbf{179.44}[kip]$ Eq. J4-4

Block shear	[Kip]	160.95	140.00	DL	0.87	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 1[in] + 1/16\ [in] = \mathbf{1.06}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = \mathbf{0.186}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (8 - 1)*3[in])*0.313[in] = \mathbf{6.95}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (8 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{4.9}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*4.9[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*6.95[in2] + 1*58000[lb/in2]*0.186[in2])) = \mathbf{160.95}[kip]$ Eq. J4-5

Resulting tension capacity due prying action	[Kip]	29.39	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 140[kip]/(0.442[in2]*16) = \mathbf{19796.38}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3 \cdot F_{nt} - F_{nt} \cdot f_v/((1/\Omega) \cdot F_{nv}), 0.0), F_{nt}) = \min(\max(1.3 \cdot 90000$[lb/in2] - 90000[lb/in2]*19796.38[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **42763.57**[lb/in2] Eq. J3-3

$(1/\Omega)R_n = (1/\Omega) \cdot F'_{nt} \cdot A_b$ = 0.5*42763.57[lb/in2]*0.442[in2] = **9.45**[kip] Eq. J3-2

$f_v = F/(A_b \cdot N_{bolts})$ = 140[kip]/(0.442[in2]*16) = **19796.38**[lb/in2] Sec. J3.7

$F'_{nt} = \min(\max(1.3 \cdot F_{nt} - F_{nt} \cdot f_v/((1/\Omega) \cdot F_{nv}), 0.0), F_{nt}) = \min(\max(1.3 \cdot 90000$[lb/in2] - 90000[lb/in2]*19796.38[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **42763.57**[lb/in2] Eq. J3-3

$(1/\Omega)R_n = (1/\Omega) \cdot F'_{nt} \cdot A_b$ = 0.5*42763.57[lb/in2]*0.442[in2] = **9.45**[kip] Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25 \cdot b + d/2)$ = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

$\rho = b'/a'$ = 2.34[in]/1.5[in] = **1.56** p. 9-12

$\delta = 1 - d'/p$ = 1 - 0.813[in]/3[in] = **0.729** p. 9-11

$t_c = ((3.33 \cdot B \cdot b')/((1/\Omega) \cdot p \cdot F_u))^{0.5}$ = ((3.33*9.45[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))$^{0.5}$ = **0.921**[in] p. 9-12

$\alpha' = (1/(\delta \cdot (1 + \rho))) \cdot ((t_c/t_p)^2 - 1)$ = (1/(0.729*(1 + 1.56)))*((0.921[in]/0.313[in])^2 - 1) = **4.11** p. 9-13

$Q = (t_p/t_c)^2 \cdot (1 + \delta)$ = (0.313[in]/0.921[in])^2*(1 + 0.729) = **0.199** p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25 \cdot b + d/2)$ = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

$\rho = b'/a'$ = 2.34[in]/1.5[in] = **1.56** p. 9-12

$\delta = 1 - d'/p$ = 1 - 0.813[in]/2.75[in] = **0.705** p. 9-11

$t_c = ((3.33 \cdot B \cdot b')/((1/\Omega) \cdot p \cdot F_u))^{0.5}$ = ((3.33*9.45[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **0.962**[in] p. 9-12

$\alpha' = (1/(\delta \cdot (1 + \rho))) \cdot ((t_c/t_p)^2 - 1)$ = (1/(0.705*(1 + 1.56)))*((0.962[in]/0.313[in])^2 - 1) = **4.69** p. 9-13

$Q = (t_p/t_c)^2 \cdot (1 + \delta)$ = (0.313[in]/0.962[in])^2*(1 + 0.705) = **0.18** p. 9-13

HasEqualLengths → **False**

$Q = (2 \cdot Q_{ext} + (n - 2) \cdot Q_{int})/n$ = (2*0.18 + (8 - 2)*0.199)/8 = **0.194** p. 9-13

$T_{avail} = 16 \cdot (B \cdot Q)$ = 16 * (9.45[kip]*0.194) = **29.39**[kip] p. 9-10

Beam

Bolt bearing under shear load [Kip] 257.40 140.00 DL 0.54 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 4.51[in] - 0.813[in]/2) = **4.1**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega) \cdot (\min(k_1 \cdot L_{c\text{-}end}, k_2 \cdot d) + \min(k_1 \cdot L_{c\text{-}spa}, k_2 \cdot d) \cdot (n - 1)) \cdot t_p \cdot F_u \cdot n_c$ = 0.5*(min(1.2*4.1[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(8 - 1))*0.55[in]*65000[lb/in2]*1 = **257.4**[kip] Eq. J3-6

Shear yielding [Kip] 330.22 140.00 DL 0.42 Eq. J4-3

$A_g = L_p \cdot t_p$ = 30.02[in]*0.55[in] = **16.51**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega) \cdot 0.60 \cdot F_y \cdot A_g$ = 0.667*0.60*50000[lb/in2]*16.51[in2] = **330.22**[kip] Eq. J4-3

Shear rupture [Kip] 246.89 140.00 DL 0.57 Eq. J4-4

$L_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$L_e = L - n \cdot L_h$ = 30.02[in] - 8*0.875[in] = **23.02**[in] DG4 Eq. 3-13

$A_{nv} = L_e \cdot t_p$ = 23.02[in]*0.55[in] = **12.66**[in2] Sec. J4-2

$(1/\Omega)R_n = (1/\Omega) \cdot 0.60 \cdot F_u \cdot A_{nv}$ = 0.5*0.60*65000[lb/in2]*12.66[in2] = **246.89**[kip] Eq. J4-4

Block shear [Kip] 235.61 140.00 DL 0.59 Eq. J4-5

$dh_h = d_h + 1/16\,\text{[in]} = 0.813\text{[in]} + 1/16\,\text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\,\text{[in]} = 0.813\text{[in]} + 1/16\,\text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.25\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)*0.875\text{[in]})*0.55\text{[in]} = \mathbf{0.997}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (4.51\text{[in]} + (8 - 1)*3\text{[in]})*0.55\text{[in]} = \mathbf{14.03}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (4.51\text{[in]} + (8 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.55\text{[in]} = \mathbf{10.42}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*65000\text{[lb/in2]}*10.42\text{[in2]} + 1*65000\text{[lb/in2]}*0.997\text{[in2]}, 0.6*50000\text{[lb/in2]}*14.03\text{[in2]} + 1*65000\text{[lb/in2]}*0.997\text{[in2]}) = \mathbf{235.61}\text{[kip]}$ Eq. J4-5

Flexural yielding [Kip] 392.28 140.00 DL 0.36 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000\text{[lb/in2]}*82.61\text{[in3]}/6.31\text{[in]} = \mathbf{392.28}\text{[kip]}$ p. 9-6

Flexural rupture [Kip] 425.82 140.00 DL 0.33 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000\text{[lb/in2]}*82.61\text{[in3]}/6.31\text{[in]} = \mathbf{425.82}\text{[kip]}$ p. 9-6

Local web buckling [Kip] 392.28 140.00 DL 0.36 p. 9-8, p. 9-7

$h_o = d - d_c = 32.9\text{[in]} - 2.88\text{[in]} = \mathbf{30.02}\text{[in]}$ p. 9-7

$IsBeamCopedAtBothFlanges = (c_t{<=}2*d)$ and $(d_{ct}{<=}0.2*d)$ and $(c_b{<=}2*d)$ and $(d_{cb}{<=}0.2*d) = (5.81\text{[in]}{<=}2*32.9\text{[in]})$ and $(1.44\text{[in]}{<=}0.2*32.9\text{[in]})$ and $(5.81\text{[in]}{<=}2*32.9\text{[in]})$ and $(1.44\text{[in]}{<=}0.2*32.9\text{[in]}) =$ **True** p. 9-8

$f_d = 3.5 - 7.5*(d_c/d) = 3.5 - 7.5*(1.44\text{[in]}/32.9\text{[in]}) = \mathbf{3.17}$ p. 9-8

$F_{cr} = 0.62*\pi*E*t_w^2/(c*h_o)*f_d = 0.62*\pi*2.90E{+}07\text{[lb/in2]}*0.55\text{[in]}^2/(5.81\text{[in]}*30.02\text{[in]})*3.17 = \mathbf{3.11E{+}05}\text{[lb/in2]}$ p. 9-8

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e = 0.599*\min(50000\text{[lb/in2]}, 3.11E{+}05\text{[lb/in2]})*82.61\text{[in3]}/6.31\text{[in]} = \mathbf{392.28}\text{[kip]}$ p. 9-7

<u>Support</u>

Bolt bearing under shear load [Kip] 365.04 140.00 DL 0.38 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.20E{+}31\text{[in]} - 0.813\text{[in]}/2) = \mathbf{1.20E{+}31}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E{+}31\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(8 - 1))*0.39\text{[in]}*65000\text{[lb/in2]}*1) = \mathbf{365.04}\text{[kip]}$ Eq. J3-6

Global critical strength ratio **0.87**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}:Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

c: Coped length

C_2: Edge distance increment

c_b: Bottom cope length

c_t: Top cope length

c_{max}: Maximum coped length

d: Nominal bolt diameter

d_c: Coped depth

d_{cb}: Bottom cope depth

d_{cbmax}: Maximum bottom coped depth

d_{ct}: Top cope depth

d_{ctmax}: Maximum top coped depth

d_h: Nominal hole dimension

d_{top}: Beam top edge distance

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

d: Beam depth

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

e: Load eccentricity

E: Elastic modulus

F: Required shear force for combined tension and shear

F_{cr}: Critical stress, flexural stress buckling

f_d: Plate buckling model adjustment factor for beam coped at both flanges

F_{nt}: Nominal tensile stress

F_{nv}:Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}:Nominal tensile stress modified to include the effects of shear stress

h_o: Reduced beam depth

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsBeamCopedAtBothFlanges: Is beam coped at both flanges

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

L_{c-end}: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

S_{net}: Net section modulus

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

L_{c-spa}: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

t_w: Web thickness

U_{bs}: Stress index

w: Weld size

Z_{net}: Net plastic section modulus

Current Date: 2016-05-05 1:09 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB4.cnx\

Steel connections

Results

Connection name	:	**DA BCW All bolted**
Connection ID	:	**SC-01-17W**

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W36x247

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	80.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	17.50	16.05	32.10	✔	p. 10-8
$L_{min} = T/2 = 32.1$[in]$/2 = \mathbf{16.05}$[in]						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 36.7$[in] $- \max(2.3$[in], 2.3[in]$) - \max(2.3$[in], 2.3[in]$) = \mathbf{32.1}$[in]						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0.125[in] = **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Beam

Top cope length	[in]	7.03	--	73.40	✔

$c_{max} = 2*d = 2*36.7$[in] = **73.4**[in]

Bottom cope length	[in]	7.03	--	73.40	✔

$c_{max} = 2*d = 2*36.7$[in] = **73.4**[in]

Top cope depth	[in]	2.30	--	9.60	✔

$d_{ctmax} = \min(d/2, d_{top} - w)$ = min(36.7[in]/2, 9.6[in] - 0[in]) = **9.6**[in]

Bottom cope depth	[in]	2.30	--	9.60	✔

$d_{cbmax} = \min(d/2, d - L - d_{top} - w)$ = min(36.7[in]/2, 36.7[in] - 17.5[in] - 9.6[in] - 0[in]) = **9.6**[in]

Vertical edge distance	[in]	8.55	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Angle (Beam side)

Bolts shear	[Kip]	127.30	80.00	DL	0.63	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (6*10.61$[kip]) = **127.3**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	181.48	80.00	DL	0.44	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(6 - 1))*0.313[in]*58000[lb/in2]*1) = **181.48**[kip] — Eq. J3-6

Shear yielding	[Kip]	157.50	80.00	DL	0.51	Eq. J4-3

$A_g = L_p*t_p = 17.5$[in]*0.313[in] = **5.47**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]*5.47[in2]) = **157.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	133.22	80.00	DL	0.60	Eq. J4-4

$L_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h = 17.5$[in] - 6*0.875[in] = **12.25**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 12.25$[in]*0.313[in] = **3.83**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]*3.83[in2]) = **133.22**[kip] — Eq. J4-4

Block shear	[Kip]	124.41	80.00	DL	0.64	Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25$[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.313[in] = **0.254**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] + (6 - 1)*3[in])*0.313[in] = **5.08**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25$[in] + (6 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **3.57**[in2] — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*3.57[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*5.08[in2] + 1*58000[lb/in2]*0.254[in2])) = \mathbf{124.41}[kip]$ Eq. J4-5

Angle (Support side)

Bolts shear	[Kip]	127.30	80.00	DL	0.63	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (6*10.61[kip]) = \mathbf{127.3}[kip]$ Tables (7-1..14)

Bolt bearing under shear load	[Kip]	181.48	80.00	DL	0.44	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(6/(1*6))*(\min(1.2*0.844[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(6 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{181.48}[kip]$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	157.50	80.00	DL	0.51	Eq. J4-3

$A_g = L_p*t_p = 17.5[in]*0.313[in] = \mathbf{5.47}[in2]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*5.47[in2]) = \mathbf{157.5}[kip]$ Eq. J4-3

Shear rupture	[Kip]	133.22	80.00	DL	0.60	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 17.5[in] - 6*0.875[in] = \mathbf{12.25}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 12.25[in]*0.313[in] = \mathbf{3.83}[in2]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*3.83[in2]) = \mathbf{133.22}[kip]$ Eq. J4-4

Block shear	[Kip]	120.45	80.00	DL	0.66	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 1[in] + 1/16\ [in] = \mathbf{1.06}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = \mathbf{0.186}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (6 - 1)*3[in])*0.313[in] = \mathbf{5.08}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (6 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{3.57}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*3.57[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*5.08[in2] + 1*58000[lb/in2]*0.186[in2])) = \mathbf{120.45}[kip]$ Eq. J4-5

Resulting tension capacity due prying action	[Kip]	21.86	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 80[kip]/(0.442[in2]*12) = \mathbf{15082.96}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*15082.96\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{60438.91}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*60438.91\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{13.36}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 80\text{[kip]}/(0.442\text{[in2]}*12) = \mathbf{15082.96}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*15082.96\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{60438.91}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*60438.91\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{13.36}\text{[kip]}$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*13.36\text{[kip]}*2.34\text{[in]})/(0.5*3\text{[in]}*58000\text{[lb/in2]}))^{0.5} = \mathbf{1.09}\text{[in]}$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.09\text{[in]}/0.313\text{[in]})^2 - 1) = \mathbf{6.03}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313\text{[in]}/1.09\text{[in]})^2*(1 + 0.729) = \mathbf{0.141}$ p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/2.75\text{[in]} = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*13.36\text{[kip]}*2.34\text{[in]})/(0.5*2.75\text{[in]}*58000\text{[lb/in2]}))^{0.5} = \mathbf{1.14}\text{[in]}$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.14\text{[in]}/0.313\text{[in]})^2 - 1) = \mathbf{6.86}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313\text{[in]}/1.14\text{[in]})^2*(1 + 0.705) = \mathbf{0.127}$ p. 9-13

$HasEqualLengths \rightarrow$ **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.127 + (6 - 2)*0.141)/6 = \mathbf{0.136}$ p. 9-13

$T_{avail} = 12 * (B*Q) = 12 * (13.36\text{[kip]}*0.136) = \mathbf{21.86}\text{[kip]}$ p. 9-10

Beam

Bolt bearing under shear load	[Kip]	280.80	80.00	DL	0.28	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 8.55\text{[in]} - 0.813\text{[in]}/2) = \mathbf{8.14}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*8.14\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(6 - 1))*0.8\text{[in]}*65000\text{[lb/in2]}*1 = \mathbf{280.8}\text{[kip]}$ Eq. J3-6

Shear yielding	[Kip]	513.60	80.00	DL	0.16	Eq. J4-3

$A_g = L_p*t_p = 32.1\text{[in]}*0.8\text{[in]} = \mathbf{25.68}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000\text{[lb/in2]}*25.68\text{[in2]} = \mathbf{513.6}\text{[kip]}$ Eq. J4-3

Shear rupture	[Kip]	418.86	80.00	DL	0.19	Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 32.1\text{[in]} - 6*0.875\text{[in]} = \mathbf{26.85}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 26.85\text{[in]}*0.8\text{[in]} = \mathbf{21.48}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000\text{[lb/in2]}*21.48\text{[in2]} = \mathbf{418.86}\text{[kip]}$ Eq. J4-4

Block shear	[Kip]	329.72	80.00	DL	0.24	Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (2.25[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.8[in] = **1.45**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (8.55[in] + (6 - 1)*3[in])*0.8[in] = **18.84**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (8.55[in] + (6 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.8[in] = **14.99**[in2] — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$ = 0.5*min(0.6*65000[lb/in2]*14.99[in2] + 1*65000[lb/in2]*1.45[in2], 0.6*50000[lb/in2]*18.84[in2] + 1*65000[lb/in2]*1.45[in2]) = **329.73**[kip] — Eq. J4-5

Flexural yielding	[Kip]	546.27	80.00	DL	0.15	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e$ = 0.599*50000[lb/in2]*137.39[in3]/7.53[in] = **546.27**[kip] — p. 9-6

Flexural rupture	[Kip]	592.98	80.00	DL	0.13	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e$ = 0.5*65000[lb/in2]*137.39[in3]/7.53[in] = **592.98**[kip] — p. 9-6

Local web buckling	[Kip]	546.27	80.00	DL	0.15	p. 9-8, p. 9-7

$h_o = d - d_c$ = 36.7[in] - 4.6[in] = **32.1**[in] — p. 9-7

$IsBeamCopedAtBothFlanges = (c_t<=2*d)$ and $(d_{ct}<=0.2*d)$ and $(c_b<=2*d)$ and $(d_{cb}<=0.2*d)$ = (7.03[in]<=2*36.7[in]) and (2.3[in]<=0.2*36.7[in]) and (7.03[in]<=2*36.7[in]) and (2.3[in]<=0.2*36.7[in]) = **True** — p. 9-8

$f_d = 3.5 - 7.5*(d_c/d)$ = 3.5 - 7.5*(2.3[in]/36.7[in]) = **3.03** — p. 9-8

$F_{cr} = 0.62*\pi*E*t_w^2/(c*h_o)*f_d$ = 0.62*π*2.90E+07[lb/in2]*0.8[in]^2/(7.03[in]*32.1[in])*3.03 = **4.85E+05**[lb/in2] — p. 9-8

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e$ = 0.599*min(50000[lb/in2], 4.85E+05[lb/in2])*137.39[in3]/7.53[in] = **546.27**[kip] — p. 9-7

Support

Bolt bearing under shear load	[Kip]	308.88	80.00	DL	0.26	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c)$ = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(6 - 1))*0.44[in]*65000[lb/in2]*1) = **308.88**[kip] — Eq. J3-6

Global critical strength ratio **0.66**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}:Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

c: Coped length

C_2: Edge distance increment

c_b: Bottom cope length

c_t: Top cope length

c_{max}: Maximum coped length

d: Nominal bolt diameter

d_c: Coped depth

d_{cb}: Bottom cope depth

d_{cbmax}: Maximum bottom coped depth

d_{ct}: Top cope depth

d_{ctmax}: Maximum top coped depth

d_h: Nominal hole dimension

d_{top}: Beam top edge distance

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

d: Beam depth

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

e: Load eccentricity

E: Elastic modulus

F: Required shear force for combined tension and shear

F_{cr}: Critical stress, flexural stress buckling

f_d: Plate buckling model adjustment factor for beam coped at both flanges

F_{nt}: Nominal tensile stress

F_{nv}:Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}:Nominal tensile stress modified to include the effects of shear stress

h_o: Reduced beam depth

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsBeamCopedAtBothFlanges: Is beam coped at both flanges

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

S_{net}: Net section modulus

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

t_w: Web thickness

U_{bs}: Stress index

w: Weld size

Z_{net}: Net plastic section modulus

Current Date: 2016-05-05 1:07 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB4.cnx\

Steel connections

Results

Connection name : DA BCW All bolted

Connection ID : SC-01-18W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W36x282

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	80.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	17.50	16.03	32.06	✔	p. 10-8

$L_{min} = T/2 = 32.06[in]/2 = \mathbf{16.03}[in]$ p. 10-8

$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 37.1[in] - \max(2.52[in], 2.52[in]) - \max(2.52[in], 2.52[in]) = \mathbf{32.06}[in]$ p. 10-8

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d$ = 8/3*0.75[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p$, 12 [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

t_{pmax} = 5/8 [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1[in] + 0.125[in] = **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.08	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d$ = 8/3*0.75[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p$, 12 [in]) = min(24*0.295[in], 12 [in]) = **7.08**[in] — Sec. J3.5

Beam

Top cope length	[in]	3.86	--	74.20	✔

$c_{max} = 2*d$ = 2*37.1[in] = **74.2**[in]

Bottom cope length	[in]	3.86	--	74.20	✔

$c_{max} = 2*d$ = 2*37.1[in] = **74.2**[in]

Top cope depth	[in]	2.52	--	9.80	✔

$d_{ctmax} = \min(d/2, d_{top} - w)$ = min(37.1[in]/2, 9.8[in] - 0[in]) = **9.8**[in]

Bottom cope depth	[in]	2.52	--	9.80	✔

$d_{cbmax} = \min(d/2, d - L - d_{top} - w)$ = min(37.1[in]/2, 37.1[in] - 17.5[in] - 9.8[in] - 0[in]) = **9.8**[in]

Vertical edge distance	[in]	8.53	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	127.30	80.00	DL	0.63	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (6*10.61$[kip]$)$ $=$ **127.3**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	181.48	80.00	DL	0.44	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2)$ $=$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in] $- 0.813$[in]$)$ $=$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(6 - 1))*0.313$[in]$*58000$[lb/in2]$*1)$ $=$ **181.48**[kip] — Eq. J3-6

Shear yielding	[Kip]	157.50	80.00	DL	0.51	Eq. J4-3

$A_g = L_p*t_p = 17.5$[in]$*0.313$[in] $=$ **5.47**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*5.47$[in2]$)$ $=$ **157.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	133.22	80.00	DL	0.60	Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h = 17.5$[in] $- 6*0.875$[in] $=$ **12.25**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 12.25$[in]$*0.313$[in] $=$ **3.83**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*3.83$[in2]$)$ $=$ **133.22**[kip] — Eq. J4-4

Block shear	[Kip]	124.41	80.00	DL	0.64	Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25$[in] $+ (1 - 1)*3$[in] $- (1 - 0.5)*0.875$[in]$)*0.313$[in] $=$ **0.254**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] $+ (6 - 1)*3$[in]$)*0.313$[in] $=$ **5.08**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25$[in] $+ (6 - 1)*(3$[in] $- 0.875$[in]$) - 0.875$[in]$/2)*0.313$[in] $=$ **3.57**[in2] — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*3.57[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*5.08[in2] + 1*58000[lb/in2]*0.254[in2])) = \mathbf{124.41}[kip]$ Eq. J4-5

Angle (Support side)

Bolts shear	[Kip]	127.30	80.00	DL	0.63	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (6*10.61[kip]) = \mathbf{127.3}[kip]$ Tables (7-1..14)

Bolt bearing under shear load	[Kip]	181.48	80.00	DL	0.44	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(6/(1*6))*(\min(1.2*0.844[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(6 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{181.48}[kip]$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	157.50	80.00	DL	0.51	Eq. J4-3

$A_g = L_p*t_p = 17.5[in]*0.313[in] = \mathbf{5.47}[in2]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*5.47[in2]) = \mathbf{157.5}[kip]$ Eq. J4-3

Shear rupture	[Kip]	133.22	80.00	DL	0.60	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 17.5[in] - 6*0.875[in] = \mathbf{12.25}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 12.25[in]*0.313[in] = \mathbf{3.83}[in2]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*3.83[in2]) = \mathbf{133.22}[kip]$ Eq. J4-4

Block shear	[Kip]	120.45	80.00	DL	0.66	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 1[in] + 1/16\ [in] = \mathbf{1.06}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = \mathbf{0.186}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (6 - 1)*3[in])*0.313[in] = \mathbf{5.08}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (6 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{3.57}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*3.57[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*5.08[in2] + 1*58000[lb/in2]*0.186[in2])) = \mathbf{120.45}[kip]$ Eq. J4-5

Resulting tension capacity due prying action	[Kip]	21.86	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 80[kip]/(0.442[in2]*12) = \mathbf{15082.96}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*15082.96[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{60438.91}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*60438.91[lb/in2]*0.442[in2] = \mathbf{13.36}[kip]$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 80[kip]/(0.442[in2]*12) = \mathbf{15082.96}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*15082.96[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{60438.91}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*60438.91[lb/in2]*0.442[in2] = \mathbf{13.36}[kip]$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/3[in] = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*13.36[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))^{0.5} = \mathbf{1.09}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.09[in]/0.313[in])^2 - 1) = \mathbf{6.03}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.09[in])^2*(1 + 0.729) = \mathbf{0.141}$ p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*13.36[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} = \mathbf{1.14}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.14[in]/0.313[in])^2 - 1) = \mathbf{6.86}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.14[in])^2*(1 + 0.705) = \mathbf{0.127}$ p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.127 + (6 - 2)*0.141)/6 = \mathbf{0.136}$ p. 9-13

$T_{avail} = 12 * (B*Q) = 12 * (13.36[kip]*0.136) = \mathbf{21.86}[kip]$ p. 9-10

Beam

Bolt bearing under shear load	[Kip]	310.64	80.00	DL	0.26	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 8.53[in] - 0.813[in]/2) = \mathbf{8.12}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*8.12[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(6 - 1))*0.885[in]*65000[lb/in2]*1 = \mathbf{310.64}[kip]$ Eq. J3-6

Shear yielding	[Kip]	567.46	80.00	DL	0.14	Eq. J4-3

$A_g = L_p*t_p = 32.06[in]*0.885[in] = \mathbf{28.37}[in2]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*28.37[in2] = \mathbf{567.46}[kip]$ Eq. J4-3

Shear rupture	[Kip]	462.67	80.00	DL	0.17	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 32.06[in] - 6*0.875[in] = \mathbf{26.81}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 26.81[in]*0.885[in] = \mathbf{23.73}[in2]$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000[lb/in2]*23.73[in2] = \mathbf{462.67}[kip]$ Eq. J4-4

Block shear	[Kip]	364.49	80.00	DL	0.22	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (2.25[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.885[in] = **1.6**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (8.53[in] + (6 - 1)*3[in])*0.885[in] = **20.82**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (8.53[in] + (6 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.885[in] = **16.56**[in2] — Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 — Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$ = 0.5*min(0.6*65000[lb/in2]*16.56[in2] + 1*65000[lb/in2]*1.6[in2], 0.6*50000[lb/in2]*20.82[in2] + 1*65000[lb/in2]*1.6[in2]) = **364.49**[kip] — Eq. J4-5

Flexural yielding	[Kip]	1041.68	80.00	DL	0.08	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e$ = 0.599*50000[lb/in2]*151.61[in3]/4.36[in] = **1041.68**[kip] — p. 9-6

Flexural rupture	[Kip]	1130.75	80.00	DL	0.07	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e$ = 0.5*65000[lb/in2]*151.61[in3]/4.36[in] = **1130.75**[kip] — p. 9-6

Local web buckling	[Kip]	1041.68	80.00	DL	0.08	p. 9-8, p. 9-7

$h_o = d - d_c$ = 37.1[in] - 5.04[in] = **32.06**[in] — p. 9-7

IsBeamCopedAtBothFlanges = $(c_t<=2*d)$ and $(d_{ct}<=0.2*d)$ and $(c_b<=2*d)$ and $(d_{cb}<=0.2*d)$ = (3.86[in]<=2*37.1[in]) and (2.52[in]<=0.2*37.1[in]) and (3.86[in]<=2*37.1[in]) and (2.52[in]<=0.2*37.1[in]) = **True** — p. 9-8

$f_d = 3.5 - 7.5*(d_c/d)$ = 3.5 - 7.5*(2.52[in]/37.1[in]) = **2.99** — p. 9-8

$F_{cr} = 0.62*\pi*E*t_w^2/(c*h_o)*f_d$ = 0.62*π*2.90E+07[lb/in2]*0.885[in]^2/(3.86[in]*32.06[in])*2.99 = **1.07E+06**[lb/in2] — p. 9-8

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e$ = 0.599*min(50000[lb/in2], 1.07E+06[lb/in2])*151.61[in3]/4.36[in] = **1041.68**[kip] — p. 9-7

Support

Bolt bearing under shear load	[Kip]	207.09	80.00	DL	0.39	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] — Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c)$ = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(6 - 1))*0.295[in]*65000[lb/in2]*1) = **207.09**[kip] — Eq. J3-6

Global critical strength ratio **0.66**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}:Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

c: Coped length

C_2: Edge distance increment

c_b: Bottom cope length

c_t: Top cope length

c_{max}: Maximum coped length

d: Nominal bolt diameter

d_c: Coped depth

d_{cb}: Bottom cope depth

d_{cbmax}: Maximum bottom coped depth

d_{ct}: Top cope depth

d_{ctmax}: Maximum top coped depth

d_h: Nominal hole dimension

d_{top}: Beam top edge distance

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

d: Beam depth

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

e: Load eccentricity

E: Elastic modulus

F: Required shear force for combined tension and shear

F_{cr}: Critical stress, flexural stress buckling

f_d: Plate buckling model adjustment factor for beam coped at both flanges

F_{nt}: Nominal tensile stress

F_{nv}:Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}:Nominal tensile stress modified to include the effects of shear stress

h_o: Reduced beam depth

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsBeamCopedAtBothFlanges: Is beam coped at both flanges

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

S_{net}: Net section modulus

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

t_w: Web thickness

U_{bs}: Stress index

w: Weld size

Z_{net}: Net plastic section modulus

Current Date: 2016-05-05 1:10 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-01W Beam to Column Web Shear Double Angle All Bolted\B2C WEB4.cnx\

Steel connections

Results

Connection name : DA BCW All bolted

Connection ID : SC-01-19W

Family: Beam - Column web (BCW)

Type: Angle(s)

Description: B:W36x302

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	80.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	17.50	16.02	32.04	✔	p. 10-8
$L_{min} = T/2 = 32.04$[in]$/2 =$ **16.02**[in]						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 37.3$[in] $- \max(2.63$[in], 2.63[in]$) - \max(2.63$[in], 2.63[in]$) =$ **32.04**[in]						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in]						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0.125[in] = **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Beam

Top cope length	[in]	7.03	--	74.60	✔

$c_{max} = 2*d = 2*37.3$[in] = **74.6**[in]

Bottom cope length	[in]	7.03	--	74.60	✔

$c_{max} = 2*d = 2*37.3$[in] = **74.6**[in]

Top cope depth	[in]	2.63	--	9.90	✔

$d_{ctmax} = \min(d/2, d_{top} - w)$ = min(37.3[in]/2, 9.9[in] - 0[in]) = **9.9**[in]

Bottom cope depth	[in]	2.63	--	9.90	✔

$d_{cbmax} = \min(d/2, d - L - d_{top} - w)$ = min(37.3[in]/2, 37.3[in] - 17.5[in] - 9.9[in] - 0[in]) = **9.9**[in]

Vertical edge distance	[in]	8.52	1.00	--		Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.25	1.00	--		Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Angle (Beam side)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	127.30	80.00	DL	0.63	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (6*10.61$[kip]$)$ $=$ **127.3**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	181.48	80.00	DL	0.44	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(6 - 1))*0.313$[in]$*58000$[lb/in2]$*1) =$ **181.48**[kip] — Eq. J3-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Kip]	157.50	80.00	DL	0.51	Eq. J4-3

$A_g = L_p*t_p = 17.5$[in]$*0.313$[in] $=$ **5.47**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*5.47$[in2]$) =$ **157.5**[kip] — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear rupture	[Kip]	133.22	80.00	DL	0.60	Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h = 17.5$[in] $- 6*0.875$[in] $=$ **12.25**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 12.25$[in]$*0.313$[in] $=$ **3.83**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*3.83$[in2]$) =$ **133.22**[kip] — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear	[Kip]	124.41	80.00	DL	0.64	Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25$[in] $+ (1 - 1)*3$[in] $- (1 - 0.5)*0.875$[in]$)*0.313$[in] $=$ **0.254**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] $+ (6 - 1)*3$[in]$)*0.313$[in] $=$ **5.08**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25$[in] $+ (6 - 1)*(3$[in] $- 0.875$[in]$) - 0.875$[in]$/2)*0.313$[in] $=$ **3.57**[in2] — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\mathrm{[lb/in2]}*3.57\mathrm{[in2]} + 1*58000\mathrm{[lb/in2]}*0.254\mathrm{[in2]}, 0.6*36000\mathrm{[lb/in2]}*5.08\mathrm{[in2]} + 1*58000\mathrm{[lb/in2]}*0.254\mathrm{[in2]})) = \mathbf{124.41}\mathrm{[kip]}$ Eq. J4-5

<u>Angle (Support side)</u>

Bolts shear [Kip] 127.30 80.00 DL 0.63 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\mathrm{[lb/in2]}*0.442\mathrm{[in2]} = \mathbf{10.61}\mathrm{[kip]}$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (6*10.61\mathrm{[kip]}) = \mathbf{127.3}\mathrm{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 181.48 80.00 DL 0.44 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\mathrm{[in]} - 0.813\mathrm{[in]}/2) = \mathbf{0.844}\mathrm{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\mathrm{[in]} - 0.813\mathrm{[in]}) = \mathbf{2.19}\mathrm{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(6/(1*6))*(\min(1.2*0.844\mathrm{[in]}, 2.4*0.75\mathrm{[in]}) + \min(1.2*2.19\mathrm{[in]}, 2.4*0.75\mathrm{[in]})*(6 - 1))*0.313\mathrm{[in]}*58000\mathrm{[lb/in2]}*1) = \mathbf{181.48}\mathrm{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 157.50 80.00 DL 0.51 Eq. J4-3

$A_g = L_p*t_p = 17.5\mathrm{[in]}*0.313\mathrm{[in]} = \mathbf{5.47}\mathrm{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\mathrm{[lb/in2]}*5.47\mathrm{[in2]}) = \mathbf{157.5}\mathrm{[kip]}$ Eq. J4-3

Shear rupture [Kip] 133.22 80.00 DL 0.60 Eq. J4-4

$L_h = d_h + 1/16\ \mathrm{[in]} = 0.813\mathrm{[in]} + 1/16\ \mathrm{[in]} = \mathbf{0.875}\mathrm{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 17.5\mathrm{[in]} - 6*0.875\mathrm{[in]} = \mathbf{12.25}\mathrm{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 12.25\mathrm{[in]}*0.313\mathrm{[in]} = \mathbf{3.83}\mathrm{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\mathrm{[lb/in2]}*3.83\mathrm{[in2]}) = \mathbf{133.22}\mathrm{[kip]}$ Eq. J4-4

Block shear [Kip] 120.45 80.00 DL 0.66 Eq. J4-5

$dh_h = d_h + 1/16\ \mathrm{[in]} = 1\mathrm{[in]} + 1/16\ \mathrm{[in]} = \mathbf{1.06}\mathrm{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \mathrm{[in]} = 0.813\mathrm{[in]} + 1/16\ \mathrm{[in]} = \mathbf{0.875}\mathrm{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13\mathrm{[in]} + (1 - 1)*5.5\mathrm{[in]} - (1 - 0.5)*1.06\mathrm{[in]})*0.313\mathrm{[in]} = \mathbf{0.186}\mathrm{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\mathrm{[in]} + (6 - 1)*3\mathrm{[in]})*0.313\mathrm{[in]} = \mathbf{5.08}\mathrm{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\mathrm{[in]} + (6 - 1)*(3\mathrm{[in]} - 0.875\mathrm{[in]}) - 0.875\mathrm{[in]}/2)*0.313\mathrm{[in]} = \mathbf{3.57}\mathrm{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\mathrm{[lb/in2]}*3.57\mathrm{[in2]} + 1*58000\mathrm{[lb/in2]}*0.186\mathrm{[in2]}, 0.6*36000\mathrm{[lb/in2]}*5.08\mathrm{[in2]} + 1*58000\mathrm{[lb/in2]}*0.186\mathrm{[in2]})) = \mathbf{120.45}\mathrm{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 21.86 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 80\mathrm{[kip]}/(0.442\mathrm{[in2]}*12) = \mathbf{15082.96}\mathrm{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*15082.96\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{60438.91}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*60438.91\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{13.36}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 80\text{[kip]}/(0.442\text{[in2]}*12) = \mathbf{15082.96}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*15082.96\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{60438.91}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*60438.91\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{13.36}\text{[kip]}$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*13.36\text{[kip]}*2.34\text{[in]})/(0.5*3\text{[in]}*58000\text{[lb/in2]}))^{0.5} = \mathbf{1.09}\text{[in]}$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.09\text{[in]}/0.313\text{[in]})^2 - 1) = \mathbf{6.03}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313\text{[in]}/1.09\text{[in]})^2*(1 + 0.729) = \mathbf{0.141}$ p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/2.75\text{[in]} = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*13.36\text{[kip]}*2.34\text{[in]})/(0.5*2.75\text{[in]}*58000\text{[lb/in2]}))^{0.5} = \mathbf{1.14}\text{[in]}$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.14\text{[in]}/0.313\text{[in]})^2 - 1) = \mathbf{6.86}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313\text{[in]}/1.14\text{[in]})^2*(1 + 0.705) = \mathbf{0.127}$ p. 9-13

$HasEqualLengths \rightarrow$ **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.127 + (6 - 2)*0.141)/6 = \mathbf{0.136}$ p. 9-13

$T_{avail} = 12 * (B*Q) = 12 * (13.36\text{[kip]}*0.136) = \mathbf{21.86}\text{[kip]}$ p. 9-10

Beam

Bolt bearing under shear load [Kip] 331.70 80.00 DL 0.24 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 8.52\text{[in]} - 0.813\text{[in]}/2) = \mathbf{8.11}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*8.11\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(6 - 1))*0.945\text{[in]}*65000\text{[lb/in2]}*1 = \mathbf{331.7}\text{[kip]}$ Eq. J3-6

Shear yielding [Kip] 605.56 80.00 DL 0.13 Eq. J4-3

$A_g = L_p*t_p = 32.04\text{[in]}*0.945\text{[in]} = \mathbf{30.28}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000\text{[lb/in2]}*30.28\text{[in2]} = \mathbf{605.56}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 493.67 80.00 DL 0.16 Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 32.04\text{[in]} - 6*0.875\text{[in]} = \mathbf{26.79}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 26.79\text{[in]}*0.945\text{[in]} = \mathbf{25.32}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000\text{[lb/in2]}*25.32\text{[in2]} = \mathbf{493.67}\text{[kip]}$ Eq. J4-4

Block shear	[Kip]	389.06	80.00	DL	0.21	Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (2.25[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.945[in] = **1.71**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (8.52[in] + (6 - 1)*3[in])*0.945[in] = **22.23**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (8.52[in] + (6 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.945[in] = **17.68**[in2] — Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$ = 0.5*min(0.6*65000[lb/in2]*17.68[in2] + 1*65000[lb/in2]*1.71[in2], 0.6*50000[lb/in2]*22.23[in2] + 1*65000[lb/in2]*1.71[in2]) = **389.06**[kip] — Eq. J4-5

Flexural yielding	[Kip]	642.87	80.00	DL	0.12	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e$ = 0.599*50000[lb/in2]*161.68[in3]/7.53[in] = **642.87**[kip] — p. 9-6

Flexural rupture	[Kip]	697.84	80.00	DL	0.11	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e$ = 0.5*65000[lb/in2]*161.68[in3]/7.53[in] = **697.84**[kip] — p. 9-6

Local web buckling	[Kip]	642.87	80.00	DL	0.12	p. 9-8, p. 9-7

$h_o = d - d_c$ = 37.3[in] - 5.26[in] = **32.04**[in] — p. 9-7

IsBeamCopedAtBothFlanges = $(c_t<=2*d)$ and $(d_{ct}<=0.2*d)$ and $(c_b<=2*d)$ and $(d_{cb}<=0.2*d)$ = (7.03[in]<=2*37.3[in]) and (2.63[in]<=0.2*37.3[in]) and (7.03[in]<=2*37.3[in]) and (2.63[in]<=0.2*37.3[in]) = **True** — p. 9-8

$f_d = 3.5 - 7.5*(d_c/d)$ = 3.5 - 7.5*(2.63[in]/37.3[in]) = **2.97** — p. 9-8

$F_{cr} = 0.62*\pi*E*t_w^2/(c*h_o)*f_d$ = 0.62*π*2.90E+07[lb/in2]*0.945[in]^2/(7.03[in]*32.04[in])*2.97 = **6.65E+05**[lb/in2] — p. 9-8

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e$ = 0.599*min(50000[lb/in2], 6.65E+05[lb/in2])*161.68[in3]/7.53[in] = **642.87**[kip] — p. 9-7

Support

Bolt bearing under shear load	[Kip]	308.88	80.00	DL	0.26	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c)$ = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(6 - 1))*0.44[in]*65000[lb/in2]*1) = **308.88**[kip] — Eq. J3-6

Global critical strength ratio **0.66**

NOTATION

a: Plate depth

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

a': Distance for prying action

α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength

B: Available tensile strength per bolt

B: Available strength of all bolts

b': Distance for prying action

b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.

C: Bolt group coefficient

c: Coped length

C_2: Edge distance increment

c_b: Bottom cope length

c_t: Top cope length

c_{max}: Maximum coped length

d: Nominal bolt diameter

d_c: Coped depth

d_{cb}: Bottom cope depth

d_{cbmax}: Maximum bottom coped depth

d_{ct}: Top cope depth

d_{ctmax}: Maximum top coped depth

d_h: Nominal hole dimension

d_{top}: Beam top edge distance

d': Width of the hole along the length of the fitting

δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle

d: Beam depth

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

e: Load eccentricity

E: Elastic modulus

F: Required shear force for combined tension and shear

F_{cr}: Critical stress, flexural stress buckling

f_d: Plate buckling model adjustment factor for beam coped at both flanges

F_{nt}: Nominal tensile stress

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

F'_{nt}: Nominal tensile stress modified to include the effects of shear stress

h_o: Reduced beam depth

HasEqualLengths: Has equal tributary length for interior and exterior bolts

IsBeamCopedAtBothFlanges: Is beam coped at both flanges

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

N_{bolts}: Number of bolts

n_c: Number of bolt columns

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts

Q: Prying action coefficient

Q_{ext}: Prying action coefficient for exterior bolts

Q_{int}: Prying action coefficient for interior bolts

Q: Prying action coefficient

ρ: Prying distances ratio

s_{max}: Maximum spacing

s_{min}: Minimum spacing

S_{net}: Net section modulus

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_{avail}: Available tensile strength per bolt including effects of prying action

t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

t_w: Web thickness

U_{bs}: Stress index

w: Weld size

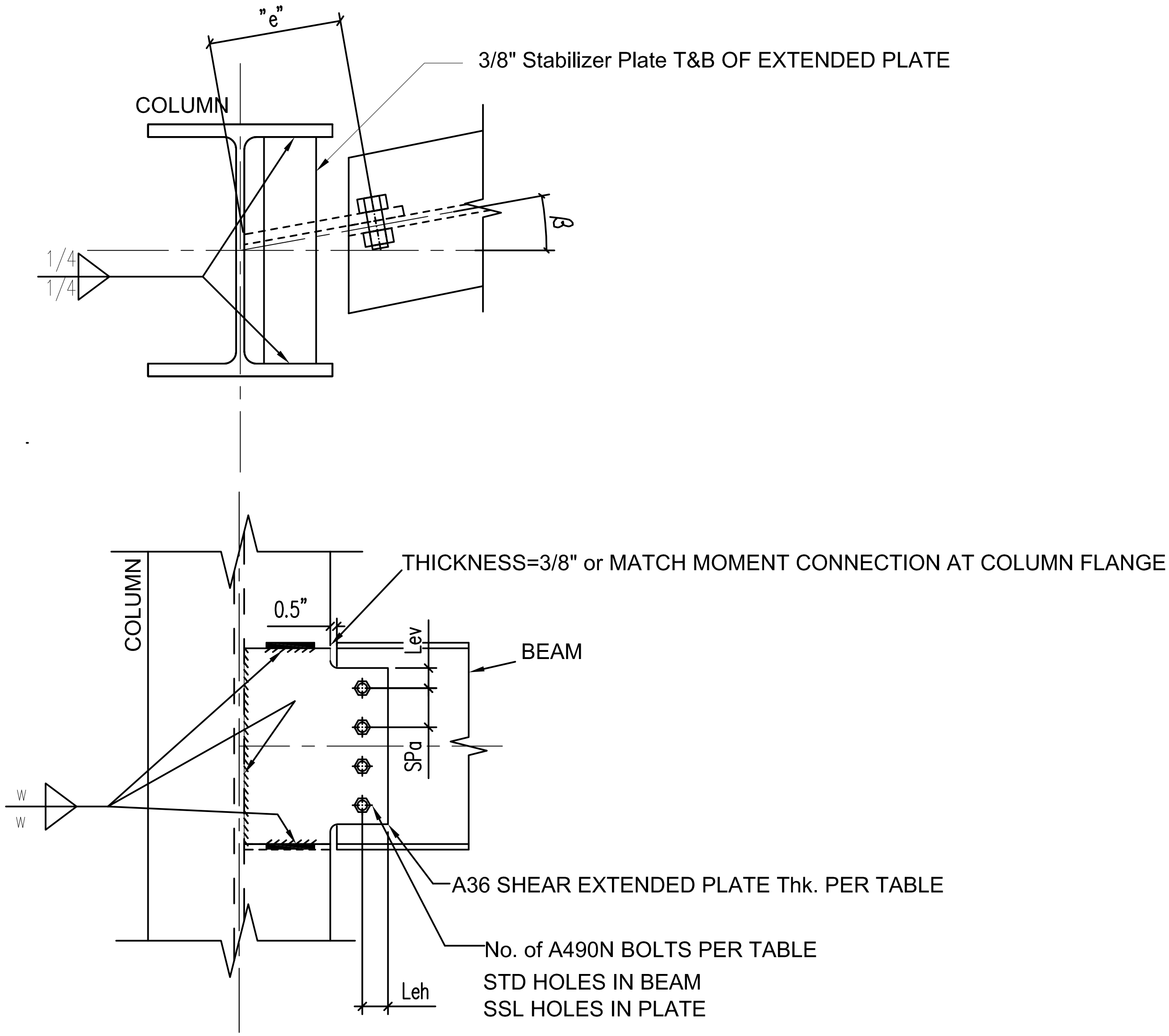
Z_{net}: Net plastic section modulus

SC-02 BEAM TO WF COLUMN WEB WITH SKEWED ANGLE USINTG EXTENDED SHEAR TAB

Connection ID	Beam Size	Design Reaction (kip) "R"	Beam Skew Angles (Deg) "β"	Single Plate (A36 Steel)				Bolt Size and Grade	Bolt Rows x Col "Row"	Bolt Spacing （inch） "Spa."	Distance between Weld to Bolts Max (inch) "e"
				Plate Size (inch) "t_p"	Plate weld size to support Column* (inch) "w"	Bolt edge distance					
						Vertical "L_{ev}" (inch)	Horizontal "L_{eh}" (inch)				
SC-02-01	W14x22	10	20	3/8“	1/4“	1.75	2	1" A490N	3x1	3	7 1/8
SC-02-02	W16x26	30	26	1/2“	5/16“	1.75	2	1" A490N	4x2	3	7 3/8
SC-02-03	W16x31	10	26	3/8“	1/4“	1.75	2	1" A490N	3x1	3	8 7/16
SC-02-04	W24x55	40	26	3/8“	1/4“	1.75	2	1" A490N	6x1	3	7 3/8
SC-02-05	W24x62	60	26	3/8“	1/4“	1.75	2	1" A490N	7x1	3	7 3/8
SC-02-06	W24x76	40	26	3/8“	1/4"	1.75	2	1" A490N	6x1	3	8 7/16
SC-02-07	W24x131	70	26	1/2“	5/16“	1.75	2	1" A490N	7x1	3	9 7/16
SC-02-08	W27x84	60	26	3/8“	1/4“	1.75	2	1" A490N	7x1	3	10 15/16
SC-02-09	W27x94	80	26	3/8“	1/4“	1.75	2	1" A490N	8x1	3	8 1/2
SC-02-10	W33x118	75	26	3/8“	1/4“	1.75	2	1" A490N	8x1	3	9 9/16
SC-02-11	W36x487	80	26	1/2“	5/16“	1.75	2	1" A490N	9x1	3	9 3/4

Short Slotted Hole on Extended Plate
Stabilizer Plate 3/8" Plate T&B of Extended Plate, filling between flanges
Make sure eccentricity values not greater than values in Table.
Plate or beam bolt horizontal edge distance no less than 2 inch.
*Per Table 10-13 in AISC Maunal 13th,
3/8" Plate Use 1/2" fillet weld size at obtuse angle side of plate
1/2" Plate Use 1/2" fillet weld size at obtuse angle side of plate and bevel the plate edge

SC-02 Beam to Column Shear Connection with a Skewed Angle



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Steel connections

Results

Connection name	:	**SP BCW**
Connection ID	:	**SC-02-1**

Family: Beam - Column web (BCW)

Type: Single plate

Description: B:W14x22

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru** [Kip]	**Pu** [Kip]	**Pu** [Kip]	**Mu22** [Kip*ft]	**Mu33** [Kip*ft]	**Load type**
DL	10.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
Plate (beam side)						
Vertical edge distance	[in]	1.75	1.75	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1.75\text{[in]} + 0\text{[in]} = \mathbf{1.75}\text{[in]}$						Tables J3.4, J3.5
Horizontal edge distance	[in]	2.00	1.87	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1.75\text{[in]} + 0.125\text{[in]} = \mathbf{1.88}\text{[in]}$						Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.67	5.52	✔	Sec. J3.3, Sec. J3.5

s_{min} = 8/3*d = 8/3*1[in] = **2.67**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

s_{max} = min(24*t_p, 12 [in]) = min(24*0.23[in], 12 [in]) = **5.52**[in] — Sec. J3.5

Beam

Thickness	[in]	0.23	--	0.55	✔	p. 10-151, p. 10-102

t_{pmax} = (3/16 [in])/sinα = (3/16 [in])/0.342 = **0.548**[in] — p. 10-151

t_{pmax} = d/2 + 1/16 [in] = 1[in]/2 + 1/16 [in] = **0.563**[in] — p. 10-102

t_{pmax} = d/2 + 1/16 [in] = 1[in]/2 + 1/16 [in] = **0.563**[in] — p. 10-102

Vertical edge distance	[in]	3.85	1.75	--	✔	Tables J3.4, J3.5

L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.33	1.75	--	✔	Tables J3.4, J3.5

L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Support

Weld size	[1/16in]	4	4	--	✔	p. 10-101

w_{min} = (5/8)*t_p = (5/8)*0.375[in] = **0.0195** — p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Plate (beam side)						
Bolts shear	[Kip]	19.36	10.00	DL	0.52	Tables (7-1..14)

(n>=10) and (n<=12) and (*IsStandardHole*) → (3>=10) and (3<=12) and (False) → **False**

BoltFactor = 1 — p. 10-102

$(1/\Omega)R_n$ = $(1/\Omega)$*F_{nv}*A_b = 0.5*60000[lb/in2]*0.785[in2] = **23.55**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = C*$(1/\Omega)R_n$*$BoltFactor$ = 0.822*23.55[kip]*1 = **19.36**[kip] — Tables (7-1..14)

Flexure with the Von-Mises shear reduction	[Kip*ft]	14.81	5.92	DL	0.40	p. 10-103

A_g = L_p*t_p = 9.5[in]*0.375[in] = **3.56**[in2] — Sec. D3-1

f_v = V/A_g = 10[kip]/3.56[in2] = **2807.02**[lb/in2] — p. 10-103

$(1/\Omega)F_{cr}$ = (max(0, $((1/\Omega)*F_y)^2$ - 3*f_v^2))$^{1/2}$ = (max(0, (0.599*36000[lb/in2])^2 - 3*2807.02[lb/in2]^2))$^{1/2}$ = **21001.46**[lb/in2] — p. 10-103

Z_x = t_p*L^2/4 = 0.375[in]*9.5[in]^2/4 = **8.46**[in3] — T. 17-27

$(1/\Omega)M_n = (1/\Omega)F_{cr}*Z$ = 21001.46[lb/in2]*8.46[in3] = **14.81**[kip*ft] — p. 10-103

Bolt bearing under shear load	[Kip]	18.22	10.00	DL	0.55	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.75[in] - 1.06[in]/2) = **1.22**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(0.822/(1*3))*(min(1.2*1.22[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(3 - 1))*0.375[in]*58000[lb/in2]*1 = **18.22**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	51.30	10.00	DL	0.19	Eq. J4-3

$A_g = L_p*t_p$ = 9.5[in]*0.375[in] = **3.56**[in2] — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*36000[lb/in2]*3.56[in2] = **51.3**[kip] — Eq. J4-3

Shear rupture	[Kip]	39.97	10.00	DL	0.25	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 9.5[in] - 3*1.13[in] = **6.13**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 6.13[in]*0.375[in] = **2.3**[in2] — Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv}$ = 0.5*0.60*58000[lb/in2]*2.3[in2] = **39.97**[kip] — Eq. J4-4

Block shear	[Kip]	45.66	10.00	DL	0.22	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1.31[in] + 1/16 [in] = **1.38**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (2[in] + (1 - 1)*3[in] - (1 - 0.5)*1.38[in])*0.375[in] = **0.492**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.75[in] + (3 - 1)*3[in])*0.375[in] = **2.91**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.75[in] + (3 - 1)*(3[in] - 1.13[in]) - 1.13[in]/2)*0.375[in] = **1.85**[in2] — Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 — Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$ = 0.5*min(0.6*58000[lb/in2]*1.85[in2] + 1*58000[lb/in2]*0.492[in2], 0.6*36000[lb/in2]*2.91[in2] + 1*58000[lb/in2]*0.492[in2]) = **45.66**[kip] — Eq. J4-5

Flexural rupture	[Kip]	25.65	10.00	DL	0.39	p. 9-6

$L_h = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] — Sec. D3-2

$Z_{net} = t_p/4*(L^2 - s^2*n*(n^2 - 1)*L_h/L)$ = 0.375[in]/4*(9.5[in]^2 - 3[in]^2*3*(3^2 - 1)*1.13[in]/9.5[in]) = **6.06**[in3] — 4

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e$ = 0.5*58000[lb/in2]*6.06[in3]/6.86[in] = **25.65**[kip] — p. 9-6

<u>Plate (support side)</u>

Weld capacity	[Kip]	96.74	10.00	DL	0.10	Tables 8-4 .. 8-11

e = 0 — p. 10-135

$(1/\Omega)R_n = 2 * ((1/\Omega)*C*C_1*D*L)$ = 2 * (0.5*1.86[kip/in]*1*4*13.03[in]) = **96.74**[kip] — Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load	[Kip]	14.44	10.00	DL	0.69		p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 3.85[in] - 1.06[in]/2) = **3.32**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(0.822/(1*3))*(min(1.2*3.32[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(3 - 1))*0.23[in]*65000[lb/in2]*1 = **14.44**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	63.02	10.00	DL	0.16		Eq. J4-3

$A_g = L_p*t_p$ = 13.7[in]*0.23[in] = **3.15**[in2] — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*3.15[in2] = **63.02**[kip] — Eq. J4-3

Support

Welds rupture	[Kip/ft]	173.16	9.21	DL	0.05		p. 9-5

$R_n = 0.6*F_u*t_p$ = 0.6*65000[lb/in2]*0.37[in] = **14.43**[kip/in] — p. 9-5

$e = 0$ — p. 10-135

$D_{min} = P/((1/\Omega)*C*C_1*L)$ = 5[kip]/(0.5*1.86[kip/in]*1*13.03[in]) = **0.413** — tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] = 0.6*70000[lb/in2]*(2)^{1/2}/2*0.413/16 [in] = **0.767**[kip/in] — p. 9-5

Global critical strength ratio **0.69**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}:Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

c: Coped length

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Load eccentricity

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

h_o: Reduced beam depth

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_p: Plate length

L: Length of weld

λ: Slenderness

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)F_{cr}$: Design or allowable flexural stress buckling

$(1/\Omega)M_n$: Design or allowable strength

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

$sin\alpha$: Sine of the skew angle

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

t_w: Web thickness

U_{bs}: Stress index

V: Shear load

w_{min}: Minimum weld size required

Z: Plastic modulus

Z_{net}: Net plastic section modulus

Z_x: Plastic section modulus about the x-axis

REFERENCES

{4} AISC 2005, Design Examples Version 13.0, pp. IIA-63, IIA_86, IIA-98

Current Date: 2016-05-06 4:08 PM

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Steel connections

Results

Connection name : SP BCW

Connection ID : SC-02-2

Family: Beam - Column web (BCW)

Type: Single plate

Description: B:W16x26

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru** [Kip]	**Pu** [Kip]	**Pu** [Kip]	**Mu22** [Kip*ft]	**Mu33** [Kip*ft]	**Load type**
DL	30.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Plate (beam side)						
Vertical edge distance	[in]	1.75	1.75	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1.75[\text{in}] + 0[\text{in}] = \mathbf{1.75}[\text{in}]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	2.00	1.87	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1.75[\text{in}] + 0.125[\text{in}] = \mathbf{1.88}[\text{in}]$						Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.67	6.00	✔	Sec. J3.3, Sec. J3.5

s_{min} = 8/3*d = 8/3*1[in] = **2.67**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

s_{max} = min(24*t_p, 12 [in]) = min(24*0.25[in], 12 [in]) = **6**[in] — Sec. J3.5

Horizontal center-to-center spacing (gage)	[in]	3.00	2.67	6.00	✔	Sec. J3.3, Sec. J3.5

s_{min} = 8/3*d = 8/3*1[in] = **2.67**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

s_{max} = min(24*t_p, 12 [in]) = min(24*0.25[in], 12 [in]) = **6**[in] — Sec. J3.5

Beam

Thickness	[in]	0.25	--	0.43	✔	p. 10-151, p. 10-102

t_{pmax} = (3/16 [in])/sinα = (3/16 [in])/0.438 = **0.428**[in] — p. 10-151

t_{pmax} = d/2 + 1/16 [in] = 1[in]/2 + 1/16 [in] = **0.563**[in] — p. 10-102

t_{pmax} = d/2 + 1/16 [in] = 1[in]/2 + 1/16 [in] = **0.563**[in] — p. 10-102

Vertical edge distance	[in]	3.35	1.75	--	✔	Tables J3.4, J3.5

L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.22	1.75	--	✔	Tables J3.4, J3.5

L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Support

Weld size	[1/16in]	5	5	--	✔	p. 10-101

w_{min} = (5/8)*t_p = (5/8)*0.5[in] = **0.026** — p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Plate (beam side)						
Bolts shear	[Kip]	63.89	30.00	DL	0.47	Tables (7-1..14)

(n>=10) and (n<=12) and (*IsStandardHole*) → (4>=10) and (4<=12) and (False) → **False**

BoltFactor = 1 — p. 10-102

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*60000[lb/in2]*0.785[in2] = **23.55**[kip] — Eq. J3-1

$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor$ = 2.71*23.55[kip]*1 = **63.89**[kip] — Tables (7-1..14)

Flexure with the Von-Mises shear reduction	[Kip*ft]	32.37	21.92	DL	0.68	p. 10-103

$A_g = L_p*t_p$ = 12.5[in]*0.5[in] = **6.25**[in2] — Sec. D3-1

$f_v = V/A_g$ = 30[kip]/6.25[in2] = **4800**[lb/in2] — p. 10-103

$(1/\Omega)F_{cr} = (\max(0, ((1/\Omega)*F_y)^2 - 3*f_v^2))^{1/2}$ = (max(0, (0.599*36000[lb/in2])^2 - 3*4800[lb/in2]^2))$^{1/2}$ = **19889.18**[lb/in2] — p. 10-103

$Z_x = t_p*L^2/4$ = 0.5[in]*12.5[in]^2/4 = **19.53**[in3] — T. 17-27

$(1/\Omega)M_n = (1/\Omega)F_{cr}*Z$ = 19889.18[lb/in2]*19.53[in3] = **32.37**[kip*ft] — p. 10-103

Bolt bearing under shear load	[Kip]	82.98	30.00	DL	0.36	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.75[in] - 1.06[in]/2) = **1.22**[in] — Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(2.71/(2*4))*(min(1.2*1.22[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(4 - 1))*0.5[in]*58000[lb/in2]*2 = **82.98**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	90.00	30.00	DL	0.33	Eq. J4-3

$A_g = L_p*t_p$ = 12.5[in]*0.5[in] = **6.25**[in2] — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*36000[lb/in2]*6.25[in2] = **90**[kip] — Eq. J4-3

Shear rupture	[Kip]	69.60	30.00	DL	0.43	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 12.5[in] - 4*1.13[in] = **8**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 8[in]*0.5[in] = **4**[in2] — Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv}$ = 0.5*0.60*58000[lb/in2]*4[in2] = **69.6**[kip] — Eq. J4-4

Block shear	[Kip]	79.35	30.00	DL	0.38	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1.31[in] + 1/16 [in] = **1.38**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (2[in] + (2 - 1)*3[in] - (2 - 0.5)*1.38[in])*0.5[in] = **1.47**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.75[in] + (4 - 1)*3[in])*0.5[in] = **5.38**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.75[in] + (4 - 1)*(3[in] - 1.13[in]) - 1.13[in]/2)*0.5[in] = **3.41**[in2] — Sec. J4-3

IsStressUniform → **False**

U_{bs} = 0.5 — Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$ = 0.5*min(0.6*58000[lb/in2]*3.41[in2] + 0.5*58000[lb/in2]*1.47[in2], 0.6*36000[lb/in2]*5.38[in2] + 0.5*58000[lb/in2]*1.47[in2]) = **79.35**[kip] — Eq. J4-5

Flexural rupture	[Kip]	57.09	30.00	DL	0.53	p. 9-6

$L_h = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] — Sec. D3-2

$Z_{net} = t_p/4*(L^2 - s^2*n*(n^2 - 1)*L_h/L)$ = 0.5[in]/4*(12.5[in]^2 - 3[in]^2*4*(4^2 - 1)*1.13[in]/12.5[in]) = **13.46**[in3] — 4

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e$ = 0.5*58000[lb/in2]*13.46[in3]/6.84[in] = **57.09**[kip] — p. 9-6

Plate (support side)

Weld capacity	[Kip]	139.30	30.00	DL	0.22	Tables 8-4 .. 8-11

$e = 0$ — p. 10-135

$(1/\Omega)R_n$ = 2 * ((1/Ω)*C*C_1*D*L) = 2 * (0.5*1.86[kip/in]*1*5*15.01[in]) = **139.3**[kip] — Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load	[Kip]	51.66	30.00	DL	0.58	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 3.35[in] - 1.06[in]/2) = **2.82**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(2.71/(2*4))*(min(1.2*2.82[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(4 - 1))*0.25[in]*65000[lb/in2]*2 = **51.66**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	78.50	30.00	DL	0.38	Eq. J4-3

$A_g = L_p*t_p$ = 15.7[in]*0.25[in] = **3.93**[in2] — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*3.93[in2] = **78.5**[kip] — Eq. J4-3

Support

Welds rupture	[Kip/ft]	135.72	23.98	DL	0.18	p. 9-5

$R_n = 0.6*F_u*t_p$ = 0.6*65000[lb/in2]*0.29[in] = **11.31**[kip/in] — p. 9-5

$e = 0$ — p. 10-135

$D_{min} = P/((1/\Omega)*C*C_1*L)$ = 15[kip]/(0.5*1.86[kip/in]*1*15.01[in]) = **1.08** — tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] = 0.6*70000[lb/in2]*(2)^{1/2}/2*1.08/16 [in] = **2**[kip/in] — p. 9-5

Global critical strength ratio **0.68**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

c: Coped length

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Load eccentricity

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

h_o: Reduced beam depth

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_p: Plate length

L: Length of weld

λ: Slenderness

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)F_{cr}$: Design or allowable flexural stress buckling

$(1/\Omega)M_n$: Design or allowable strength

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

$sin\alpha$: Sine of the skew angle

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

t_w: Web thickness

U_{bs}: Stress index

V: Shear load

w_{min}: Minimum weld size required

Z: Plastic modulus

Z_{net}: Net plastic section modulus

Z_x: Plastic section modulus about the x-axis

REFERENCES

{4} AISC 2005, Design Examples Version 13.0, pp. IIA-63, IIA_86, IIA-98

Current Date: 2016-05-06 4:11 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-02 Beam to Column Shear with Skewed Angle\B2C WEB5.cnx\

Steel connections

Results

Connection name	:	**SP BCW**
Connection ID	:	**SC-02-3**

Family: Beam - Column web (BCW)

Type: Single plate

Description: B:W16x31

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru** [Kip]	**Pu** [Kip]	**Pu** [Kip]	**Mu22** [Kip*ft]	**Mu33** [Kip*ft]	**Load type**
DL	10.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Plate (beam side)						
Vertical edge distance	[in]	1.75	1.75	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75\text{[in]} + 0\text{[in]} = \mathbf{1.75}\text{[in]}$ Tables J3.4, J3.5

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Horizontal edge distance	[in]	2.00	1.87	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75\text{[in]} + 0.125\text{[in]} = \mathbf{1.88}\text{[in]}$ Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.67	6.60	Sec. J3.3, Sec. J3.5

s_{min} = 8/3*d = 8/3*1[in] = **2.67**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

s_{max} = min(24*t_p, 12 [in]) = min(24*0.275[in], 12 [in]) = **6.6**[in] — Sec. J3.5

Beam

Thickness	[in]	0.28	--	0.43	p. 10-151, p. 10-102

t_{pmax} = (3/16 [in])/$sin\alpha$ = (3/16 [in])/0.438 = **0.428**[in] — p. 10-151

t_{pmax} = d/2 + 1/16 [in] = 1[in]/2 + 1/16 [in] = **0.563**[in] — p. 10-102

t_{pmax} = d/2 + 1/16 [in] = 1[in]/2 + 1/16 [in] = **0.563**[in] — p. 10-102

Vertical edge distance	[in]	4.95	1.75	--	Tables J3.4, J3.5

L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.24	1.75	--	Tables J3.4, J3.5

L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Support

Weld size	[1/16in]	4	4	--	p. 10-101

w_{min} = (5/8)*t_p = (5/8)*0.375[in] = **0.0195** — p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Plate (beam side)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	16.48	10.00	DL	0.61	Tables (7-1..14)

(n>=10) and (n<=12) and (*IsStandardHole*) → (3>=10) and (3<=12) and (False) → **False**

BoltFactor = 1 — p. 10-102

$(1/\Omega)R_n$ = $(1/\Omega)$*F_{nv}*A_b = 0.5*60000[lb/in2]*0.785[in2] = **23.55**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = C*$(1/\Omega)R_n$*$BoltFactor$ = 0.7*23.55[kip]*1 = **16.48**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Flexure with the Von-Mises shear reduction	[Kip*ft]	14.81	6.98	DL	0.47	p. 10-103

A_g = L_p*t_p = 9.5[in]*0.375[in] = **3.56**[in2] — Sec. D3-1

f_v = V/A_g = 10[kip]/3.56[in2] = **2807.02**[lb/in2] — p. 10-103

$(1/\Omega)F_{cr}$ = (max(0, $((1/\Omega)*F_y)^2$ - 3*f_v^2))$^{1/2}$ = (max(0, (0.599*36000[lb/in2])^2 - 3*2807.02[lb/in2]^2))$^{1/2}$ = **21001.46**[lb/in2] — p. 10-103

Z_x = t_p*L^2/4 = 0.375[in]*9.5[in]^2/4 = **8.46**[in3] — T. 17-27

$(1/\Omega)M_n = (1/\Omega)F_{cr}*Z$ = 21001.46[lb/in2]*8.46[in3] = **14.81**[kip*ft] p. 10-103

Bolt bearing under shear load [Kip] 15.51 10.00 DL 0.64 p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.75[in] - 1.06[in]/2) = **1.22**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(0.7/(1*3))*(min(1.2*1.22[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(3 - 1))*0.375[in]*58000[lb/in2]*1 = **15.51**[kip] p. 7-18, Sec. J3.10

Shear yielding [Kip] 51.30 10.00 DL 0.19 Eq. J4-3

$A_g = L_p*t_p$ = 9.5[in]*0.375[in] = **3.56**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*36000[lb/in2]*3.56[in2] = **51.3**[kip] Eq. J4-3

Shear rupture [Kip] 39.97 10.00 DL 0.25 Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$L_e = L - n*L_h$ = 9.5[in] - 3*1.13[in] = **6.13**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 6.13[in]*0.375[in] = **2.3**[in2] Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv}$ = 0.5*0.60*58000[lb/in2]*2.3[in2] = **39.97**[kip] Eq. J4-4

Block shear [Kip] 45.66 10.00 DL 0.22 Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1.31[in] + 1/16 [in] = **1.38**[in] Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (2[in] + (1 - 1)*3[in] - (1 - 0.5)*1.38[in])*0.375[in] = **0.492**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.75[in] + (3 - 1)*3[in])*0.375[in] = **2.91**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.75[in] + (3 - 1)*(3[in] - 1.13[in]) - 1.13[in]/2)*0.375[in] = **1.85**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$ = 0.5*min(0.6*58000[lb/in2]*1.85[in2] + 1*58000[lb/in2]*0.492[in2], 0.6*36000[lb/in2]*2.91[in2] + 1*58000[lb/in2]*0.492[in2]) = **45.66**[kip] Eq. J4-5

Flexural rupture [Kip] 22.46 10.00 DL 0.45 p. 9-6

$L_h = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$Z_{net} = t_p/4*(L^2 - s^2*n*(n^2 - 1)*L_h/L)$ = 0.375[in]/4*(9.5[in]^2 - 3[in]^2*3*(3^2 - 1)*1.13[in]/9.5[in]) = **6.06**[in3] 4

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e$ = 0.5*58000[lb/in2]*6.06[in3]/7.83[in] = **22.46**[kip] p. 9-6

Plate (support side)

Weld capacity [Kip] 111.52 10.00 DL 0.09 Tables 8-4 .. 8-11

e = 0 p. 10-135

$(1/\Omega)R_n = 2 * ((1/\Omega)*C*C_1*D*L)$ = 2 * (0.5*1.86[kip/in]*1*4*15.02[in]) = **111.52**[kip] Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load	[Kip]	14.70	10.00	DL	0.68	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 4.95[in] - 1.06[in]/2) = **4.42**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(0.7/(1*3))*(min(1.2*4.42[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(3 - 1))*0.275[in]*65000[lb/in2]*1 = **14.7**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	87.45	10.00	DL	0.11	Eq. J4-3

$A_g = L_p*t_p$ = 15.9[in]*0.275[in] = **4.37**[in2] — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*4.37[in2] = **87.45**[kip] — Eq. J4-3

Support

Welds rupture	[Kip/ft]	159.12	7.99	DL	0.05	p. 9-5

$R_n = 0.6*F_u*t_p$ = 0.6*65000[lb/in2]*0.34[in] = **13.26**[kip/in] — p. 9-5

$e = 0$ — p. 10-135

$D_{min} = P/((1/\Omega)*C*C_1*L)$ = 5[kip]/(0.5*1.86[kip/in]*1*15.02[in]) = **0.359** — tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] = 0.6*70000[lb/in2]*$(2)^{1/2}$/2*0.359/16 [in] = **0.666**[kip/in] — p. 9-5

Global critical strength ratio **0.68**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

c: Coped length

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Load eccentricity

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

h_o: Reduced beam depth

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_p: Plate length

L: Length of weld

λ: Slenderness

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)F_{cr}$: Design or allowable flexural stress buckling

$(1/\Omega)M_n$: Design or allowable strength

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

$sin\alpha$: Sine of the skew angle

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

t_w: Web thickness

U_{bs}: Stress index

V: Shear load

w_{min}: Minimum weld size required

Z: Plastic modulus

Z_{net}: Net plastic section modulus

Z_x: Plastic section modulus about the x-axis

REFERENCES

{4} AISC 2005, Design Examples Version 13.0, pp. IIA-63, IIA_86, IIA-98

Current Date: 2016-05-06 4:17 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-02 Beam to Column Shear with Skewed Angle\B2C WEB5.cnx\

Steel connections

Results

Connection name	:	**SP BCW**
Connection ID	:	**SC-02-4**

Family: Beam - Column web (BCW)

Type: Single plate

Description: B:W24x55

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru** [Kip]	**Pu** [Kip]	**Pu** [Kip]	**Mu22** [Kip*ft]	**Mu33** [Kip*ft]	**Load type**
DL	40.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
Plate (beam side)						
Vertical edge distance	[in]	1.75	1.75	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75[\text{in}] + 0[\text{in}] = \mathbf{1.75}[\text{in}]$ Tables J3.4, J3.5

Horizontal edge distance	[in]	2.00	1.87	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75[\text{in}] + 0.125[\text{in}] = \mathbf{1.88}[\text{in}]$ Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.67	9.00	✓	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*1[in] = \mathbf{2.67}[in]$ — Sec. J3.3

$IsCorrosionConsidered \rightarrow$ **False**

$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.375[in], 12\ [in]) = \mathbf{9}[in]$ — Sec. J3.5

<u>Beam</u>

Thickness	[in]	0.39	--	0.43	✓	p. 10-151, p. 10-102

$t_{pmax} = (3/16\ [in])/\sin\alpha = (3/16\ [in])/0.438 = \mathbf{0.428}[in]$ — p. 10-151

$t_{pmax} = d/2 + 1/16\ [in] = 1[in]/2 + 1/16\ [in] = \mathbf{0.563}[in]$ — p. 10-102

$t_{pmax} = d/2 + 1/16\ [in] = 1[in]/2 + 1/16\ [in] = \mathbf{0.563}[in]$ — p. 10-102

Vertical edge distance	[in]	4.30	1.75	--	✓	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = \mathbf{1.75}[in]$ — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.19	1.75	--	✓	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = \mathbf{1.75}[in]$ — Tables J3.4, J3.5

<u>Support</u>

Weld size	[1/16in]	5	4	--	✓	p. 10-101

$w_{min} = (5/8)*t_p = (5/8)*0.375[in] = \mathbf{0.0195}$ — p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

<u>Plate (beam side)</u>

Bolts shear	[Kip]	72.37	40.00	DL	0.55	Tables (7-1..14)

$(n>=10)$ and $(n<=12)$ and $(IsStandardHole) \rightarrow (6>=10)$ and $(6<=12)$ and $(False) \rightarrow$ **False**

$BoltFactor = 1$ — p. 10-102

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*60000[lb/in2]*0.785[in2] = \mathbf{23.55}[kip]$ — Eq. J3-1

$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor = 3.07*23.55[kip]*1 = \mathbf{72.37}[kip]$ — Tables (7-1..14)

Flexure with the Von-Mises shear reduction	[Kip*ft]	51.08	24.30	DL	0.48	p. 10-103

$A_g = L_p*t_p = 18.5[in]*0.375[in] = \mathbf{6.94}[in2]$ — Sec. D3-1

$f_v = V/A_g = 40[kip]/6.94[in2] = \mathbf{5765.77}[lb/in2]$ — p. 10-103

$(1/\Omega)F_{cr} = (\max(0, ((1/\Omega)*F_y)^2 - 3*f_v^2))^{1/2} = (\max(0, (0.599*36000[lb/in2])^2 - 3*5765.77[lb/in2]^2))^{1/2} = \mathbf{19104.11}[lb/in2]$ — p. 10-103

$Z_x = t_p*L^2/4 = 0.375[in]*18.5[in]^2/4 = \mathbf{32.09}[in3]$ — T. 17-27

$(1/\Omega)M_n = (1/\Omega)F_{cr}*Z$ = 19104.11[lb/in2]*32.09[in3] = **51.08**[kip*ft] p. 10-103

Bolt bearing under shear load	[Kip]	72.90	40.00	DL	0.55	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.75[in] - 1.06[in]/2) = **1.22**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(3.07/(1*6))*(min(1.2*1.22[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(6 - 1))*0.375[in]*58000[lb/in2]*1 = **72.9**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	99.90	40.00	DL	0.40	Eq. J4-3

$A_g = L_p*t_p$ = 18.5[in]*0.375[in] = **6.94**[in2] — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*36000[lb/in2]*6.94[in2] = **99.9**[kip] — Eq. J4-3

Shear rupture	[Kip]	76.67	40.00	DL	0.52	Eq. J4-4

$L_h = d_h + 1/16$ [in] = 1.06[in] + 1/16 [in] = **1.13**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 18.5[in] - 6*1.13[in] = **11.75**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 11.75[in]*0.375[in] = **4.41**[in2] — Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv}$ = 0.5*0.60*58000[lb/in2]*4.41[in2] = **76.67**[kip] — Eq. J4-4

Block shear	[Kip]	82.11	40.00	DL	0.49	Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 1.31[in] + 1/16 [in] = **1.38**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 1.06[in] + 1/16 [in] = **1.13**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (2[in] + (1 - 1)*3[in] - (1 - 0.5)*1.38[in])*0.375[in] = **0.492**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.75[in] + (6 - 1)*3[in])*0.375[in] = **6.28**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.75[in] + (6 - 1)*(3[in] - 1.13[in]) - 1.13[in]/2)*0.375[in] = **3.96**[in2] — Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$ = 0.5*min(0.6*58000[lb/in2]*3.96[in2] + 1*58000[lb/in2]*0.492[in2], 0.6*36000[lb/in2]*6.28[in2] + 1*58000[lb/in2]*0.492[in2]) = **82.11**[kip] — Eq. J4-5

Flexural rupture	[Kip]	90.16	40.00	DL	0.44	p. 9-6

$L_h = d_h + 1/16$ [in] = 1.06[in] + 1/16 [in] = **1.13**[in] — Sec. D3-2

$Z_{net} = t_p/4*(L^2 - s^2*n*(n^2 - 1)*L_h/L)$ = 0.375[in]/4*(18.5[in]^2 - 3[in]^2*6*(6^2 - 1)*1.13[in]/18.5[in]) = **21.31**[in3] — 4

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e$ = 0.5*58000[lb/in2]*21.31[in3]/6.86[in] = **90.16**[kip] — p. 9-6

<u>Plate (support side)</u>

Weld capacity	[Kip]	209.65	40.00	DL	0.19	Tables 8-4 .. 8-11

$e = 0$ — p. 10-135

$(1/\Omega)R_n = 2 * ((1/\Omega)*C*C_1*D*L)$ = 2 * (0.5*1.86[kip/in]*1*5*22.59[in]) = **209.65**[kip] — Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load	[Kip]	92.22	40.00	DL	0.43	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 4.3[in] - 1.06[in]/2) = **3.77**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(3.07/(1*6))*(min(1.2*3.77[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(6 - 1))*0.395[in]*65000[lb/in2]*1 = **92.22**[kip] p. 7-18, Sec. J3.10

Shear yielding	[Kip]	186.44	40.00	DL	0.21	Eq. J4-3

$A_g = L_p*t_p$ = 23.6[in]*0.395[in] = **9.32**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*9.32[in2] = **186.44**[kip] Eq. J4-3

Support

Welds rupture	[Kip/ft]	173.16	21.25	DL	0.12	p. 9-5

$R_n = 0.6*F_u*t_p$ = 0.6*65000[lb/in2]*0.37[in] = **14.43**[kip/in] p. 9-5

$e = 0$ p. 10-135

$D_{min} = P/((1/\Omega)*C*C_1*L)$ = 20[kip]/(0.5*1.86[kip/in]*1*22.59[in]) = **0.954** tables 8-4..11

HasWeldsOnBothSides $\rightarrow$ **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] = 0.6*70000[lb/in2]*(2)^{1/2}/2*0.954/16 [in] = **1.77**[kip/in] p. 9-5

Global critical strength ratio **0.55**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

c: Coped length

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Load eccentricity

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

h_o: Reduced beam depth

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

L: Length

L_{c-end}: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_p: Plate length

L: Length of weld

λ: Slenderness

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)F_{cr}$: Design or allowable flexural stress buckling

$(1/\Omega)M_n$: Design or allowable strength

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

$sin\alpha$: Sine of the skew angle

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

L_{c-spa}: Distance between adjacent holes edges

t_p: Thickness of the connected material

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

t_w: Web thickness

U_{bs}: Stress index

V: Shear load

w_{min}: Minimum weld size required

Z: Plastic modulus

Z_{net}: Net plastic section modulus

Z_x: Plastic section modulus about the x-axis

REFERENCES

{4} AISC 2005, Design Examples Version 13.0, pp. IIA-63, IIA_86, IIA-98

Current Date: 2016-05-06 4:06 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-02 Beam to Column Shear with Skewed Angle\B2C WEB3.cnx\

Steel connections

Results

Connection name : SP BCW

Connection ID : SC-02-5

Family: Beam - Column web (BCW)

Type: Single plate

Description: B:W24x62

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru**	**Pu**	**Pu**	**Mu22**	**Mu33**	**Load type**
	[Kip]	[Kip]	[Kip]	[Kip*ft]	[Kip*ft]	
DL	60.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Plate (beam side)						
Vertical edge distance	[in]	1.75	1.75	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = \mathbf{1.75}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	2.00	1.87	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0.125[in] = \mathbf{1.88}[in]$						Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.67	9.00	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*1$[in] = **2.67**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.375$[in], 12 [in]) = **9**[in] — Sec. J3.5

Beam

Thickness	[in]	0.43	--	0.43	p. 10-151, p. 10-102

$t_{pmax} = (3/16$ [in]$)/\sin\alpha = (3/16$ [in])/0.438 = **0.428**[in] — p. 10-151

$t_{pmax} = d/2 + 1/16$ [in] = 1[in]/2 + 1/16 [in] = **0.563**[in] — p. 10-102

$t_{pmax} = d/2 + 1/16$ [in] = 1[in]/2 + 1/16 [in] = **0.563**[in] — p. 10-102

Vertical edge distance	[in]	2.85	1.75	--	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75$[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.17	1.75	--	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75$[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Support

Weld size	[1/16in]	5	4	--	p. 10-101

$w_{min} = (5/8)*t_p = (5/8)*0.375$[in] = **0.0195** — p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Plate (beam side)

Bolts shear	[Kip]	94.83	60.00	DL	0.63	Tables (7-1..14)

(n>=10) and (n<=12) and (*IsStandardHole*) → (7>=10) and (7<=12) and (False) → **False**

BoltFactor = 1 — p. 10-102

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*60000$[lb/in2]*0.785[in2] = **23.55**[kip] — Eq. J3-1

$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor = 4.03*23.55$[kip]*1 = **94.83**[kip] — Tables (7-1..14)

Flexure with the Von-Mises shear reduction	[Kip*ft]	62.40	36.33	DL	0.58	p. 10-103

$A_g = L_p*t_p = 21.5$[in]*0.375[in] = **8.06**[in2] — Sec. D3-1

$f_v = V/A_g = 60$[kip]/8.06[in2] = **7441.86**[lb/in2] — p. 10-103

$(1/\Omega)F_{cr} = (\max(0, ((1/\Omega)*F_y)^2 - 3*f_v^2))^{1/2} = (\max(0, (0.599*36000$[lb/in2]$)^2 - 3*7441.86$[lb/in2]$^2))^{1/2}$ = **17278.76**[lb/in2] — p. 10-103

$Z_x = t_p*L^2/4 = 0.375$[in]*21.5[in]^2/4 = **43.34**[in3] — T. 17-27

$(1/\Omega)M_n = (1/\Omega)F_{cr}*Z$ = 17278.76[lb/in2]*43.34[in3] = **62.4**[kip*ft] p. 10-103

Bolt bearing under shear load	[Kip]	96.41	60.00	DL	0.62	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.75[in] - 1.06[in]/2) = **1.22**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(4.03/(1*7))*(min(1.2*1.22[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(7 - 1))*0.375[in]*58000[lb/in2]*1 = **96.41**[kip] p. 7-18, Sec. J3.10

Shear yielding	[Kip]	116.10	60.00	DL	0.52	Eq. J4-3

$A_g = L_p*t_p$ = 21.5[in]*0.375[in] = **8.06**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*36000[lb/in2]*8.06[in2] = **116.1**[kip] Eq. J4-3

Shear rupture	[Kip]	88.90	60.00	DL	0.67	Eq. J4-4

$L_h = d_h + 1/16$ [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$L_e = L - n*L_h$ = 21.5[in] - 7*1.13[in] = **13.63**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 13.63[in]*0.375[in] = **5.11**[in2] Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv}$ = 0.5*0.60*58000[lb/in2]*5.11[in2] = **88.9**[kip] Eq. J4-4

Block shear	[Kip]	94.26	60.00	DL	0.64	Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 1.31[in] + 1/16 [in] = **1.38**[in] Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (2[in] + (1 - 1)*3[in] - (1 - 0.5)*1.38[in])*0.375[in] = **0.492**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.75[in] + (7 - 1)*3[in])*0.375[in] = **7.41**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.75[in] + (7 - 1)*(3[in] - 1.13[in]) - 1.13[in]/2)*0.375[in] = **4.66**[in2] Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$ = 0.5*min(0.6*58000[lb/in2]*4.66[in2] + 1*58000[lb/in2]*0.492[in2], 0.6*36000[lb/in2]*7.41[in2] + 1*58000[lb/in2]*0.492[in2]) = **94.26**[kip] Eq. J4-5

Flexural rupture	[Kip]	120.93	60.00	DL	0.50	p. 9-6

$L_h = d_h + 1/16$ [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$Z_{net} = t_p/4*(L^2 - s^2*n*(n^2 - 1)*L_h/L)$ = 0.375[in]/4*(21.5[in]^2 - 3[in]^2*7*(7^2 - 1)*1.13[in]/21.5[in]) = **28.5**[in3] 4

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e$ = 0.5*58000[lb/in2]*28.5[in3]/6.84[in] = **120.93**[kip] p. 9-6

<u>Plate (support side)</u>

Weld capacity	[Kip]	209.00	60.00	DL	0.29	Tables 8-4 .. 8-11

$e = 0$ p. 10-135

$(1/\Omega)R_n = 2 * ((1/\Omega)*C*C_1*D*L)$ = 2 * (0.5*1.86[kip/in]*1*5*22.52[in]) = **209**[kip] Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load	[Kip]	131.43	60.00	DL	0.46		p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 2.85[in] - 1.06[in]/2) = **2.32**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(4.03/(1*7))*(min(1.2*2.32[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(7 - 1))*0.43[in]*65000[lb/in2]*1 = **131.43**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	203.82	60.00	DL	0.29		Eq. J4-3

$A_g = L_p*t_p$ = 23.7[in]*0.43[in] = **10.19**[in2] — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*10.19[in2] = **203.82**[kip] — Eq. J4-3

Support

Welds rupture	[Kip/ft]	135.72	31.97	DL	0.24		p. 9-5

$R_n = 0.6*F_u*t_p$ = 0.6*65000[lb/in2]*0.29[in] = **11.31**[kip/in] — p. 9-5

$e = 0$ — p. 10-135

$D_{min} = P/((1/\Omega)*C*C_1*L)$ = 30[kip]/(0.5*1.86[kip/in]*1*22.52[in]) = **1.44** — tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] = 0.6*70000[lb/in2]*(2)^{1/2}/2*1.44/16 [in] = **2.66**[kip/in] — p. 9-5

Global critical strength ratio **0.67**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

c: Coped length

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Load eccentricity

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

h_o: Reduced beam depth

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_p: Plate length

L: Length of weld

λ: Slenderness

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)F_{cr}$: Design or allowable flexural stress buckling

$(1/\Omega)M_n$: Design or allowable strength

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

$sin\alpha$: Sine of the skew angle

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

t_w: Web thickness

U_{bs}: Stress index

V: Shear load

w_{min}: Minimum weld size required

Z: Plastic modulus

Z_{net}: Net plastic section modulus

Z_x: Plastic section modulus about the x-axis

REFERENCES

{4} AISC 2005, Design Examples Version 13.0, pp. IIA-63, IIA_86, IIA-98

Current Date: 2016-05-06 4:14 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-02 Beam to Column Shear with Skewed Angle\B2C WEB5.cnx\

Steel connections

Results

Connection name	:	**SP BCW**
Connection ID	:	**SC-02-6**

Family: Beam - Column web (BCW)

Type: Single plate

Description: B:W24x76

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru** [Kip]	**Pu** [Kip]	**Pu** [Kip]	**Mu22** [Kip*ft]	**Mu33** [Kip*ft]	**Load type**
DL	40.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Plate (beam side)						
Vertical edge distance	[in]	1.75	1.75	--	✔	Tables J3.4, J3.5
Horizontal edge distance	[in]	2.00	1.87	--	✔	Tables J3.4, J3.5

Vertical edge distance:

$L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = \mathbf{1.75}[in]$ Tables J3.4, J3.5

Horizontal edge distance:

$L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0.125[in] = \mathbf{1.88}[in]$ Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.67	9.00	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*1$[in] = **2.67**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.375$[in], 12 [in]) = **9**[in] — Sec. J3.5

Beam

Vertical edge distance	[in]	4.45	1.75	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75$[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.17	1.75	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75$[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Support

Weld size	[1/16in]	5	4	--	✔	p. 10-101

$w_{min} = (5/8)*t_p = (5/8)*0.375$[in] = **0.0195** — p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Plate (beam side)

Bolts shear	[Kip]	65.00	40.00	DL	0.62	Tables (7-1..14)

(n>=10) and (n<=12) and (*IsStandardHole*) → (6>=10) and (6<=12) and (False) → **False**

BoltFactor = 1 — p. 10-102

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*60000$[lb/in2]*0.785[in2] = **23.55**[kip] — Eq. J3-1

$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor = 2.76*23.55$[kip]*1 = **65**[kip] — Tables (7-1..14)

Flexure with the Von-Mises shear reduction	[Kip*ft]	51.08	27.77	DL	0.54	p. 10-103

$A_g = L_p*t_p = 18.5$[in]*0.375[in] = **6.94**[in2] — Sec. D3-1

$f_v = V/A_g = 40$[kip]/6.94[in2] = **5765.77**[lb/in2] — p. 10-103

$(1/\Omega)F_{cr} = (\max(0, ((1/\Omega)*F_y)^2 - 3*f_v^2))^{1/2} = (\max(0, (0.599*36000$[lb/in2]$)^2 - 3*5765.77$[lb/in2]$^2))^{1/2}$ = **19104.11**[lb/in2] — p. 10-103

$Z_x = t_p*L^2/4 = 0.375$[in]*18.5[in]^2/4 = **32.09**[in3] — T. 17-27

$(1/\Omega)M_n = (1/\Omega)F_{cr}*Z = 19104.11$[lb/in2]*32.09[in3] = **51.08**[kip*ft] — p. 10-103

Bolt bearing under shear load	[Kip]	65.47	40.00	DL	0.61	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.75$[in] - 1.06[in]/2) = **1.22**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] - 1.06[in]) = **1.94**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(2.76/(1*6))*(\min(1.2*1.22[in], 2.4*1[in]) + \min(1.2*1.94[in], 2.4*1[in])*(6 - 1))*0.375[in]*58000[lb/in2]*1 = \mathbf{65.47}[kip]$ — p. 7-18, Sec. J3.10

Shear yielding [Kip] 99.90 40.00 DL 0.40 Eq. J4-3

$A_g = L_p*t_p = 18.5[in]*0.375[in] = \mathbf{6.94}[in2]$ — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*36000[lb/in2]*6.94[in2] = \mathbf{99.9}[kip]$ — Eq. J4-3

Shear rupture [Kip] 76.67 40.00 DL 0.52 Eq. J4-4

$L_h = d_h + 1/16\ [in] = 1.06[in] + 1/16\ [in] = \mathbf{1.13}[in]$ — Sec. D3-2

$L_e = L - n*L_h = 18.5[in] - 6*1.13[in] = \mathbf{11.75}[in]$ — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 11.75[in]*0.375[in] = \mathbf{4.41}[in2]$ — Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*58000[lb/in2]*4.41[in2] = \mathbf{76.67}[kip]$ — Eq. J4-4

Block shear [Kip] 82.11 40.00 DL 0.49 Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 1.31[in] + 1/16\ [in] = \mathbf{1.38}[in]$ — Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 1.06[in] + 1/16\ [in] = \mathbf{1.13}[in]$ — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2[in] + (1 - 1)*3[in] - (1 - 0.5)*1.38[in])*0.375[in] = \mathbf{0.492}[in2]$ — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.75[in] + (6 - 1)*3[in])*0.375[in] = \mathbf{6.28}[in2]$ — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.75[in] + (6 - 1)*(3[in] - 1.13[in]) - 1.13[in]/2)*0.375[in] = \mathbf{3.96}[in2]$ — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*58000[lb/in2]*3.96[in2] + 1*58000[lb/in2]*0.492[in2], 0.6*36000[lb/in2]*6.28[in2] + 1*58000[lb/in2]*0.492[in2]) = \mathbf{82.11}[kip]$ — Eq. J4-5

Flexural rupture [Kip] 79.31 40.00 DL 0.50 p. 9-6

$L_h = d_h + 1/16\ [in] = 1.06[in] + 1/16\ [in] = \mathbf{1.13}[in]$ — Sec. D3-2

$Z_{net} = t_p/4*(L^2 - s^2*n*(n^2 - 1)*L_h/L) = 0.375[in]/4*(18.5[in]^2 - 3[in]^2*6*(6^2 - 1)*1.13[in]/18.5[in]) = \mathbf{21.31}[in3]$ — 4

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*58000[lb/in2]*21.31[in3]/7.79[in] = \mathbf{79.31}[kip]$ — p. 9-6

Plate (support side)

Weld capacity [Kip] 209.19 40.00 DL 0.19 Tables 8-4 .. 8-11

$e = 0$ — p. 10-135

$(1/\Omega)R_n = 2 * ((1/\Omega)*C*C_1*D*L) = 2 * (0.5*1.86[kip/in]*1*5*22.54[in]) = \mathbf{209.19}[kip]$ — Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load [Kip] 92.26 40.00 DL 0.43 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \max(0.0, L_e - d_h/2) = \max(0.0, 4.45[in] - 1.06[in]/2) = \mathbf{3.92}[in]$ — Sec. J4.10

$L_{c\text{-}spa} = \max(0.0, s - d_h) = \max(0.0, 3[in] - 1.06[in]) = \mathbf{1.94}[in]$ — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*$

$(n - 1))*t_p*F_u*n_c$ = 0.5*(2.76/(1*6))*(min(1.2*3.92[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(6 - 1))*0.44[in]*65000[lb/in2]*1 = **92.26**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	210.32	40.00	DL	0.19	Eq. J4-3

$A_g = L_p*t_p$ = 23.9[in]*0.44[in] = **10.52**[in2] — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*10.52[in2] = **210.32**[kip] — Eq. J4-3

Support

Welds rupture	[Kip/ft]	194.22	21.30	DL	0.11	p. 9-5

$R_n = 0.6*F_u*t_p$ = 0.6*65000[lb/in2]*0.415[in] = **16.19**[kip/in] — p. 9-5

$e = 0$ — p. 10-135

$D_{min} = P/((1/\Omega)*C*C_1*L)$ = 20[kip]/(0.5*1.86[kip/in]*1*22.54[in]) = **0.956** — tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] = 0.6*70000[lb/in2]*(2)^{1/2}/2*0.956/16 [in] = **1.77**[kip/in] — p. 9-5

Global critical strength ratio **0.62**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

c: Coped length

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Load eccentricity

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

h_o: Reduced beam depth

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_p: Plate length

L: Length of weld

λ: Slenderness

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)F_{cr}$: Design or allowable flexural stress buckling

$(1/\Omega)M_n$: Design or allowable strength

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

t_p: Plate thickness

t_w: Web thickness

U_{bs}: Stress index

V: Shear load

w_{min}: Minimum weld size required

Z: Plastic modulus

Z_{net}: Net plastic section modulus

Z_x: Plastic section modulus about the x-axis

REFERENCES

{4} AISC 2005, Design Examples Version 13.0, pp. IIA-63, IIA_86, IIA-98

Current Date: 2016-05-06 4:04 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-02 Beam to Column Shear with Skewed Angle\B2C WEB2.cnx\

Steel connections

Results

Connection name : **SP BCW**

Connection ID : **SC-02-7**

Family: Beam - Column web (BCW)

Type: Single plate

Description: B:W24x131

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru** [Kip]	**Pu** [Kip]	**Pu** [Kip]	**Mu22** [Kip*ft]	**Mu33** [Kip*ft]	**Load type**
DL	70.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
Plate (beam side)						
Vertical edge distance	[in]	1.75	1.75	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1.75[\text{in}] + 0[\text{in}] = \mathbf{1.75}[\text{in}]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	2.00	1.87	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1.75[\text{in}] + 0.125[\text{in}] = \mathbf{1.88}[\text{in}]$						Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.67	12.00	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*1$[in] = **2.67**[in] Sec. J3.3

IsCorrosionConsidered → **False**

s_{max} = min(24*t_p, 12 [in]) = min(24*0.5[in], 12 [in]) = **12**[in] Sec. J3.5

Beam

Vertical edge distance	[in]	3.25	1.75	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1.75[in] + 0[in] = **1.75**[in] Tables J3.4, J3.5

Horizontal edge distance	[in]	2.07	1.75	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1.75[in] + 0[in] = **1.75**[in] Tables J3.4, J3.5

Support

Weld size	[1/16in]	5	5	--	✔	p. 10-101

$w_{min} = (5/8)*t_p$ = (5/8)*0.5[in] = **0.026** p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Plate (beam side)

Bolts shear	[Kip]	77.47	70.00	DL	0.90	Tables (7-1..14)

(n>=10) and (n<=12) and (*IsStandardHole*) → (7>=10) and (7<=12) and (False) → **False**

BoltFactor = 1 p. 10-102

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*60000[lb/in2]*0.785[in2] = **23.55**[kip] Eq. J3-1

$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor$ = 3.29*23.55[kip]*1 = **77.47**[kip] Tables (7-1..14)

Flexure with the Von-Mises shear reduction	[Kip*ft]	88.46	55.18	DL	0.62	p. 10-103

$A_g = L_p*t_p$ = 21.5[in]*0.5[in] = **10.75**[in2] Sec. D3-1

$f_v = V/A_g$ = 70[kip]/10.75[in2] = **6511.63**[lb/in2] p. 10-103

$(1/\Omega)F_{cr} = (\max(0, ((1/\Omega)*F_y)^2 - 3*f_v^2))^{1/2}$ = (max(0, (0.599*36000[lb/in2])^2 - 3*6511.63[lb/in2]^2))$^{1/2}$ = **18371.05**[lb/in2] p. 10-103

$Z_x = t_p*L^2/4$ = 0.5[in]*21.5[in]^2/4 = **57.78**[in3] T. 17-27

$(1/\Omega)M_n = (1/\Omega)F_{cr}*Z$ = 18371.05[lb/in2]*57.78[in3] = **88.46**[kip*ft] p. 10-103

Bolt bearing under shear load	[Kip]	105.02	70.00	DL	0.67	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.75[in] - 1.06[in]/2) = **1.22**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(3.29/(1*7))*(\min(1.2*1.22\mathrm{[in]}, 2.4*1\mathrm{[in]}) + \min(1.2*1.94\mathrm{[in]}, 2.4*1\mathrm{[in]})*(7 - 1))*0.5\mathrm{[in]}*58000\mathrm{[lb/in2]}*1 = \mathbf{105.02}\mathrm{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 154.80 70.00 DL 0.45 Eq. J4-3

$A_g = L_p*t_p = 21.5\mathrm{[in]}*0.5\mathrm{[in]} = \mathbf{10.75}\mathrm{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*36000\mathrm{[lb/in2]}*10.75\mathrm{[in2]} = \mathbf{154.8}\mathrm{[kip]}$ Eq. J4-3

Shear rupture [Kip] 118.54 70.00 DL 0.59 Eq. J4-4

$L_h = d_h + 1/16\ \mathrm{[in]} = 1.06\mathrm{[in]} + 1/16\ \mathrm{[in]} = \mathbf{1.13}\mathrm{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 21.5\mathrm{[in]} - 7*1.13\mathrm{[in]} = \mathbf{13.63}\mathrm{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 13.63\mathrm{[in]}*0.5\mathrm{[in]} = \mathbf{6.81}\mathrm{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*58000\mathrm{[lb/in2]}*6.81\mathrm{[in2]} = \mathbf{118.54}\mathrm{[kip]}$ Eq. J4-4

Block shear [Kip] 125.68 70.00 DL 0.56 Eq. J4-5

$dh_h = d_h + 1/16\ \mathrm{[in]} = 1.31\mathrm{[in]} + 1/16\ \mathrm{[in]} = \mathbf{1.38}\mathrm{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \mathrm{[in]} = 1.06\mathrm{[in]} + 1/16\ \mathrm{[in]} = \mathbf{1.13}\mathrm{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2\mathrm{[in]} + (1 - 1)*3\mathrm{[in]} - (1 - 0.5)*1.38\mathrm{[in]})*0.5\mathrm{[in]} = \mathbf{0.656}\mathrm{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.75\mathrm{[in]} + (7 - 1)*3\mathrm{[in]})*0.5\mathrm{[in]} = \mathbf{9.88}\mathrm{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.75\mathrm{[in]} + (7 - 1)*(3\mathrm{[in]} - 1.13\mathrm{[in]}) - 1.13\mathrm{[in]}/2)*0.5\mathrm{[in]} = \mathbf{6.22}\mathrm{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*58000\mathrm{[lb/in2]}*6.22\mathrm{[in2]} + 1*58000\mathrm{[lb/in2]}*0.656\mathrm{[in2]}, 0.6*36000\mathrm{[lb/in2]}*9.88\mathrm{[in2]} + 1*58000\mathrm{[lb/in2]}*0.656\mathrm{[in2]}) = \mathbf{125.68}\mathrm{[kip]}$ Eq. J4-5

Flexural rupture [Kip] 125.16 70.00 DL 0.56 p. 9-6

$L_h = d_h + 1/16\ \mathrm{[in]} = 1.06\mathrm{[in]} + 1/16\ \mathrm{[in]} = \mathbf{1.13}\mathrm{[in]}$ Sec. D3-2

$Z_{net} = t_p/4*(L^2 - s^2*n*(n^2 - 1)*L_h/L) = 0.5\mathrm{[in]}/4*(21.5\mathrm{[in]}^2 - 3\mathrm{[in]}^2*7*(7^2 - 1)*1.13\mathrm{[in]}/21.5\mathrm{[in]}) = \mathbf{38}\mathrm{[in3]}$ 4

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*58000\mathrm{[lb/in2]}*38\mathrm{[in3]}/8.81\mathrm{[in]} = \mathbf{125.16}\mathrm{[kip]}$ p. 9-6

Plate (support side)

Weld capacity [Kip] 209.56 70.00 DL 0.33 Tables 8-4 .. 8-11

$e = 0$ p. 10-135

$(1/\Omega)R_n = 2 * ((1/\Omega)*C*C_1*D*L) = 2 * (0.5*1.86\mathrm{[kip/in]}*1*5*22.58\mathrm{[in]}) = \mathbf{209.56}\mathrm{[kip]}$ Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load [Kip] 151.07 70.00 DL 0.46 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 3.25\mathrm{[in]} - 1.06\mathrm{[in]}/2) = \mathbf{2.72}\mathrm{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\mathrm{[in]} - 1.06\mathrm{[in]}) = \mathbf{1.94}\mathrm{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*$

$(n - 1))*t_p*F_u*n_c$ = 0.5*(3.29/(1*7))*(min(1.2*2.72[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(7 - 1))*0.605[in]*65000[lb/in2]*1 = **151.07**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	296.45	70.00	DL	0.24		Eq. J4-3

$A_g = L_p*t_p$ = 24.5[in]*0.605[in] = **14.82**[in2] — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*14.82[in2] = **296.45**[kip] — Eq. J4-3

Support

Welds rupture	[Kip/ft]	182.52	37.20	DL	0.20		p. 9-5

$R_n = 0.6*F_u*t_p$ = 0.6*65000[lb/in2]*0.39[in] = **15.21**[kip/in] — p. 9-5

$e = 0$ — p. 10-135

$D_{min} = P/((1/\Omega)*C*C_1*L)$ = 35[kip]/(0.5*1.86[kip/in]*1*22.58[in]) = **1.67** — tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] = 0.6*70000[lb/in2]*(2)^{1/2}/2*1.67/16 [in] = **3.1**[kip/in] — p. 9-5

Global critical strength ratio **0.90**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

c: Coped length

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Load eccentricity

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

h_o: Reduced beam depth

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_p: Plate length

L: Length of weld

λ: Slenderness

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)F_{cr}$: Design or allowable flexural stress buckling

$(1/\Omega)M_n$: Design or allowable strength

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

t_p: Plate thickness

t_w: Web thickness

U_{bs}: Stress index

V: Shear load

w_{min}: Minimum weld size required

Z: Plastic modulus

Z_{net}: Net plastic section modulus

Z_x: Plastic section modulus about the x-axis

REFERENCES

{4} AISC 2005, Design Examples Version 13.0, pp. IIA-63, IIA_86, IIA-98

Current Date: 2016-05-06 4:01 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-02 Beam to Column Shear with Skewed Angle\B2C WEB2.cnx\

Steel connections

Results

Connection name : SP BCW

Connection ID : SC-02-8

Family: Beam - Column web (BCW)

Type: Single plate

Description: B:W27x84

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru** [Kip]	**Pu** [Kip]	**Pu** [Kip]	**Mu22** [Kip*ft]	**Mu33** [Kip*ft]	**Load type**
DL	60.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Plate (beam side)						
Vertical edge distance	[in]	1.75	1.75	--	✓	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75\text{[in]} + 0\text{[in]} = \mathbf{1.75}\text{[in]}$ Tables J3.4, J3.5

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Horizontal edge distance	[in]	2.00	1.87	--	✓	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75\text{[in]} + 0.125\text{[in]} = \mathbf{1.88}\text{[in]}$ Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.67	9.00	✔	Sec. J3.3, Sec. J3.5

s_{min} = 8/3*d = 8/3*1[in] = **2.67**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

s_{max} = min(24*t_p, 12 [in]) = min(24*0.375[in], 12 [in]) = **9**[in] — Sec. J3.5

Beam

Vertical edge distance	[in]	4.35	1.75	--	✔	Tables J3.4, J3.5

L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.16	1.75	--	✔	Tables J3.4, J3.5

L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Support

Weld size	[1/16in]	4	4	--	✔	p. 10-101

w_{min} = (5/8)*t_p = (5/8)*0.375[in] = **0.0195** — p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Plate (beam side)

Bolts shear	[Kip]	69.16	60.00	DL	0.87	Tables (7-1..14)

(n>=10) and (n<=12) and (*IsStandardHole*) → (7>=10) and (7<=12) and (False) → **False**

BoltFactor = 1 — p. 10-102

$(1/\Omega)R_n$ = $(1/\Omega)$*F_{nv}*A_b = 0.5*60000[lb/in2]*0.785[in2] = **23.55**[kip] — Eq. J3-1

$(1/\Omega)R_n$ = C*$(1/\Omega)R_n$*$BoltFactor$ = 2.94*23.55[kip]*1 = **69.16**[kip] — Tables (7-1..14)

Flexure with the Von-Mises shear reduction	[Kip*ft]	62.40	54.11	DL	0.87	p. 10-103

A_g = L_p*t_p = 21.5[in]*0.375[in] = **8.06**[in2] — Sec. D3-1

f_v = V/A_g = 60[kip]/8.06[in2] = **7441.86**[lb/in2] — p. 10-103

$(1/\Omega)F_{cr}$ = (max(0, $((1/\Omega)*F_y)^2$ - 3*f_v^2))$^{1/2}$ = (max(0, (0.599*36000[lb/in2])^2 - 3*7441.86[lb/in2]^2))$^{1/2}$ = **17278.76**[lb/in2] — p. 10-103

Z_x = t_p*L^2/4 = 0.375[in]*21.5[in]^2/4 = **43.34**[in3] — T. 17-27

$(1/\Omega)M_n$ = $(1/\Omega)F_{cr}$*Z = 17278.76[lb/in2]*43.34[in3] = **62.4**[kip*ft] — p. 10-103

Bolt bearing under shear load	[Kip]	70.32	60.00	DL	0.85	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.75[in] - 1.06[in]/2) = **1.22**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(2.94/(1*7))*(\min(1.2*1.22\text{[in]}, 2.4*1\text{[in]}) + \min(1.2*1.94\text{[in]}, 2.4*1\text{[in]})*(7 - 1))*0.375\text{[in]}*58000\text{[lb/in2]}*1 = \mathbf{70.32}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 116.10 60.00 DL 0.52 Eq. J4-3

$A_g = L_p*t_p = 21.5\text{[in]}*0.375\text{[in]} = \mathbf{8.06}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*36000\text{[lb/in2]}*8.06\text{[in2]} = \mathbf{116.1}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 88.90 60.00 DL 0.67 Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 1.06\text{[in]} + 1/16\text{ [in]} = \mathbf{1.13}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 21.5\text{[in]} - 7*1.13\text{[in]} = \mathbf{13.63}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 13.63\text{[in]}*0.375\text{[in]} = \mathbf{5.11}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*58000\text{[lb/in2]}*5.11\text{[in2]} = \mathbf{88.9}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 94.26 60.00 DL 0.64 Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 1.31\text{[in]} + 1/16\text{ [in]} = \mathbf{1.38}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 1.06\text{[in]} + 1/16\text{ [in]} = \mathbf{1.13}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)*1.38\text{[in]})*0.375\text{[in]} = \mathbf{0.492}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.75\text{[in]} + (7 - 1)*3\text{[in]})*0.375\text{[in]} = \mathbf{7.41}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.75\text{[in]} + (7 - 1)*(3\text{[in]} - 1.13\text{[in]}) - 1.13\text{[in]}/2)*0.375\text{[in]} = \mathbf{4.66}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*58000\text{[lb/in2]}*4.66\text{[in2]} + 1*58000\text{[lb/in2]}*0.492\text{[in2]}, 0.6*36000\text{[lb/in2]}*7.41\text{[in2]} + 1*58000\text{[lb/in2]}*0.492\text{[in2]}) = \mathbf{94.26}\text{[kip]}$ Eq. J4-5

Flexural rupture [Kip] 82.41 60.00 DL 0.73 p. 9-6

$L_h = d_h + 1/16\text{ [in]} = 1.06\text{[in]} + 1/16\text{ [in]} = \mathbf{1.13}\text{[in]}$ Sec. D3-2

$Z_{net} = t_p/4*(L^2 - s^2*n*(n^2 - 1)*L_h/L) = 0.375\text{[in]}/4*(21.5\text{[in]}^2 - 3\text{[in]}^2*7*(7^2 - 1)*1.13\text{[in]}/21.5\text{[in]}) = \mathbf{28.5}\text{[in3]}$ 4

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*58000\text{[lb/in2]}*28.5\text{[in3]}/10.03\text{[in]} = \mathbf{82.41}\text{[kip]}$ p. 9-6

<u>Plate (support side)</u>

Weld capacity [Kip] 188.73 60.00 DL 0.32 Tables 8-4 .. 8-11

$e = 0$ p. 10-135

$(1/\Omega)R_n = 2 * ((1/\Omega)*C*C_1*D*L) = 2 * (0.5*1.86\text{[kip/in]}*1*4*25.42\text{[in]}) = \mathbf{188.73}\text{[kip]}$ Tables 8-4 .. 8-11

<u>Beam</u>

Bolt bearing under shear load [Kip] 102.55 60.00 DL 0.59 p. 7-18, Sec. J3.10

$L_{c-end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 4.35\text{[in]} - 1.06\text{[in]}/2) = \mathbf{3.82}\text{[in]}$ Sec. J4.10

$L_{c-spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3\text{[in]} - 1.06\text{[in]}) = \mathbf{1.94}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*$

$(n - 1))*t_p*F_u*n_c$ = 0.5*(2.94/(1*7))*(min(1.2*3.82[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(7 - 1))*0.46[in]*65000[lb/in2]*1 = **102.55**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	245.64	60.00	DL	0.24	Eq. J4-3

$A_g = L_p*t_p$ = 26.7[in]*0.46[in] = **12.28**[in2] — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*12.28[in2] = **245.64**[kip] — Eq. J4-3

<u>Support</u>

Welds rupture	[Kip/ft]	205.92	28.32	DL	0.14	p. 9-5

$R_n = 0.6*F_u*t_p$ = 0.6*65000[lb/in2]*0.44[in] = **17.16**[kip/in] — p. 9-5

$e = 0$ — p. 10-135

$D_{min} = P/((1/\Omega)*C*C_1*L)$ = 30[kip]/(0.5*1.86[kip/in]*1*25.42[in]) = **1.27** — tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] = 0.6*70000[lb/in2]*(2)^{1/2}/2*1.27/16 [in] = **2.36**[kip/in] — p. 9-5

Global critical strength ratio **0.87**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

c: Coped length

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Load eccentricity

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

h_o: Reduced beam depth

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_p: Plate length

L: Length of weld

λ: Slenderness

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)F_{cr}$: Design or allowable flexural stress buckling

$(1/\Omega)M_n$: Design or allowable strength

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

t_p: Plate thickness

t_w: Web thickness

U_{bs}: Stress index

V: Shear load

w_{min}: Minimum weld size required

Z: Plastic modulus

Z_{net}: Net plastic section modulus

Z_x: Plastic section modulus about the x-axis

REFERENCES

{4} AISC 2005, Design Examples Version 13.0, pp. IIA-63, IIA_86, IIA-98

Current Date: 2016-05-06 4:03 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-02 Beam to Column Shear with Skewed Angle\B2C WEB2.cnx\

Steel connections

Results

Connection name	**:**	**SP BCW**
Connection ID	**:**	**SC-02-9**

Family: Beam - Column web (BCW)

Type: Single plate

Description: B:W27x94

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru** [Kip]	**Pu** [Kip]	**Pu** [Kip]	**Mu22** [Kip*ft]	**Mu33** [Kip*ft]	**Load type**
DL	80.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
Plate (beam side)						
Vertical edge distance	[in]	1.75	1.75	--	✓	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75\text{[in]} + 0\text{[in]} = \mathbf{1.75}\text{[in]}$ Tables J3.4, J3.5

Horizontal edge distance	[in]	2.00	1.87	--	✓	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75\text{[in]} + 0.125\text{[in]} = \mathbf{1.88}\text{[in]}$ Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.67	9.00	✔	Sec. J3.3, Sec. J3.5

s_{min} = 8/3*d = 8/3*1[in] = **2.67**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

s_{max} = min(24*t_p, 12 [in]) = min(24*0.375[in], 12 [in]) = **9**[in] — Sec. J3.5

Beam

Vertical edge distance	[in]	2.95	1.75	--	✔	Tables J3.4, J3.5

L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.15	1.75	--	✔	Tables J3.4, J3.5

L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Support

Weld size	[1/16in]	4	4	--	✔	p. 10-101

w_{min} = (5/8)*t_p = (5/8)*0.375[in] = **0.0195** — p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Plate (beam side)

Bolts shear	[Kip]	107.66	80.00	DL	0.74	Tables (7-1..14)

(n>=10) and (n<=12) and (*IsStandardHole*) → (8>=10) and (8<=12) and (False) → **False**

BoltFactor = 1 — p. 10-102

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*60000[lb/in2]*0.785[in2] = **23.55**[kip] — Eq. J3-1

$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor$ = 4.57*23.55[kip]*1 = **107.66**[kip] — Tables (7-1..14)

Flexure with the Von-Mises shear reduction	[Kip*ft]	72.23	55.83	DL	0.77	p. 10-103

$A_g = L_p*t_p$ = 24.5[in]*0.375[in] = **9.19**[in2] — Sec. D3-1

$f_v = V/A_g$ = 80[kip]/9.19[in2] = **8707.48**[lb/in2] — p. 10-103

$(1/\Omega)F_{cr} = (\max(0, ((1/\Omega)*F_y)^2 - 3*f_v^2))^{1/2}$ = (max(0, (0.599*36000[lb/in2])^2 - 3*8707.48[lb/in2]^2))$^{1/2}$ = **15402.55**[lb/in2] — p. 10-103

$Z_x = t_p*L^2/4$ = 0.375[in]*24.5[in]^2/4 = **56.27**[in3] — T. 17-27

$(1/\Omega)M_n = (1/\Omega)F_{cr}*Z$ = 15402.55[lb/in2]*56.27[in3] = **72.23**[kip*ft] — p. 10-103

Bolt bearing under shear load	[Kip]	110.23	80.00	DL	0.73	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.75[in] - 1.06[in]/2) = **1.22**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*$
$(n - 1))*t_p*F_u*n_c$ = 0.5*(4.57/(1*8))*(min(1.2*1.22[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*
1[in])*(8 - 1))*0.375[in]*58000[lb/in2]*1 = **110.23**[kip] p. 7-18,
Sec. J3.10

Shear yielding	[Kip]	132.30	80.00	DL	0.60		Eq. J4-3

$A_g = L_p*t_p$ = 24.5[in]*0.375[in] = **9.19**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*36000[lb/in2]*9.19[in2] = **132.3**[kip] Eq. J4-3

Shear rupture	[Kip]	101.14	80.00	DL	0.79		Eq. J4-4

$L_h = d_h + 1/16$ [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$L_e = L - n*L_h$ = 24.5[in] - 8*1.13[in] = **15.5**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 15.5[in]*0.375[in] = **5.81**[in2] Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv}$ = 0.5*0.60*58000[lb/in2]*5.81[in2] = **101.14**[kip] Eq. J4-4

Block shear	[Kip]	106.41	80.00	DL	0.75		Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 1.31[in] + 1/16 [in] = **1.38**[in] Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (2[in] + (1 - 1)*3[in] - (1 - 0.5)*
1.38[in])*0.375[in] = **0.492**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.75[in] + (8 - 1)*3[in])*0.375[in] = **8.53**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.75[in] + (8 - 1)*(3[in] - 1.13[in]) -
1.13[in]/2)*0.375[in] = **5.37**[in2] Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$ =
0.5*min(0.6*58000[lb/in2]*5.37[in2] + 1*58000[lb/in2]*0.492[in2], 0.6*36000[lb/in2]*8.53[in2] + 1*58000[lb/in2]*0.492[in2]) = **106.41**[kip] Eq. J4-5

Flexural rupture	[Kip]	136.10	80.00	DL	0.59		p. 9-6

$L_h = d_h + 1/16$ [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$Z_{net} = t_p/4*(L^2 - s^2*n*(n^2 - 1)*L_h/L)$ = 0.375[in]/4*(24.5[in]^2 - 3[in]^2*8*(8^2 -
1)*1.13[in]/24.5[in]) = **36.75**[in3] 4

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e$ = 0.5*58000[lb/in2]*36.75[in3]/7.83[in] = **136.1**[kip] p. 9-6

Plate (support side)

Weld capacity	[Kip]	188.66	80.00	DL	0.42		Tables 8-4 .. 8-11

$e = 0$ p. 10-135

$(1/\Omega)R_n = 2 * ((1/\Omega)*C*C_1*D*L)$ = 2 * (0.5*1.86[kip/in]*1*4*25.41[in]) = **188.66**[kip] Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load	[Kip]	169.95	80.00	DL	0.47		p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 2.95[in] - 1.06[in]/2) = **2.42**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*$

$(n - 1))*t_p*F_u*n_c$ = 0.5*(4.57/(1*8))*(min(1.2*2.42[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(8 - 1))*0.49[in]*65000[lb/in2]*1 = **169.95**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	263.62	80.00	DL	0.30	Eq. J4-3

$A_g = L_p*t_p$ = 26.9[in]*0.49[in] = **13.18**[in2] — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*13.18[in2] = **263.62**[kip] — Eq. J4-3

<u>Support</u>

Welds rupture	[Kip/ft]	159.12	37.78	DL	0.24	p. 9-5

$R_n = 0.6*F_u*t_p$ = 0.6*65000[lb/in2]*0.34[in] = **13.26**[kip/in] — p. 9-5

$e = 0$ — p. 10-135

$D_{min} = P/((1/\Omega)*C*C_1*L)$ = 40[kip]/(0.5*1.86[kip/in]*1*25.41[in]) = **1.7** — tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] = 0.6*70000[lb/in2]*(2)^{1/2}/2*1.7/16 [in] = **3.15**[kip/in] — p. 9-5

Global critical strength ratio **0.79**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

c: Coped length

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Load eccentricity

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

h_o: Reduced beam depth

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_p: Plate length

L: Length of weld

λ: Slenderness

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)F_{cr}$: Design or allowable flexural stress buckling

$(1/\Omega)M_n$: Design or allowable strength

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

t_p: Plate thickness

t_w: Web thickness

U_{bs}: Stress index

V: Shear load

w_{min}: Minimum weld size required

Z: Plastic modulus

Z_{net}: Net plastic section modulus

Z_x: Plastic section modulus about the x-axis

REFERENCES

{4} AISC 2005, Design Examples Version 13.0, pp. IIA-63, IIA_86, IIA-98

Current Date: 2016-05-06 4:15 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-02 Beam to Column Shear with Skewed Angle\B2C WEB5.cnx\

Steel connections

Results

Connection name : SP BCW

Connection ID : SC-02-10

Family: Beam - Column web (BCW)

Type: Single plate

Description: B:W33x118

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru**	**Pu**	**Pu**	**Mu22**	**Mu33**	**Load type**
	[Kip]	[Kip]	[Kip]	[Kip*ft]	[Kip*ft]	
DL	75.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
Plate (beam side)						
Vertical edge distance	[in]	1.75	1.75	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = \mathbf{1.75}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	2.00	1.87	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0.125[in] = \mathbf{1.88}[in]$						Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.67	9.00	✔	Sec. J3.3, Sec. J3.5

s_{min} = 8/3*d = 8/3*1[in] = **2.67**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

s_{max} = min(24*t_p, 12 [in]) = min(24*0.375[in], 12 [in]) = **9**[in] — Sec. J3.5

Beam

Vertical edge distance	[in]	5.95	1.75	--	✔	Tables J3.4, J3.5

L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.62	1.75	--	✔	Tables J3.4, J3.5

L_{emin} = e_{dmin} + C_2 = 1.75[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Support

Weld size	[1/16in]	4	4	--	✔	p. 10-101

w_{min} = (5/8)*t_p = (5/8)*0.375[in] = **0.0195** — p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Plate (beam side)

Bolts shear	[Kip]	94.50	75.00	DL	0.79	Tables (7-1..14)

(n>=10) and (n<=12) and (*IsStandardHole*) → (8>=10) and (8<=12) and (False) → **False**

BoltFactor = 1 — p. 10-102

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*60000[lb/in2]*0.785[in2] = **23.55**[kip] — Eq. J3-1

$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor$ = 4.01*23.55[kip]*1 = **94.5**[kip] — Tables (7-1..14)

Flexure with the Von-Mises shear reduction	[Kip*ft]	76.31	62.24	DL	0.82	p. 10-103

$A_g = L_p*t_p$ = 24.5[in]*0.375[in] = **9.19**[in2] — Sec. D3-1

$f_v = V/A_g$ = 75[kip]/9.19[in2] = **8163.27**[lb/in2] — p. 10-103

$(1/\Omega)F_{cr} = (\max(0, ((1/\Omega)*F_y)^2 - 3*f_v^2))^{1/2}$ = (max(0, (0.599*36000[lb/in2])^2 - 3*8163.27[lb/in2]^2))$^{1/2}$ = **16272.14**[lb/in2] — p. 10-103

$Z_x = t_p*L^2/4$ = 0.375[in]*24.5[in]^2/4 = **56.27**[in3] — T. 17-27

$(1/\Omega)M_n = (1/\Omega)F_{cr}*Z$ = 16272.14[lb/in2]*56.27[in3] = **76.31**[kip*ft] — p. 10-103

Bolt bearing under shear load	[Kip]	96.76	75.00	DL	0.78	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.75[in] - 1.06[in]/2) = **1.22**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*$
$(n - 1))*t_p*F_u*n_c$ = 0.5*(4.01/(1*8))*(min(1.2*1.22[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*
1[in])*(8 - 1))*0.375[in]*58000[lb/in2]*1 = **96.76**[kip] p. 7-18, Sec. J3.10

Shear yielding	[Kip]	132.30	75.00	DL	0.57		Eq. J4-3

$A_g = L_p*t_p$ = 24.5[in]*0.375[in] = **9.19**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*36000[lb/in2]*9.19[in2] = **132.3**[kip] Eq. J4-3

Shear rupture	[Kip]	101.14	75.00	DL	0.74		Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$L_e = L - n*L_h$ = 24.5[in] - 8*1.13[in] = **15.5**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 15.5[in]*0.375[in] = **5.81**[in2] Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv}$ = 0.5*0.60*58000[lb/in2]*5.81[in2] = **101.14**[kip] Eq. J4-4

Block shear	[Kip]	106.41	75.00	DL	0.70		Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1.31[in] + 1/16 [in] = **1.38**[in] Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (2[in] + (1 - 1)*3[in] - (1 - 0.5)*
1.38[in])*0.375[in] = **0.492**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.75[in] + (8 - 1)*3[in])*0.375[in] = **8.53**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.75[in] + (8 - 1)*(3[in] - 1.13[in]) -
1.13[in]/2)*0.375[in] = **5.37**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$ =
0.5*min(0.6*58000[lb/in2]*5.37[in2] + 1*58000[lb/in2]*0.492[in2], 0.6*36000[lb/in2]*8.53[in2] + 1*58000[lb/
in2]*0.492[in2]) = **106.41**[kip] Eq. J4-5

Flexural rupture	[Kip]	114.52	75.00	DL	0.65		p. 9-6

$L_h = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$Z_{net} = t_p/4*(L^2 - s^2*n*(n^2 - 1)*L_h/L)$ = 0.375[in]/4*(24.5[in]^2 - 3[in]^2*8*(8^2 -
1)*1.13[in]/24.5[in]) = **36.75**[in3] 4

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e$ = 0.5*58000[lb/in2]*36.75[in3]/9.31[in] = **114.52**[kip] p. 9-6

Plate (support side)

Weld capacity	[Kip]	233.28	75.00	DL	0.32		Tables 8-4 .. 8-11

e = 0 p. 10-135

$(1/\Omega)R_n = 2 * ((1/\Omega)*C*C_1*D*L)$ = 2 * (0.5*1.86[kip/in]*1*4*31.42[in]) = **233.28**[kip] Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load	[Kip]	167.44	75.00	DL	0.45		p. 7-18, Sec. J3.10

$L_{c-end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 5.95[in] - 1.06[in]/2) = **5.42**[in] Sec. J4.10

$L_{c-spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*$

$(n - 1))*t_p*F_u*n_c$ = 0.5*(4.01/(1*8))*(min(1.2*5.42[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(8 - 1))*0.55[in]*65000[lb/in2]*1 = **167.44**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	361.90	75.00	DL	0.21		Eq. J4-3

$A_g = L_p*t_p$ = 32.9[in]*0.55[in] = **18.1**[in2] — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*18.1[in2] = **361.9**[kip] — Eq. J4-3

Support

Welds rupture	[Kip/ft]	182.52	28.64	DL	0.16		p. 9-5

$R_n = 0.6*F_u*t_p$ = 0.6*65000[lb/in2]*0.39[in] = **15.21**[kip/in] — p. 9-5

$e = 0$ — p. 10-135

$D_{min} = P/((1/\Omega)*C*C_1*L)$ = 37.5[kip]/(0.5*1.86[kip/in]*1*31.42[in]) = **1.29** — tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] = 0.6*70000[lb/in2]*$(2)^{1/2}$/2*1.29/16 [in] = **2.39**[kip/in] — p. 9-5

Global critical strength ratio **0.82**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

c: Coped length

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Load eccentricity

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

h_o: Reduced beam depth

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_p: Plate length

L: Length of weld

λ: Slenderness

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)F_{cr}$: Design or allowable flexural stress buckling

$(1/\Omega)M_n$: Design or allowable strength

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

t_p: Plate thickness

t_w: Web thickness

U_{bs}: Stress index

V: Shear load

w_{min}: Minimum weld size required

Z: Plastic modulus

Z_{net}: Net plastic section modulus

Z_x: Plastic section modulus about the x-axis

REFERENCES

{4} AISC 2005, Design Examples Version 13.0, pp. IIA-63, IIA_86, IIA-98

Current Date: 2016-05-06 4:10 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-02 Beam to Column Shear with Skewed Angle\B2C WEB5.cnx\

Steel connections

Results

Connection name : SP BCW

Connection ID : SC-02-11

Family: Beam - Column web (BCW)

Type: Single plate

Description: B:W36x487

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru** [Kip]	**Pu** [Kip]	**Pu** [Kip]	**Mu22** [Kip*ft]	**Mu33** [Kip*ft]	**Load type**
DL	80.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Plate (beam side)						
Vertical edge distance	[in]	1.75	1.75	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1.75$[in] $+ 0$[in] $=$ **1.75**[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	2.00	1.87	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1.75$[in] $+ 0.125$[in] $=$ **1.88**[in]						Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.67	12.00	✔	Sec. J3.3, Sec. J3.5

s_{min} = 8/3*d = 8/3*1[in] = **2.67**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

s_{max} = min(24*t_p, 12 [in]) = min(24*0.5[in], 12 [in]) = **12**[in] — Sec. J3.5

Beam

Vertical edge distance	[in]	7.65	1.75	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1.75[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.68	1.75	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1.75[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Support

Weld size	[1/16in]	5	5	--	✔	p. 10-101

w_{min} = (5/8)*t_p = (5/8)*0.5[in] = **0.026** — p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Plate (beam side)						
Bolts shear	[Kip]	121.46	80.00	DL	0.66	Tables (7-1..14)

(n>=10) and (n<=12) and (*IsStandardHole*) → (9>=10) and (9<=12) and (False) → **False**

BoltFactor = 1 — p. 10-102

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*60000[lb/in2]*0.785[in2] = **23.55**[kip] — Eq. J3-1

$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor$ = 5.16*23.55[kip]*1 = **121.46**[kip] — Tables (7-1..14)

Flexure with the Von-Mises shear reduction	[Kip*ft]	150.12	62.49	DL	0.42	p. 10-103

$A_g = L_p*t_p$ = 27.5[in]*0.5[in] = **13.75**[in2] — Sec. D3-1

$f_v = V/A_g$ = 80[kip]/13.75[in2] = **5818.18**[lb/in2] — p. 10-103

$(1/\Omega)F_{cr} = (\max(0, ((1/\Omega)*F_y)^2 - 3*f_v^2))^{1/2}$ = (max(0, (0.599*36000[lb/in2])^2 - 3*5818.18[lb/in2]^2))$^{1/2}$ = **19056.38**[lb/in2] — p. 10-103

$Z_x = t_p*L^2/4$ = 0.5[in]*27.5[in]^2/4 = **94.53**[in3] — T. 17-27

$(1/\Omega)M_n = (1/\Omega)F_{cr}*Z$ = 19056.38[lb/in2]*94.53[in3] = **150.12**[kip*ft] — p. 10-103

Bolt bearing under shear load	[Kip]	166.70	80.00	DL	0.48	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.75[in] - 1.06[in]/2) = **1.22**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(5.16/(1*9))*(min(1.2*1.22[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(9 - 1))*0.5[in]*58000[lb/in2]*1 = **166.7**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	198.00	80.00	DL	0.40		Eq. J4-3

$A_g = L_p*t_p$ = 27.5[in]*0.5[in] = **13.75**[in2] — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*36000[lb/in2]*13.75[in2] = **198**[kip] — Eq. J4-3

Shear rupture	[Kip]	151.16	80.00	DL	0.53		Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] — Sec. D3-2

$L_e = L - n*L_h$ = 27.5[in] - 9*1.13[in] = **17.38**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 17.38[in]*0.5[in] = **8.69**[in2] — Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv}$ = 0.5*0.60*58000[lb/in2]*8.69[in2] = **151.16**[kip] — Eq. J4-4

Block shear	[Kip]	158.08	80.00	DL	0.51		Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1.31[in] + 1/16 [in] = **1.38**[in] — Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (2[in] + (1 - 1)*3[in] - (1 - 0.5)*1.38[in])*0.5[in] = **0.656**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.75[in] + (9 - 1)*3[in])*0.5[in] = **12.88**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.75[in] + (9 - 1)*(3[in] - 1.13[in]) - 1.13[in]/2)*0.5[in] = **8.09**[in2] — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$ = 0.5*min(0.6*58000[lb/in2]*8.09[in2] + 1*58000[lb/in2]*0.656[in2], 0.6*36000[lb/in2]*12.88[in2] + 1*58000[lb/in2]*0.656[in2]) = **158.08**[kip] — Eq. J4-5

Flexural rupture	[Kip]	201.64	80.00	DL	0.40		p. 9-6

$L_h = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] — Sec. D3-2

$Z_{net} = t_p/4*(L^2 - s^2*n*(n^2 - 1)*L_h/L)$ = 0.5[in]/4*(27.5[in]^2 - 3[in]^2*9*(9^2 - 1)*1.13[in]/27.5[in]) = **61.39**[in3] — 4

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e$ = 0.5*58000[lb/in2]*61.39[in3]/8.83[in] = **201.64**[kip] — p. 9-6

Plate (support side)

Weld capacity	[Kip]	314.99	80.00	DL	0.25		Tables 8-4 .. 8-11

$e = 0$ — p. 10-135

$(1/\Omega)R_n = 2 * ((1/\Omega)*C*C_1*D*L)$ = 2 * (0.5*1.86[kip/in]*1*5*33.94[in]) = **314.99**[kip] — Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load	[Kip]	586.65	80.00	DL	0.14		p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 7.65[in] - 1.06[in]/2) = **7.12**[in] — Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*$

$(n - 1))*t_p*F_u*n_c$ = 0.5*(5.16/(1*9))*(min(1.2*7.12[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(9 - 1))*1.5[in]*65000[lb/in2]*1 = **586.65**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	1179.00	80.00	DL	0.07	Eq. J4-3

$A_g = L_p*t_p$ = 39.3[in]*1.5[in] = **58.95**[in2] — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*58.95[in2] = **1179**[kip] — Eq. J4-3

Support

Welds rupture	[Kip/ft]	159.12	28.29	DL	0.18	p. 9-5

$R_n = 0.6*F_u*t_p$ = 0.6*65000[lb/in2]*0.34[in] = **13.26**[kip/in] — p. 9-5

$e = 0$ — p. 10-135

$D_{min} = P/((1/\Omega)*C*C_1*L)$ = 40[kip]/(0.5*1.86[kip/in]*1*33.94[in]) = **1.27** — tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] = 0.6*70000[lb/in2]*$(2)^{1/2}$/2*1.27/16 [in] = **2.36**[kip/in] — p. 9-5

Global critical strength ratio **0.66**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

c: Coped length

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Load eccentricity

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

f_v: Required shear stress

F_y: Specified minimum yield stress

h_o: Reduced beam depth

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_p: Plate length

L: Length of weld

λ: Slenderness

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)F_{cr}$: Design or allowable flexural stress buckling

$(1/\Omega)M_n$: Design or allowable strength

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

t_p: Plate thickness

t_w: Web thickness

U_{bs}: Stress index

V: Shear load

w_{min}: Minimum weld size required

Z: Plastic modulus

Z_{net}: Net plastic section modulus

Z_x: Plastic section modulus about the x-axis

REFERENCES

{4} AISC 2005, Design Examples Version 13.0, pp. IIA-63, IIA_86, IIA-98

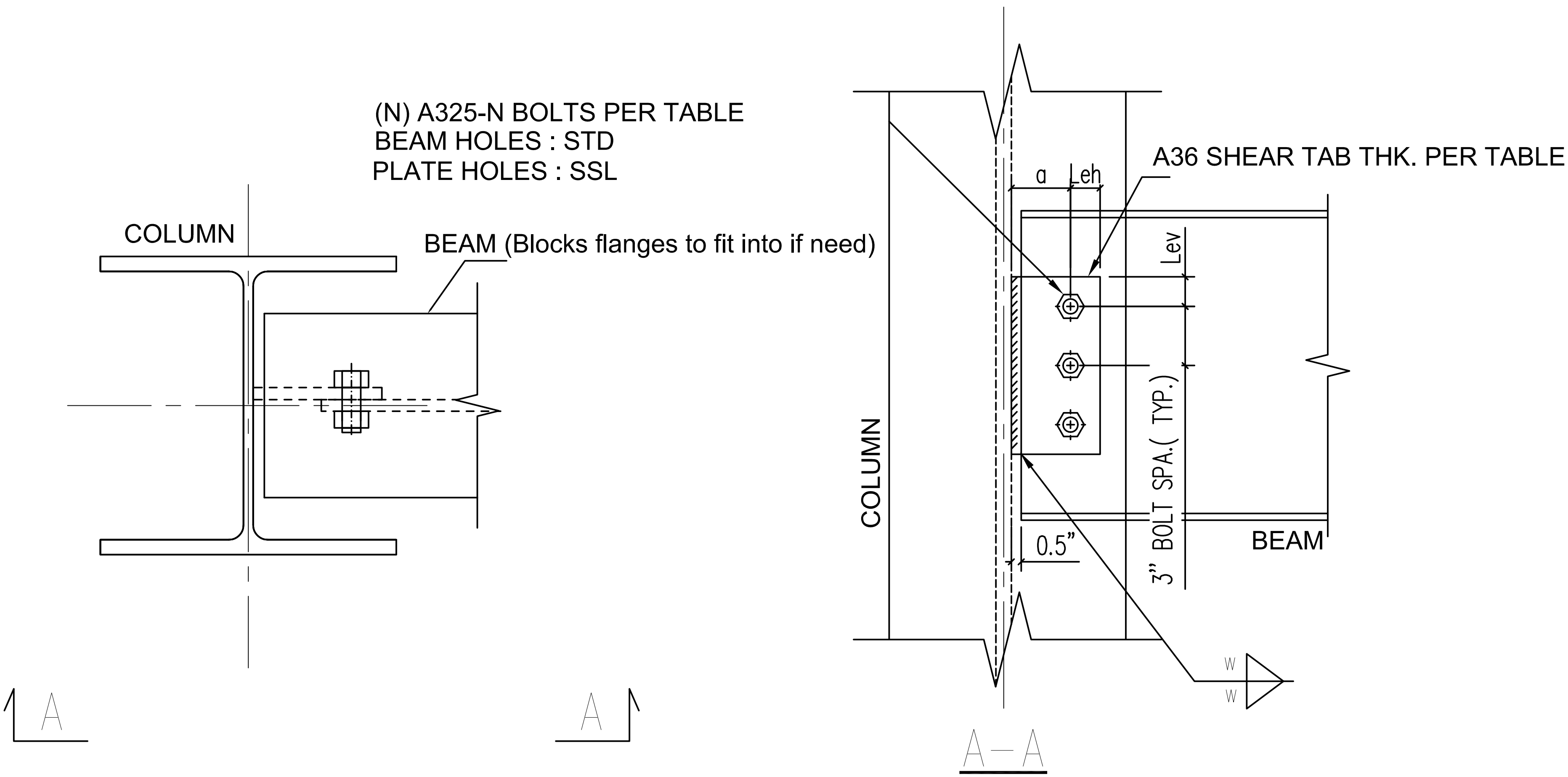
SC-03 BEAM TO COLUMN (WF, HSS, and PIPE) SHEAR TAB CONNECTION

Connection ID	Beam Size	Column	Design Reaction (kip) "R"	SKEW (Degree) "β"	Single Plate (A36 Steel)				Bolt Size and Grade	Bolt Row x Col.	Bolt Spacing (inch) "Spa."	Distance between Weld to Bolts (inch) "a"
					Plate Size (inch) "t_p"	Plate weld size to support Column (inch) "w"	Bolt edge distance					
							Vertical "L_{ev}" (inch)	Horizontal "L_{eh}" (inch)				
SC-03-1	W12X26	W10x45 WEB	≤25	0	3/8"	1/4"	1.5	1.5	3/4" A325N	3x1	3	3
SC-03-2	W16X26	W10x33 WEB	≤30	6	3/8"	5/16"	1.5	1.5	3/4" A325N	4X1	3	3
SC-03-3	W16X31	W10X49 WEB	≤40	6	3/8"	5/16"	1.5	1.5	3/4" A325N	4X1	3	3
SC-03-4	W18x35	W10X49 WEB	≤20	6	3/8"	5/16"	1.5	1.5	3/4" A325N	5X1	3	3
			≤40						3/4" A325N			
SC-03-5	W14x22	W10x49 FLANGE	≤20	6	3/8"	5/16"	1.5	1.5	3/4" A325N	4X1	3	3

*Short Slotted Hole on Shear Tab

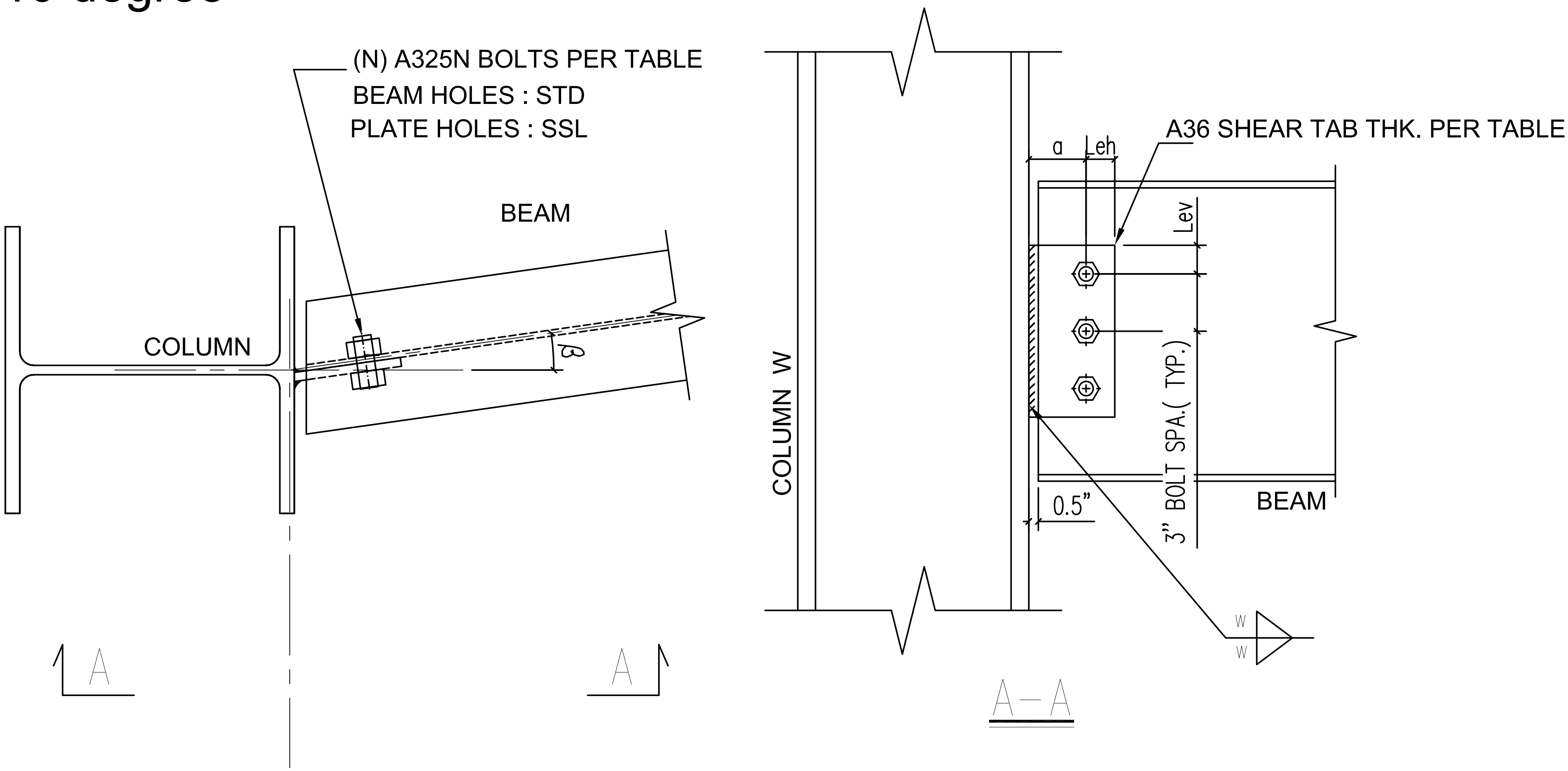
*Cope (Narrow down) Beam flanges only to fit between column flanges

SC-03 Beam to Column Shear Tab Connection



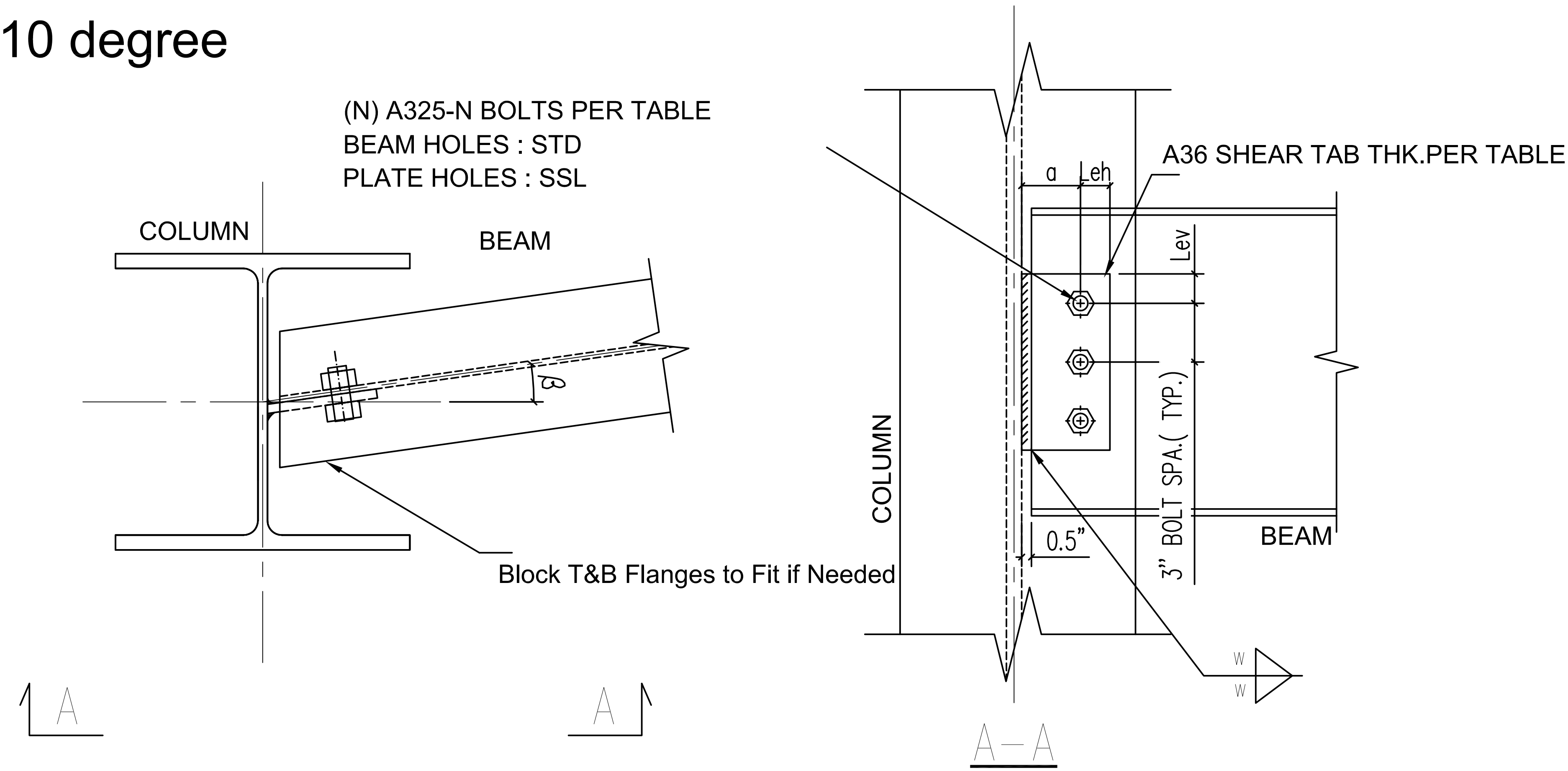
SC-03 Beam to Column Shear Tab Connection

β<10 degree



SC-03	Beam to Column Shear Tab Connection

β<10 degree



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File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-03 Beam to HSS_PIPE_W Column Shear Tab Design\B2C WEB22.cnx\

Steel connections

Results

Connection name : SP BCW

Connection ID : SC-03-1

Family: Beam - Column web (BCW)

Type: Single plate

Description: B:W12x26

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru**	**Pu**	**Pu**	**Mu22**	**Mu33**	**Load type**
	[Kip]	[Kip]	[Kip]	[Kip*ft]	[Kip*ft]	
DL	25.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Shear plate						
Length	[in]	9.00	5.42	10.84	✔	p. 10-104

$L_{min} = T/2 = 10.84$[in]$/2 = \mathbf{5.42}$[in] p. 10-104

$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 12.2$[in] $- \max(0.68$[in], 0[in]$) - \max(0.68$[in], 0[in]$) = \mathbf{10.84}$[in] p. 10-49

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Thickness	[in]	0.38	--	0.44	✔	p. 10-102

$t_{pmax} = d/2 + 1/16$ [in] $= 0.75$[in]$/2 + 1/16$ [in] $= \mathbf{0.438}$[in] p. 10-102

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Vertical edge distance	[in]	1.50	1.25	--	✔	Tables J3.4,

J3.5

$L_{emin} = e_{dmin} + C_2$ = 1.25[in] + 0[in] = **1.25**[in] — Tables J3.4, J3.5

	Unit					References
Horizontal edge distance	[in]	1.50	1.50	--	✔	p. 10-102

$L_{emin} = 2*d$ = 2*0.75[in] = **1.5**[in] — p. 10-102

	Unit					References
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.52	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d$ = 8/3*0.75[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.23[in], 12 [in]) = **5.52**[in] — Sec. J3.5

Beam

	Unit					References
Vertical edge distance	[in]	3.10	1.25	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1.25[in] + 0[in] = **1.25**[in] — Tables J3.4, J3.5

	Unit					References
Horizontal edge distance	[in]	2.50	1.50	--	✔	p. 10-102

$L_{emin} = 2*d$ = 2*0.75[in] = **1.5**[in] — p. 10-102

Support

	Unit					References
Weld size	[1/16in]	4	4	--	✔	p. 10-101

$w_{min} = (5/8)*t_p$ = (5/8)*0.375[in] = **0.0195** — p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear plate						
Bolts shear	[Kip]	31.82	25.00	DL	0.79	Tables (7-1..14)

(n>=10) and (n<=12) and (*IsStandardHole*) → (3>=10) and (3<=12) and (False) → **False**

BoltFactor = 1 — p. 10-102

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor$ = 3*10.61[kip]*1 = **31.82**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	53.42	25.00	DL	0.47	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.5[in] - 0.813[in]/2) = **1.09**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(min(1.2*1.09[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.375[in]*58000[lb/in2]*1 = **53.42**[kip] — Eq. J3-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Kip]	48.60	25.00	DL	0.51	Eq. J4-3

$A_g = L_p*t_p = 9\text{[in]}*0.375\text{[in]} = \mathbf{3.38}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*36000\text{[lb/in2]}*3.38\text{[in2]} = \mathbf{48.6}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 41.60 25.00 DL 0.60 Eq. J4-4

$L_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 9\text{[in]} - 3*0.875\text{[in]} = \mathbf{6.38}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 6.38\text{[in]}*0.375\text{[in]} = \mathbf{2.39}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*58000\text{[lb/in2]}*2.39\text{[in2]} = \mathbf{41.6}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 40.91 25.00 DL 0.61 Eq. J4-5

$dh_h = d_h + 1/16\ \text{[in]} = 1\text{[in]} + 1/16\ \text{[in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.5\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)*$
$1.06\text{[in]})*0.375\text{[in]} = \mathbf{0.363}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.5\text{[in]} + (3 - 1)*3\text{[in]})*0.375\text{[in]} = \mathbf{2.81}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.5\text{[in]} + (3 - 1)*(3\text{[in]} - 0.875\text{[in]}) -$
$0.875\text{[in]}/2)*0.375\text{[in]} = \mathbf{1.99}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) =$
$0.5*\min(0.6*58000\text{[lb/in2]}*1.99\text{[in2]} + 1*58000\text{[lb/in2]}*0.363\text{[in2]}, 0.6*36000\text{[lb/in2]}*2.81\text{[in2]} + 1*58000\text{[lb/in2]}*0.363\text{[in2]}) = \mathbf{40.91}\text{[kip]}$ Eq. J4-5

Plate (support side)

Weld capacity [Kip] 66.82 25.00 DL 0.37 Tables 8-4 .. 8-11

$(1/\Omega)R_n = (1/\Omega)*C*C_1*D*L = 0.5*3.71\text{[kip/in]}*1*4*9\text{[in]} = \mathbf{66.82}\text{[kip]}$ Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load [Kip] 40.37 25.00 DL 0.62 Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 3.1\text{[in]} - 0.813\text{[in]}/2) = \mathbf{2.69}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*$
$F_u*n_c = 0.5*(\min(1.2*2.69\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(3 - 1))*$
$0.23\text{[in]}*65000\text{[lb/in2]}*1 = \mathbf{40.37}\text{[kip]}$ Eq. J3-6

Shear yielding [Kip] 56.12 25.00 DL 0.45 Eq. J4-3

$A_g = L_p*t_p = 12.2\text{[in]}*0.23\text{[in]} = \mathbf{2.81}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000\text{[lb/in2]}*2.81\text{[in2]} = \mathbf{56.12}\text{[kip]}$ Eq. J4-3

Support

Welds rupture [Kip/ft] 163.80 33.33 DL 0.20 p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000\text{[lb/in2]}*0.35\text{[in]} = \mathbf{13.65}\text{[kip/in]}$ p. 9-5

$D_{min} = P/((1/\Omega)*C*C_1*L) = 25\text{[kip]}/(0.5*3.71\text{[kip/in]}*1*9\text{[in]}) = \mathbf{1.5}$ tables 8-4..11

$HasWeldsOnBothSides \rightarrow$ **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16\ \text{[in]} = 0.6*70000\text{[lb/in2]}*(2)^{1/2}/2*1.5/16\ \text{[in]} = \mathbf{2.78}\text{[kip/in]}$ p. 9-5

Global critical strength ratio **0.79**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L_{c-end}: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

L: Length of weld

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{min}: Minimum weld size required

Current Date: 2016-05-06 4:31 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-03 Beam to HSS_PIPE_W Column Shear Tab Design\B2C WEB2.cnx\

Steel connections

Results

Connection name : SP BCW

Connection ID : SC-03-2

Family: Beam - Column web (BCW)

Type: Single plate

Description: B:W16x26

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru** [Kip]	**Pu** [Kip]	**Pu** [Kip]	**Mu22** [Kip*ft]	**Mu33** [Kip*ft]	**Load type**
DL	30.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
Shear plate						
Length	[in]	12.00	7.10	14.21	✔	p. 10-104
$L_{min} = T/2 = 14.21$[in]$/2 = \mathbf{7.1}$[in]						p. 10-104
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 15.7$[in] $- \max(0.747$[in], 0[in]$) - \max(0.747$[in], 0[in]$) = \mathbf{14.21}$[in]						p. 10-49
Thickness	[in]	0.38	--	0.44	✔	p. 10-102
$t_{pmax} = d/2 + 1/16$ [in] $= 0.75$[in]$/2 + 1/16$ [in] $= \mathbf{0.438}$[in]						p. 10-102
Vertical edge distance	[in]	1.50	1.25	--	✔	Tables J3.4,

						J3.5
$L_{emin} = e_{dmin} + C_2 = 1.25$[in] + 0[in] = **1.25**[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.50	1.50	--	✓	p. 10-102
$L_{emin} = 2*d = 2*0.75$[in] = **1.5**[in]						p. 10-102
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.00	✓	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in]						Sec. J3.3
IsCorrosionConsidered → **False**						
$s_{max} = \min(24*t_p$, 12 [in]) = min(24*0.25[in], 12 [in]) = **6**[in]						Sec. J3.5
Beam						
Thickness	[in]	0.25	--	0.44	✓	p. 10-151, p. 10-102
t_{pmax} = (3/16 [in])/$\sin\alpha$ = (3/16 [in])/0.105 = **1.79**[in]						p. 10-151
$t_{pmax} = d/2 + 1/16$ [in] = 0.75[in]/2 + 1/16 [in] = **0.438**[in]						p. 10-102
$t_{pmax} = d/2 + 1/16$ [in] = 0.75[in]/2 + 1/16 [in] = **0.438**[in]						p. 10-102
Vertical edge distance	[in]	3.35	1.25	--	✓	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1.25$[in] + 0[in] = **1.25**[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	2.45	1.50	--	✓	p. 10-102
$L_{emin} = 2*d = 2*0.75$[in] = **1.5**[in]						p. 10-102
Support						
Weld size	[1/16in]	5	4	--	✓	p. 10-101
$w_{min} = (5/8)*t_p = (5/8)*0.375$[in] = **0.0195**						p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear plate						
Bolts shear	[Kip]	42.43	30.00	DL	0.71	Tables (7-1..14)
(n>=10) and (n<=12) and (*IsStandardHole*) → (4>=10) and (4<=12) and (False) → **False**						
BoltFactor = 1						p. 10-102
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]*0.442[in2] = **10.61**[kip]						Eq. J3-1
$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor = 4*10.61$[kip]*1 = **42.43**[kip]						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	73.00	30.00	DL	0.41	Eq. J3-6
$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.5[in] - 0.813[in]/2) = **1.09**[in]						Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0,\ s - d_h) = \text{Max}(0.0,\ 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end},\ k_2*d) + \min(k_1*L_{c\text{-}spa},\ k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*1.09\text{[in]},\ 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]},\ 2.4*0.75\text{[in]})*(4 - 1))*0.375\text{[in]}*58000\text{[lb/in2]}*1 = \mathbf{73}\text{[kip]}$ Eq. J3-6

Shear yielding	[Kip]	64.80	30.00	DL	0.46	Eq. J4-3

$A_g = L_p*t_p = 12\text{[in]}*0.375\text{[in]} = \mathbf{4.5}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*36000\text{[lb/in2]}*4.5\text{[in2]} = \mathbf{64.8}\text{[kip]}$ Eq. J4-3

Shear rupture	[Kip]	55.46	30.00	DL	0.54	Eq. J4-4

$L_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 12\text{[in]} - 4*0.875\text{[in]} = \mathbf{8.5}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8.5\text{[in]}*0.375\text{[in]} = \mathbf{3.19}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*58000\text{[lb/in2]}*3.19\text{[in2]} = \mathbf{55.46}\text{[kip]}$ Eq. J4-4

Block shear	[Kip]	53.06	30.00	DL	0.57	Eq. J4-5

$dh_h = d_h + 1/16\ \text{[in]} = 1\text{[in]} + 1/16\ \text{[in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.5\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.375\text{[in]} = \mathbf{0.363}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.5\text{[in]} + (4 - 1)*3\text{[in]})*0.375\text{[in]} = \mathbf{3.94}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.5\text{[in]} + (4 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.375\text{[in]} = \mathbf{2.79}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt},\ 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*58000\text{[lb/in2]}*2.79\text{[in2]} + 1*58000\text{[lb/in2]}*0.363\text{[in2]},\ 0.6*36000\text{[lb/in2]}*3.94\text{[in2]} + 1*58000\text{[lb/in2]}*0.363\text{[in2]}) = \mathbf{53.06}\text{[kip]}$ Eq. J4-5

Plate (support side)

Weld capacity	[Kip]	111.37	30.00	DL	0.27	Tables 8-4 .. 8-11

$(1/\Omega)R_n = (1/\Omega)*C*C_1*D*L = 0.5*3.71\text{[kip/in]}*1*5*12\text{[in]} = \mathbf{111.37}\text{[kip]}$ Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load	[Kip]	58.50	30.00	DL	0.51	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0,\ L_e - d_h/2) = \text{Max}(0.0,\ 3.35\text{[in]} - 0.813\text{[in]}/2) = \mathbf{2.94}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0,\ s - d_h) = \text{Max}(0.0,\ 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end},\ k_2*d) + \min(k_1*L_{c\text{-}spa},\ k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*2.94\text{[in]},\ 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]},\ 2.4*0.75\text{[in]})*(4 - 1))*0.25\text{[in]}*65000\text{[lb/in2]}*1 = \mathbf{58.5}\text{[kip]}$ Eq. J3-6

Shear yielding	[Kip]	78.50	30.00	DL	0.38	Eq. J4-3

$A_g = L_p*t_p = 15.7\text{[in]}*0.25\text{[in]} = \mathbf{3.93}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000\text{[lb/in2]}*3.93\text{[in2]} = \mathbf{78.5}\text{[kip]}$ Eq. J4-3

Support

Welds rupture	[Kip/ft]	135.72	30.00	DL	0.22	p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000$[lb/in2]$*0.29$[in] $=$ **11.31**[kip/in] p. 9-5

$D_{min} = P/((1/\Omega)*C*C_1*L) = 30$[kip]$/(0.5*3.71$[kip/in]$*1*12$[in]$) =$ **1.35** tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] $= 0.6*70000$[lb/in2]$*(2)^{1/2}/2*1.35/16$ [in] $=$ **2.5**[kip/in] p. 9-5

Global critical strength ratio **0.71**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L_{c-end}: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

L: Length of weld

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

$sin\alpha$: Sine of the skew angle

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{min}: Minimum weld size required

Current Date: 2016-05-06 4:32 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-03 Beam to HSS_PIPE_W Column Shear Tab Design\B2C WEB4.cnx\

Steel connections

Results

Connection name : SP BCW

Connection ID : SC-03-3

Family: Beam - Column web (BCW)

Type: Single plate

Description: B:W16x31

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru** [Kip]	**Pu** [Kip]	**Pu** [Kip]	**Mu22** [Kip*ft]	**Mu33** [Kip*ft]	**Load type**
DL	40.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
<u>Shear plate</u>						
Length	[in]	12.00	7.11	14.22	✔	p. 10-104
$L_{min} = T/2 = 14.22$[in]$/2 = \mathbf{7.11}$[in]						p. 10-104
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 15.9$[in] $- \max(0.842$[in], 0[in]$) - \max(0.842$[in], 0[in]$) = \mathbf{14.22}$[in]						p. 10-49
Thickness	[in]	0.38	--	0.44	✔	p. 10-102
$t_{pmax} = d/2 + 1/16$ [in] $= 0.75$[in]$/2 + 1/16$ [in] $= \mathbf{0.438}$[in]						p. 10-102
Vertical edge distance	[in]	1.50	1.25	--	✔	Tables J3.4,

J3.5

$L_{emin} = e_{dmin} + C_2$ = 1.25[in] + 0[in] = **1.25**[in] — Tables J3.4, J3.5

Horizontal edge distance | [in] | 1.50 | 1.50 | -- | ✔ | p. 10-102

$L_{emin} = 2*d$ = 2*0.75[in] = **1.5**[in] — p. 10-102

Vertical center-to-center spacing (pitch) | [in] | 3.00 | 2.00 | 6.60 | ✔ | Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d$ = 8/3*0.75[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.275[in], 12 [in]) = **6.6**[in] — Sec. J3.5

<u>Beam</u>

Thickness | [in] | 0.28 | -- | 0.44 | ✔ | p. 10-151, p. 10-102

$t_{pmax} = (3/16$ [in])/$\sin\alpha$ = (3/16 [in])/0.105 = **1.79**[in] — p. 10-151

$t_{pmax} = d/2 + 1/16$ [in] = 0.75[in]/2 + 1/16 [in] = **0.438**[in] — p. 10-102

$t_{pmax} = d/2 + 1/16$ [in] = 0.75[in]/2 + 1/16 [in] = **0.438**[in] — p. 10-102

Vertical edge distance | [in] | 3.45 | 1.25 | -- | ✔ | Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1.25[in] + 0[in] = **1.25**[in] — Tables J3.4, J3.5

Horizontal edge distance | [in] | 2.45 | 1.50 | -- | ✔ | p. 10-102

$L_{emin} = 2*d$ = 2*0.75[in] = **1.5**[in] — p. 10-102

<u>Support</u>

Weld size | [1/16in] | 5 | 4 | -- | ✔ | p. 10-101

$w_{min} = (5/8)*t_p$ = (5/8)*0.375[in] = **0.0195** — p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

<u>Shear plate</u>

Bolts shear | [Kip] | 42.43 | 40.00 | DL | 0.94 | Tables (7-1..14)

(n>=10) and (n<=12) and (*IsStandardHole*) → (4>=10) and (4<=12) and (False) → **False**

BoltFactor = 1 — p. 10-102

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor$ = 4*10.61[kip]*1 = **42.43**[kip] — Tables (7-1..14)

Bolt bearing under shear load | [Kip] | 73.00 | 40.00 | DL | 0.55 | Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.5[in] - 0.813[in]/2) = **1.09**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0,\ s - d_h) = \mathrm{Max}(0.0,\ 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end},\ k_2*d) + \min(k_1*L_{c\text{-}spa},\ k_2*d)*(n - 1))*t_p*$
$F_u*n_c = 0.5*(\min(1.2*1.09\text{[in]},\ 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]},\ 2.4*0.75\text{[in]})*(4 - 1))*$
$0.375\text{[in]}*58000\text{[lb/in2]}*1 = \mathbf{73}\text{[kip]}$ Eq. J3-6

Shear yielding	[Kip]	64.80	40.00	DL	0.62	Eq. J4-3

$A_g = L_p*t_p = 12\text{[in]}*0.375\text{[in]} = \mathbf{4.5}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*36000\text{[lb/in2]}*4.5\text{[in2]} = \mathbf{64.8}\text{[kip]}$ Eq. J4-3

Shear rupture	[Kip]	55.46	40.00	DL	0.72	Eq. J4-4

$L_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 12\text{[in]} - 4*0.875\text{[in]} = \mathbf{8.5}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8.5\text{[in]}*0.375\text{[in]} = \mathbf{3.19}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*58000\text{[lb/in2]}*3.19\text{[in2]} = \mathbf{55.46}\text{[kip]}$ Eq. J4-4

Block shear	[Kip]	53.06	40.00	DL	0.75	Eq. J4-5

$dh_h = d_h + 1/16\ \text{[in]} = 1\text{[in]} + 1/16\ \text{[in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.5\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)*$
$1.06\text{[in]})*0.375\text{[in]} = \mathbf{0.363}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.5\text{[in]} + (4 - 1)*3\text{[in]})*0.375\text{[in]} = \mathbf{3.94}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.5\text{[in]} + (4 - 1)*(3\text{[in]} - 0.875\text{[in]}) -$
$0.875\text{[in]}/2)*0.375\text{[in]} = \mathbf{2.79}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt},\ 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) =$
$0.5*\min(0.6*58000\text{[lb/in2]}*2.79\text{[in2]} + 1*58000\text{[lb/in2]}*0.363\text{[in2]},\ 0.6*36000\text{[lb/in2]}*3.94\text{[in2]} + 1*58000\text{[lb/in2]}*0.363\text{[in2]}) = \mathbf{53.06}\text{[kip]}$ Eq. J4-5

Plate (support side)

Weld capacity	[Kip]	111.37	40.00	DL	0.36	Tables 8-4 .. 8-11

$(1/\Omega)R_n = (1/\Omega)*C*C_1*D*L = 0.5*3.71\text{[kip/in]}*1*5*12\text{[in]} = \mathbf{111.37}\text{[kip]}$ Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load	[Kip]	64.35	40.00	DL	0.62	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0,\ L_e - d_h/2) = \mathrm{Max}(0.0,\ 3.45\text{[in]} - 0.813\text{[in]}/2) = \mathbf{3.04}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0,\ s - d_h) = \mathrm{Max}(0.0,\ 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end},\ k_2*d) + \min(k_1*L_{c\text{-}spa},\ k_2*d)*(n - 1))*t_p*$
$F_u*n_c = 0.5*(\min(1.2*3.04\text{[in]},\ 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]},\ 2.4*0.75\text{[in]})*(4 - 1))*$
$0.275\text{[in]}*65000\text{[lb/in2]}*1 = \mathbf{64.35}\text{[kip]}$ Eq. J3-6

Shear yielding	[Kip]	87.45	40.00	DL	0.46	Eq. J4-3

$A_g = L_p*t_p = 15.9\text{[in]}*0.275\text{[in]} = \mathbf{4.37}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000\text{[lb/in2]}*4.37\text{[in2]} = \mathbf{87.45}\text{[kip]}$ Eq. J4-3

Support

Welds rupture	[Kip/ft]	159.12	40.00	DL	0.25	p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000$[lb/in2]$*0.34$[in] $=$ **13.26**[kip/in] p. 9-5

$D_{min} = P/((1/\Omega)*C*C_1*L) = 40$[kip]$/(0.5*3.71$[kip/in]$*1*12$[in]$) =$ **1.8** tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] $= 0.6*70000$[lb/in2]$*(2)^{1/2}/2*1.8/16$ [in] $=$ **3.33**[kip/in] p. 9-5

Global critical strength ratio **0.94**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

L: Length of weld

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

$sin\alpha$: Sine of the skew angle

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{min}: Minimum weld size required

Current Date: 2016-05-06 4:34 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-03 Beam to HSS_PIPE_W Column Shear Tab Design\B2C WEB4.cnx\

Steel connections

Results

Connection name : SP BCW

Connection ID : SC-03-4

Family: Beam - Column web (BCW)

Type: Single plate

Description: B:W18x35

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru**	**Pu**	**Pu**	**Mu22**	**Mu33**	**Load type**
	[Kip]	[Kip]	[Kip]	[Kip*ft]	[Kip*ft]	
DL	40.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
Shear plate						
Length	[in]	15.00	8.02	16.05	✔	p. 10-104
$L_{min} = T/2 = 16.05$[in]$/2 = \mathbf{8.02}$[in]						p. 10-104
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 17.7$[in] $- \max(0.827$[in], 0[in]$) - \max(0.827$[in], 0[in]$) = \mathbf{16.05}$[in]						p. 10-49
Thickness	[in]	0.38	--	0.44	✔	p. 10-102
$t_{pmax} = d/2 + 1/16$ [in] $= 0.75$[in]$/2 + 1/16$ [in] $= \mathbf{0.438}$[in]						p. 10-102
Vertical edge distance	[in]	1.50	1.25	--	✔	Tables J3.4,

J3.5

$L_{emin} = e_{dmin} + C_2 = 1.25$[in] + 0[in] = **1.25**[in] — Tables J3.4, J3.5

	Unit				References
Horizontal edge distance	[in]	1.50	1.50	--	p. 10-102

$L_{emin} = 2*d = 2*0.75$[in] = **1.5**[in] — p. 10-102

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.20	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.3$[in], 12 [in]) = **7.2**[in] — Sec. J3.5

<u>Beam</u>

Thickness	[in]	0.30	--	0.44	p. 10-151, p. 10-102

t_{pmax} = (3/16 [in])/$sin\alpha$ = (3/16 [in])/0.105 = **1.79**[in] — p. 10-151

$t_{pmax} = d/2 + 1/16$ [in] = 0.75[in]/2 + 1/16 [in] = **0.438**[in] — p. 10-102

$t_{pmax} = d/2 + 1/16$ [in] = 0.75[in]/2 + 1/16 [in] = **0.438**[in] — p. 10-102

Vertical edge distance	[in]	2.85	1.25	--	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.25$[in] + 0[in] = **1.25**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.45	1.50	--	p. 10-102

$L_{emin} = 2*d = 2*0.75$[in] = **1.5**[in] — p. 10-102

<u>Support</u>

Weld size	[1/16in]	5	4	--	p. 10-101

$w_{min} = (5/8)*t_p = (5/8)*0.375$[in] = **0.0195** — p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Shear plate</u>						
Bolts shear	[Kip]	53.04	40.00	DL	0.75	Tables (7-1..14)

(n>=10) and (n<=12) and (*IsStandardHole*) → (5>=10) and (5<=12) and (False) → **False**

BoltFactor = 1 — p. 10-102

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor = 5*10.61$[kip]*1 = **53.04**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	92.57	40.00	DL	0.43	Eq. J3-6

$L_{c-end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.5$[in] - 0.813[in]/2) = **1.09**[in] — Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = $(1/\Omega)$*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*1.09[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.375[in]*58000[lb/in2]*1 = **92.57**[kip] Eq. J3-6

Shear yielding	[Kip]	81.00	40.00	DL	0.49	Eq. J4-3

A_g = L_p*t_p = 15[in]*0.375[in] = **5.63**[in2] Sec. D3-1

$(1/\Omega)R_n$ = $(1/\Omega)$*0.60*F_y*A_g = 0.667*0.60*36000[lb/in2]*5.63[in2] = **81**[kip] Eq. J4-3

Shear rupture	[Kip]	69.33	40.00	DL	0.58	Eq. J4-4

L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

L_e = L - n*L_h = 15[in] - 5*0.875[in] = **10.63**[in] DG4 Eq. 3-13

A_{nv} = L_e*t_p = 10.63[in]*0.375[in] = **3.98**[in2] Sec. J4-2

$(1/\Omega)R_n$ = $(1/\Omega)$*0.60*F_u*A_{nv} = 0.5*0.60*58000[lb/in2]*3.98[in2] = **69.33**[kip] Eq. J4-4

Block shear	[Kip]	65.21	40.00	DL	0.61	Eq. J4-5

dh_h = d_h + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.5[in] + (1 - 1)*3[in] - (1 - 0.5)*1.06[in])*0.375[in] = **0.363**[in2] Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.5[in] + (5 - 1)*3[in])*0.375[in] = **5.06**[in2] Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.5[in] + (5 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.375[in] = **3.59**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n$ = $(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*min(0.6*58000[lb/in2]*3.59[in2] + 1*58000[lb/in2]*0.363[in2], 0.6*36000[lb/in2]*5.06[in2] + 1*58000[lb/in2]*0.363[in2]) = **65.21**[kip] Eq. J4-5

Plate (support side)

Weld capacity	[Kip]	139.21	40.00	DL	0.29	Tables 8-4 .. 8-11

$(1/\Omega)R_n$ = $(1/\Omega)$*C*C_1*D*L = 0.5*3.71[kip/in]*1*5*15[in] = **139.21**[kip] Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load	[Kip]	87.75	40.00	DL	0.46	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 2.85[in] - 0.813[in]/2) = **2.44**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = $(1/\Omega)$*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*2.44[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.3[in]*65000[lb/in2]*1 = **87.75**[kip] Eq. J3-6

Shear yielding	[Kip]	106.20	40.00	DL	0.38	Eq. J4-3

A_g = L_p*t_p = 17.7[in]*0.3[in] = **5.31**[in2] Sec. D3-1

$(1/\Omega)R_n$ = $(1/\Omega)$*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*5.31[in2] = **106.2**[kip] Eq. J4-3

Support

Welds rupture	[Kip/ft]	159.12	32.00	DL	0.20	p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000$[lb/in2]$*0.34$[in] $=$ **13.26**[kip/in] p. 9-5

$D_{min} = P/((1/\Omega)*C*C_1*L) = 40$[kip]$/(0.5*3.71$[kip/in]$*1*15$[in]$) =$ **1.44** tables 8-4..11

$HasWeldsOnBothSides \rightarrow$ **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] $= 0.6*70000$[lb/in2]$*(2)^{1/2}/2*1.44/16$ [in] $=$ **2.67**[kip/in] p. 9-5

Global critical strength ratio **0.75**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

L: Length of weld

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

$sin\alpha$: Sine of the skew angle

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{min}: Minimum weld size required

Current Date: 2016-05-06 4:36 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-03 Beam to HSS_PIPE_W Column Shear Tab Design\B2C Flange1.cnx\

Steel connections

Results

Connection name : SP BCF

Connection ID : SC-03-5

Family: Beam - Column flange (BCF)

Type: Single plate

Description: B:W14x22

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru**	**Pu**	**Pu**	**Mu22**	**Mu33**	**Load type**
	[Kip]	[Kip]	[Kip]	[Kip*ft]	[Kip*ft]	
DL	20.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
Shear plate						
Length	[in]	12.00	6.11	12.23	✔	p. 10-104
$L_{min} = T/2 = 12.23$[in]$/2 = \mathbf{6.12}$[in]						p. 10-104
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 13.7$[in] $- \max(0.735$[in], 0[in]$) - \max(0.735$[in], 0[in]$) = \mathbf{12.23}$[in]						p. 10-49
Thickness	[in]	0.38	--	0.44	✔	p. 10-102
$t_{pmax} = d/2 + 1/16$ [in] $= 0.75$[in]$/2 + 1/16$ [in] $= \mathbf{0.438}$[in]						p. 10-102
Vertical edge distance	[in]	1.50	1.25	--	✔	Tables J3.4,

					J3.5
$L_{emin} = e_{dmin} + C_2 = 1.25$[in] $+ 0$[in] $=$ **1.25**[in]					Tables J3.4, J3.5
Horizontal edge distance	[in]	1.50	1.50	--	p. 10-102
$L_{emin} = 2*d = 2*0.75$[in] $=$ **1.5**[in]					p. 10-102
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.52	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in]					Sec. J3.3
IsCorrosionConsidered → **False**					
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.23$[in], 12 [in]$) =$ **5.52**[in]					Sec. J3.5
<u>Beam</u>					
Thickness	[in]	0.23	--	0.44	p. 10-151, p. 10-102
$t_{pmax} = (3/16$ [in]$)/\sin\alpha = (3/16$ [in]$)/0.105 =$ **1.79**[in]					p. 10-151
$t_{pmax} = d/2 + 1/16$ [in] $= 0.75$[in]$/2 + 1/16$ [in] $=$ **0.438**[in]					p. 10-102
$t_{pmax} = d/2 + 1/16$ [in] $= 0.75$[in]$/2 + 1/16$ [in] $=$ **0.438**[in]					p. 10-102
Vertical edge distance	[in]	2.35	1.25	--	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1.25$[in] $+ 0$[in] $=$ **1.25**[in]					Tables J3.4, J3.5
Horizontal edge distance	[in]	2.45	1.50	--	p. 10-102
$L_{emin} = 2*d = 2*0.75$[in] $=$ **1.5**[in]					p. 10-102
<u>Support</u>					
Weld size	[1/16in]	5	4	--	p. 10-101
$w_{min} = (5/8)*t_p = (5/8)*0.375$[in] $=$ **0.0195**					p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Shear plate</u>						
Bolts shear	[Kip]	42.43	20.00	DL	0.47	Tables (7-1..14)
$(n>=10)$ and $(n<=12)$ and (*IsStandardHole*) → (4>=10) and (4<=12) and (False) → **False**						
BoltFactor = 1						p. 10-102
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip]						Eq. J3-1
$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor = 4*10.61$[kip]$*1 =$ **42.43**[kip]						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	73.00	20.00	DL	0.27	Eq. J3-6
$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.5$[in] $- 0.813$[in]$/2) =$ **1.09**[in]						Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)$*(min($k_1$*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*1.09[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.375[in]*58000[lb/in2]*1 = **73**[kip] Eq. J3-6

Shear yielding	[Kip]	64.80	20.00	DL	0.31	Eq. J4-3

$A_g = L_p$*t_p = 12[in]*0.375[in] = **4.5**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)$*0.60*$F_y$*$A_g$ = 0.667*0.60*36000[lb/in2]*4.5[in2] = **64.8**[kip] Eq. J4-3

Shear rupture	[Kip]	55.46	20.00	DL	0.36	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$L_e = L$ - n*L_h = 12[in] - 4*0.875[in] = **8.5**[in] DG4 Eq. 3-13

$A_{nv} = L_e$*t_p = 8.5[in]*0.375[in] = **3.19**[in2] Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)$*0.60*$F_u$*$A_{nv}$ = 0.5*0.60*58000[lb/in2]*3.19[in2] = **55.46**[kip] Eq. J4-4

Block shear	[Kip]	53.06	20.00	DL	0.38	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.5[in] + (1 - 1)*3[in] - (1 - 0.5)*1.06[in])*0.375[in] = **0.363**[in2] Sec. J4-3

A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.5[in] + (4 - 1)*3[in])*0.375[in] = **3.94**[in2] Sec. J4-3

A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.5[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.375[in] = **2.79**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)$*min(0.6*$F_u$*$A_{nv}$ + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*min(0.6*58000[lb/in2]*2.79[in2] + 1*58000[lb/in2]*0.363[in2], 0.6*36000[lb/in2]*3.94[in2] + 1*58000[lb/in2]*0.363[in2]) = **53.06**[kip] Eq. J4-5

Plate (support side)

Weld capacity	[Kip]	111.37	20.00	DL	0.18	Tables 8-4 .. 8-11

$(1/\Omega)R_n = (1/\Omega)$*$C$*$C_1$*$D$*$L$ = 0.5*3.71[kip/in]*1*5*12[in] = **111.37**[kip] Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load	[Kip]	53.82	20.00	DL	0.37	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 2.35[in] - 0.813[in]/2) = **1.94**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)$*(min($k_1$*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*1.94[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.23[in]*65000[lb/in2]*1 = **53.82**[kip] Eq. J3-6

Shear yielding	[Kip]	63.02	20.00	DL	0.32	Eq. J4-3

$A_g = L_p$*t_p = 13.7[in]*0.23[in] = **3.15**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)$*0.60*$F_y$*$A_g$ = 0.667*0.60*50000[lb/in2]*3.15[in2] = **63.02**[kip] Eq. J4-3

Support

Welds rupture	[Kip/ft]	262.08	20.00	DL	0.08		p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000$[lb/in2]$*0.56$[in] = **21.84**[kip/in] p. 9-5

$D_{min} = P/((1/\Omega)*C*C_1*L) = 20$[kip]$/(0.5*3.71$[kip/in]$*1*12$[in]$)$ = **0.898** tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] $= 0.6*70000$[lb/in2]$*(2)^{1/2}/2*0.898/16$ [in] = **1.67**[kip/in] p. 9-5

Global critical strength ratio **0.47**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

L: Length of weld

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

$sin\alpha$: Sine of the skew angle

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{min}: Minimum weld size required

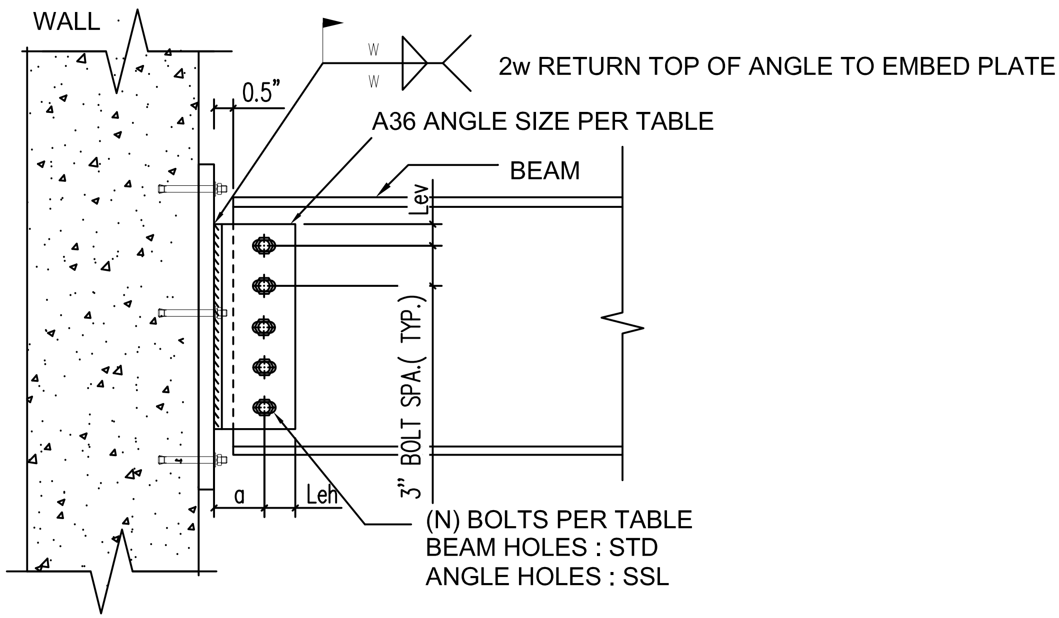
SC-04 BEAM TO EMBED. PLATE DOUBLE ANGLE CONNECTION (Weld to Support, Bolted to Beam)

Connection ID	Beam Size	Design Reaction (kip) "R"	Double Angle Size**	3/4" Dia. A325N Bolt Rows	Bolt Spacing (inch) "Spa."	Beam Side Bolt Edge Distance (inch)		Weld Size to Embed Plate* (inch) "w"
						Vertical "Lev"	Horizontal "Leh"	
SC-04-1	W8x18	15	(2)L4x4x1/2	2	3	1.25	1.25	5/16"
SC-04-2	W10x17	15	(2)L4x4x5/16	3	3	1.25	1.25	1/4"
SC-04-3	W12x19	10	(2)L4x4x5/16	3	3	1.25	1.25	1/4"
SC-04-4	W12x26	30	(2)L4x4x5/16	3	3	1.25	1.25	1/4"
SC-04-5	W14x22	10	(2)L4x4x5/16	3	3	1.25	1.25	1/4"
SC-04-6	W14x22	30	(2)L4x4x5/16	4	3	1.25	1.25	1/4"
SC-04-7	W16x26	30	(2)L4x4x5/16	4	3	1.25	1.25	1/4"
SC-04-8	W16x31	25	(2)L4x4x5/16	4	3	1.25	1.25	1/4"
SC-04-9	W18x35	35	(2)L4x4x5/16	4	3	1.25	1.25	1/4"
SC-04-10	W18x40	45	(2)L4x4x5/16	5	3	1.25	1.25	1/4"
SC-04-11	W18x65	85	(2)L4x4x1/2	5	3	1.25	1.25	5/16"
SC-04-12	W21x44	45	(2)L4x4x5/16	5	3	1.25	1.25	1/4"
SC-04-13	W24x55	50	(2)L4x4x5/16	6	3	1.25	1.25	1/4"

Short Slotted Hole on web angles against beam web.

*Weld turn to top of angle (length= 2w)

SC-04	Beam to Embed. Plate Double Angle Shear Connection



Wall and embedded plate for illustration ONLY

Current Date: 2016-05-06 4:56 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-04 Beam to Embed Plate Double Angle Weld_Bolt Shear Connection\B2W2.cnx\

Steel connections

Results

Connection name : DA BCF Weld support Bolt beam

Connection ID : SC-04-1

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W8x18

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	15.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	5.50	3.44	6.88	✔	p. 10-8
$L_{min} = T/2 = 6.88$[in]$/2 = \mathbf{3.44}$[in]						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 8.14$[in] $- \max(0.63$[in]$, 0$[in]$) - \max(0.63$[in]$, 0$[in]$) = \mathbf{6.88}$[in]						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.52	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.23$[in]$, 12$ [in]$) =$ **5.52**[in] — Sec. J3.5

Thickness	[in]	0.50	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Weld size	[1/16in]	5	3	7	✔	table J2.4, Sec. J2.2b

$w_{min} = w_{min} =$ **0.0156** — table J2.4

$t_p<1/4$ [in] → 0.5[in]$<1/4$ [in] → **False**

$w_{max} = t_p - 1/16$ [in] $= 0.5$[in] $- 1/16$ [in] $=$ **0.0365** — Sec. J2.2b

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	42.43	15.00	DL	0.35	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (2*10.61$[kip]$) =$ **42.43**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	81.56	15.00	DL	0.18	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(2 - 1))*0.5$[in]$*58000$[lb/in2]$*1) =$ **81.56**[kip] — Eq. J3-6

Shear yielding	[Kip]	79.20	15.00	DL	0.19	Eq. J4-3

$A_g = L_p*t_p = 5.5$[in]$*0.5$[in] $=$ **2.75**[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*2.75$[in2]$) =$ **79.2**[kip] Eq. J4-3

Shear rupture [Kip] 65.25 15.00 DL 0.23 Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] Sec. D3-2

$L_e = L - n*L_h = 5.5$[in] $- 2*0.875$[in] $=$ **3.75**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 3.75$[in]$*0.5$[in] $=$ **1.88**[in2] Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*1.88$[in2]$) =$ **65.25**[kip] Eq. J4-4

Block shear [Kip] 66.74 15.00 DL 0.22 Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 1$[in] $+ 1/16$ [in] $=$ **1.06**[in] Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25$[in] $+ (1 - 1)*3$[in] $- (1 - 0.5)*$
1.06[in]$)*0.5$[in] $=$ **0.359**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] $+ (2 - 1)*3$[in]$)*0.5$[in] $=$ **2.13**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25$[in] $+ (2 - 1)*(3$[in] $- 0.875$[in]$) -$
0.875[in]$/2)*0.5$[in] $=$ **1.47**[in2] Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*$
$A_{nt})) = 2 * (0.5*\min(0.6*58000$[lb/in2]$*1.47$[in2] $+ 1*58000$[lb/in2]$*0.359$[in2]$, 0.6*36000$[lb/in2]$*$
2.13[in2] $+ 1*58000$[lb/in2]$*0.359$[in2]$)) =$ **66.74**[kip] Eq. J4-5

Angle (Support side)

Weld capacity [Kip] 18.21 15.00 DL 0.82 p. 10-11

$(1/\Omega)R_n = (1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*D/16$ [in]$*L/(1 + 12.96*e^2/L^2)^{1/2} = 0.5*2*0.6*$
70000[lb/in2]$*(2)^{1/2}/2*5/16$ [in]$*5.5$[in]$/(1 + 12.96*4$[in]$^2/5.5$[in]$^2)^{1/2} =$ **18.21**[kip] p. 10-11

Shear yielding [Kip] 79.20 15.00 DL 0.19 Eq. J4-3

$A_g = L_p*t_p = 5.5$[in]$*0.5$[in] $=$ **2.75**[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*2.75$[in2]$) =$ **79.2**[kip] Eq. J4-3

Beam

Bolt bearing under shear load [Kip] 26.91 15.00 DL 0.56 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 2.57$[in] $- 0.813$[in]$/2) =$ **2.16**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*$
$F_u*n_c = 0.5*(\min(1.2*2.16$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(2 - 1))*$
0.23[in]$*65000$[lb/in2]$*1 =$ **26.91**[kip] Eq. J3-6

Shear yielding [Kip] 37.44 15.00 DL 0.40 Eq. J4-3

$A_g = L_p*t_p = 8.14$[in]$*0.23$[in] $=$ **1.87**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000$[lb/in2]$*1.87$[in2] $=$ **37.44**[kip] Eq. J4-3

Support

Welds rupture [Kip/ft] 136.19 91.72 DL 0.67 p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000$[lb/in2]$*0.291$[in] = **11.35**[kip/in] p. 9-5

$D_{min} = P*(1 + 12.96*e^2/L^2)^{1/2}*16/(1$ [in]$)/((1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*L) = 15$[kip]$*(1 + 12.96*4$[in]$^2/5.5$[in]$^2)^{1/2}*16/(1$ [in]$)/(0.5*2*0.6*70000$[lb/in2]$*(2)^{1/2}/2*5.5$[in]$)$ = **4.12** p. 10-11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] $= 0.6*70000$[lb/in2]$*(2)^{1/2}/2*4.12/16$ [in] = **7.64**[kip/in] p. 9-5

Global critical strength ratio **0.82**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Width of the leg of the connection angle attached to the support

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{max}: Maximum weld size required

w_{min}: Minimum weld size required

Current Date: 2016-05-06 4:42 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-04 Beam to Embed Plate Double Angle Weld_Bolt Shear Connection\B2W1.cnx\

Steel connections

Results

Connection name	:	**DA BCF Weld support Bolt beam**
Connection ID	:	**SC-04-2**

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W10x17

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	15.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	8.50	4.42	8.84	✔	p. 10-8
$L_{min} = T/2 = 8.84\text{[in]}/2 = \mathbf{4.42}\text{[in]}$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 10.1\text{[in]} - \max(0.63\text{[in]}, 0\text{[in]}) - \max(0.63\text{[in]}, 0\text{[in]}) = \mathbf{8.84}\text{[in]}$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.76	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

$IsCorrosionConsidered \rightarrow$ **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.24$[in], 12 [in]$) =$ **5.76**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Weld size	[1/16in]	4	3	4	✔	table J2.4, Sec. J2.2b

$w_{min} = w_{min} =$ **0.0156** — table J2.4

$t_p<1/4$ [in] $\rightarrow 0.313$[in]$<1/4$ [in] $\rightarrow$ **False**

$w_{max} = t_p - 1/16$ [in] $= 0.313$[in] $- 1/16$ [in] $=$ **0.0208** — Sec. J2.2b

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	63.65	15.00	DL	0.24	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61$[kip]$) =$ **63.65**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	15.00	DL	0.18	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in], $2.4*0.75$[in]$) + \min(1.2*2.19$[in], $2.4*0.75$[in]$)*(3 - 1))*0.313$[in]$*58000$[lb/in2]$*1) =$ **83.6**[kip] — Eq. J3-6

Shear yielding	[Kip]	76.50	15.00	DL	0.20	Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] Eq. J4-3

Shear rupture	[Kip]	63.89	15.00	DL	0.23	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$L_e = L - n*L_h$ = 8.5[in] - 3*0.875[in] = **5.88**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 5.88[in]*0.313[in] = **1.84**[in2] Sec. J4-2

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] Eq. J4-4

Block shear	[Kip]	61.96	15.00	DL	0.24	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.225**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] Sec. J4-3

$IsStressUniform \rightarrow$ **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.225[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.225[in2])) = **61.96**[kip] Eq. J4-5

Angle (Support side)

Weld capacity	[Kip]	32.08	15.00	DL	0.47	p. 10-11

$(1/\Omega)R_n = (1/\Omega)$*2*0.6*$F_{EXX}$*$(2)^{1/2}$/2*$D$/16 [in]*$L/(1 + 12.96*e^2/L^2)^{1/2}$ = 0.5*2*0.6*70000[lb/in2]*$(2)^{1/2}$/2*4/16 [in]*8.5[in]/(1 + 12.96*4[in]^2/8.5[in]^2)$^{1/2}$ = **32.08**[kip] p. 10-11

Shear yielding	[Kip]	76.50	15.00	DL	0.20	Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] Eq. J4-3

Beam

Bolt bearing under shear load	[Kip]	42.12	15.00	DL	0.36	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, $L_e - d_h/2$) = Max(0.0, 2.05[in] - 0.813[in]/2) = **1.64**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, $s - d_h$) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)$*(min($k_1$*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*1.64[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.24[in]*65000[lb/in2]*1 = **42.12**[kip] Eq. J3-6

Shear yielding	[Kip]	48.48	15.00	DL	0.31	Eq. J4-3

$A_g = L_p*t_p$ = 10.1[in]*0.24[in] = **2.42**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)$*0.60*$F_y$*$A_g$ = 0.667*0.60*50000[lb/in2]*2.42[in2] = **48.48**[kip] Eq. J4-3

Support

Welds rupture	[Kip/ft]	136.19	41.66	DL	0.31	p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000$[lb/in2]$*0.291$[in] = **11.35**[kip/in] p. 9-5

$D_{min} = P*(1 + 12.96*e^2/L^2)^{1/2}*16/(1$ [in]$)/((1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*L) = 15$[kip]$*(1 + 12.96*4$[in]$^2/8.5$[in]$^2)^{1/2}*16/(1$ [in]$)/(0.5*2*0.6*70000$[lb/in2]$*(2)^{1/2}/2*8.5$[in]$)$ = **1.87** p. 10-11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] $= 0.6*70000$[lb/in2]$*(2)^{1/2}/2*1.87/16$ [in] = **3.47**[kip/in] p. 9-5

Global critical strength ratio **0.47**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Width of the leg of the connection angle attached to the support

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{max}: Maximum weld size required

w_{min}: Minimum weld size required

Current Date: 2016-05-06 4:49 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-04 Beam to Embed Plate Double Angle Weld_Bolt Shear Connection\B2W1.cnx\

Steel connections

Results

Connection name : DA BCF Weld support Bolt beam

Connection ID : SC-04-3

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W12x19

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	10.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	8.50	5.45	10.90	✔	p. 10-8
$L_{min} = T/2 = 10.9$[in]$/2 = \mathbf{5.45}$[in]						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 12.2$[in] $- \max(0.65$[in]$, 0$[in]$) - \max(0.65$[in]$, 0$[in]$) = \mathbf{10.9}$[in]						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.64	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.235$[in], 12 [in]$) =$ **5.64**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Weld size	[1/16in]	4	3	4	✔	table J2.4, Sec. J2.2b

$w_{min} = w_{min} =$ **0.0156** — table J2.4

$t_p<1/4$ [in] $\rightarrow 0.313$[in]$<1/4$ [in] → **False**

$w_{max} = t_p - 1/16$ [in] $= 0.313$[in] $- 1/16$ [in] $=$ **0.0208** — Sec. J2.2b

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	63.65	10.00	DL	0.16	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61$[kip]$) =$ **63.65**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	10.00	DL	0.12	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in], $2.4*0.75$[in]$) + \min(1.2*2.19$[in], $2.4*0.75$[in]$)*(3 - 1))*0.313$[in]$*58000$[lb/in2]$*1) =$ **83.6**[kip] — Eq. J3-6

Shear yielding	[Kip]	76.50	10.00	DL	0.13	Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] Eq. J4-3

Shear rupture	[Kip]	63.89	10.00	DL	0.16	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$L_e = L - n*L_h$ = 8.5[in] - 3*0.875[in] = **5.88**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 5.88[in]*0.313[in] = **1.84**[in2] Sec. J4-2

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] Eq. J4-4

Block shear	[Kip]	61.96	10.00	DL	0.16	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.225**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] Sec. J4-3

$IsStressUniform \rightarrow$ **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.225[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.225[in2])) = **61.96**[kip] Eq. J4-5

Angle (Support side)

Weld capacity	[Kip]	32.08	10.00	DL	0.31	p. 10-11

$(1/\Omega)R_n = (1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*D/16$ [in]$*L/(1 + 12.96*e^2/L^2)^{1/2}$ = 0.5*2*0.6*70000[lb/in2]*$(2)^{1/2}$/2*4/16 [in]*8.5[in]/(1 + 12.96*4[in]^2/8.5[in]^2)$^{1/2}$ = **32.08**[kip] p. 10-11

Shear yielding	[Kip]	76.50	10.00	DL	0.13	Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] Eq. J4-3

Beam

Bolt bearing under shear load	[Kip]	41.24	10.00	DL	0.24	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, $L_e - d_h/2$) = Max(0.0, 3.1[in] - 0.813[in]/2) = **2.69**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, $s - d_h$) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(min(1.2*2.69[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.235[in]*65000[lb/in2]*1 = **41.24**[kip] Eq. J3-6

Shear yielding	[Kip]	57.34	10.00	DL	0.17	Eq. J4-3

$A_g = L_p*t_p$ = 12.2[in]*0.235[in] = **2.87**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*2.87[in2] = **57.34**[kip] Eq. J4-3

Support

Welds rupture	[Kip/ft]	136.19	27.77	DL	0.20	p. 9-5

R_n = 0.6*F_u*t_p = 0.6*65000[lb/in2]*0.291[in] = **11.35**[kip/in] p. 9-5

D_{min} = P*(1 + 12.96*e^2/L^2)$^{1/2}$*16/(1 [in])/((1/Ω)*2*0.6*F_{EXX}*(2)$^{1/2}$/2*L) = 10[kip]*(1 + 12.96*4[in]^2/8.5[in]^2)$^{1/2}$*16/(1 [in])/(0.5*2*0.6*70000[lb/in2]*(2)$^{1/2}$/2*8.5[in]) = **1.25** p. 10-11

HasWeldsOnBothSides → **False**

R_u = 0.6*F_{EXX}*(2)$^{1/2}$/2*D_{min}/16 [in] = 0.6*70000[lb/in2]*(2)$^{1/2}$/2*1.25/16 [in] = **2.31**[kip/in] p. 9-5

Global critical strength ratio **0.31**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Width of the leg of the connection angle attached to the support

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

L_{c-end}: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{max}: Maximum weld size required

w_{min}: Minimum weld size required

Current Date: 2016-05-06 4:58 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-04 Beam to Embed Plate Double Angle Weld_Bolt Shear Connection\B2W2.cnx\

Steel connections

Results

Connection name : DA BCF Weld support Bolt beam

Connection ID : SC-04-4

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W12x26

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	30.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	8.50	5.42	10.84	✔	p. 10-8
$L_{min} = T/2 = 10.84$[in]$/2 = \mathbf{5.42}$[in]						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 12.2$[in] $- \max(0.68$[in], 0[in]$) - \max(0.68$[in], 0[in]$) = \mathbf{10.84}$[in]						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.00	--	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.52	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.23[in], 12 [in]) = **5.52**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Weld size	[1/16in]	4	3	4	table J2.4, Sec. J2.2b

$w_{min} = w_{min}$ = **0.0156** — table J2.4

t_p<1/4 [in] → 0.313[in]<1/4 [in] → **False**

$w_{max} = t_p - 1/16$ [in] = 0.313[in] - 1/16 [in] = **0.0208** — Sec. J2.2b

Beam

Horizontal edge distance	[in]	2.25	1.00	--	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	63.65	30.00	DL	0.47	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61$[kip]) = **63.65**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	30.00	DL	0.36	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c)$ = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] — Eq. J3-6

Shear yielding	[Kip]	76.50	30.00	DL	0.39	Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g)$ = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] Eq. J4-3

Shear rupture	[Kip]	63.89	30.00	DL	0.47	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$L_e = L - n*L_h$ = 8.5[in] - 3*0.875[in] = **5.88**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 5.88[in]*0.313[in] = **1.84**[in2] Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv})$ = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] Eq. J4-4

Block shear	[Kip]	63.66	30.00	DL	0.47	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.313[in] = **0.254**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}))$ = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.254[in2])) = **63.66**[kip] Eq. J4-5

Angle (Support side)

Weld capacity	[Kip]	32.08	30.00	DL	0.94	p. 10-11

$(1/\Omega)R_n = (1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*D/16$ [in]$*L/(1 + 12.96*e^2/L^2)^{1/2}$ = 0.5*2*0.6*70000[lb/in2]$*(2)^{1/2}$/2*4/16 [in]*8.5[in]/(1 + 12.96*4[in]^2/8.5[in]$^2)^{1/2}$ = **32.08**[kip] p. 10-11

Shear yielding	[Kip]	76.50	30.00	DL	0.39	Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g)$ = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] Eq. J4-3

Beam

Bolt bearing under shear load	[Kip]	40.37	30.00	DL	0.74	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 3.1[in] - 0.813[in]/2) = **2.69**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(min(1.2*2.69[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.23[in]*65000[lb/in2]*1 = **40.37**[kip] Eq. J3-6

Shear yielding	[Kip]	56.12	30.00	DL	0.53	Eq. J4-3

$A_g = L_p*t_p$ = 12.2[in]*0.23[in] = **2.81**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*2.81[in2] = **56.12**[kip] Eq. J4-3

Support

Welds rupture	[Kip/ft]	136.19	83.32	DL	0.61	p. 9-5

R_n = 0.6*F_u*t_p = 0.6*65000[lb/in2]*0.291[in] = **11.35**[kip/in] p. 9-5

D_{min} = P*(1 + 12.96*e^2/L^2)$^{1/2}$*16/(1 [in])/(($1/\Omega$)*2*0.6*F_{EXX}*(2)$^{1/2}$/2*L) = 30[kip]*(1 + 12.96*4[in]^2/8.5[in]^2)$^{1/2}$*16/(1 [in])/(0.5*2*0.6*70000[lb/in2]*(2)$^{1/2}$/2*8.5[in]) = **3.74** p. 10-11

HasWeldsOnBothSides → **False**

R_u = 0.6*F_{EXX}*(2)$^{1/2}$/2*D_{min}/16 [in] = 0.6*70000[lb/in2]*(2)$^{1/2}$/2*3.74/16 [in] = **6.94**[kip/in] p. 9-5

Global critical strength ratio **0.94**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Width of the leg of the connection angle attached to the support

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{max}: Maximum weld size required

w_{min}: Minimum weld size required

Current Date: 2016-05-06 4:47 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-04 Beam to Embed Plate Double Angle Weld_Bolt Shear Connection\B2W1.cnx\

Steel connections

Results

Connection name : DA BCF Weld support Bolt beam

Connection ID : SC-04-5

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W14x22

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	10.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	8.50	6.11	12.23	✔	p. 10-8
$L_{min} = T/2 = 12.23\text{[in]}/2 = \mathbf{6.12}\text{[in]}$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 13.7\text{[in]} - \max(0.735\text{[in]}, 0\text{[in]}) - \max(0.735\text{[in]}, 0\text{[in]}) = \mathbf{12.23}\text{[in]}$						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.52	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

$IsCorrosionConsidered \rightarrow$ **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.23$[in]$, 12$ [in]$) =$ **5.52**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Weld size	[1/16in]	4	3	4	✔	table J2.4, Sec. J2.2b

$w_{min} = w_{min} =$ **0.0156** — table J2.4

$t_p<1/4$ [in] $\rightarrow 0.313$[in]$<1/4$ [in] $\rightarrow$ **False**

$w_{max} = t_p - 1/16$ [in] $= 0.313$[in] $- 1/16$ [in] $=$ **0.0208** — Sec. J2.2b

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	63.65	10.00	DL	0.16	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61$[kip]$) =$ **63.65**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	10.00	DL	0.12	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(3 - 1))*0.313$[in]$*58000$[lb/in2]$*1) =$ **83.6**[kip] — Eq. J3-6

Shear yielding	[Kip]	76.50	10.00	DL	0.13	Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] Eq. J4-3

Shear rupture	[Kip]	63.89	10.00	DL	0.16	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$L_e = L - n*L_h$ = 8.5[in] - 3*0.875[in] = **5.88**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 5.88[in]*0.313[in] = **1.84**[in2] Sec. J4-2

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] Eq. J4-4

Block shear	[Kip]	61.96	10.00	DL	0.16	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.225**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.225[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.225[in2])) = **61.96**[kip] Eq. J4-5

Angle (Support side)

Weld capacity	[Kip]	32.08	10.00	DL	0.31	p. 10-11

$(1/\Omega)R_n = (1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*D/16$ [in]$*L/(1 + 12.96*e^2/L^2)^{1/2}$ = 0.5*2*0.6*70000[lb/in2]*$(2)^{1/2}$/2*4/16 [in]*8.5[in]/(1 + 12.96*4[in]^2/8.5[in]^2)$^{1/2}$ = **32.08**[kip] p. 10-11

Shear yielding	[Kip]	76.50	10.00	DL	0.13	Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] Eq. J4-3

Beam

Bolt bearing under shear load	[Kip]	40.37	10.00	DL	0.25	Eq. J3-6

L_{c-end} = Max(0.0, $L_e - d_h/2$) = Max(0.0, 3.85[in] - 0.813[in]/2) = **3.44**[in] Sec. J4.10

L_{c-spa} = Max(0.0, $s - d_h$) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(min(1.2*3.44[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.23[in]*65000[lb/in2]*1 = **40.37**[kip] Eq. J3-6

Shear yielding	[Kip]	63.02	10.00	DL	0.16	Eq. J4-3

$A_g = L_p*t_p$ = 13.7[in]*0.23[in] = **3.15**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*3.15[in2] = **63.02**[kip] Eq. J4-3

Support

Welds rupture	[Kip/ft]	136.19	27.77	DL	0.20	p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000$[lb/in2]$*0.291$[in] = **11.35**[kip/in] p. 9-5

$D_{min} = P*(1 + 12.96*e^2/L^2)^{1/2}*16/(1$ [in]$)/((1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*L) = 10$[kip]$*(1 + 12.96*4$[in]$^2/8.5$[in]$^2)^{1/2}*16/(1$ [in]$)/(0.5*2*0.6*70000$[lb/in2]$*(2)^{1/2}/2*8.5$[in]$)$ = **1.25** p. 10-11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] $= 0.6*70000$[lb/in2]$*(2)^{1/2}/2*1.25/16$ [in] = **2.31**[kip/in] p. 9-5

Global critical strength ratio **0.31**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Width of the leg of the connection angle attached to the support

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

L_{c-end}: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{max}: Maximum weld size required

w_{min}: Minimum weld size required

Current Date: 2016-05-06 4:55 PM

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File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-04 Beam to Embed Plate Double Angle Weld_Bolt Shear Connection\B2W2.cnx\

Steel connections

Results

Connection name : **DA BCF Weld support Bolt beam**

Connection ID : **SC-04-6**

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W14x22

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	30.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	11.50	6.11	12.23	✔	p. 10-8
$L_{min} = T/2 = 12.23[in]/2 = \mathbf{6.12}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 13.7[in] - \max(0.735[in], 0[in]) - \max(0.735[in], 0[in]) = \mathbf{12.23}[in]$						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.52	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

$IsCorrosionConsidered \rightarrow$ **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.23$[in]$, 12$ [in]$) =$ **5.52**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Weld size	[1/16in]	4	3	4	✔	table J2.4, Sec. J2.2b

$w_{min} = w_{min} =$ **0.0156** — table J2.4

$t_p<1/4$ [in] $\rightarrow 0.313$[in]$<1/4$ [in] $\rightarrow$ **False**

$w_{max} = t_p - 1/16$ [in] $= 0.313$[in] $- 1/16$ [in] $=$ **0.0208** — Sec. J2.2b

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Angle (Beam side)

Bolts shear	[Kip]	84.86	30.00	DL	0.35	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61$[kip]$) =$ **84.86**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	30.00	DL	0.26	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*$
$t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*$
0.75[in]$)*(4 - 1))*0.313$[in]$*58000$[lb/in2]$*1) =$ **116.23**[kip] — Eq. J3-6

Shear yielding	[Kip]	103.50	30.00	DL	0.29	Eq. J4-3

$A_g = L_p*t_p = 11.5$[in]$*0.313$[in] $=$ **3.59**[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*3.59$[in2]$) =$ **103.5**[kip] Eq. J4-3

Shear rupture	[Kip]	87.00	30.00	DL	0.34	Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] Sec. D3-2

$L_e = L - n*L_h = 11.5$[in] $- 4*0.875$[in] $=$ **8**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8$[in]$*0.313$[in] $=$ **2.5**[in2] Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*2.5$[in2]$) =$ **87**[kip] Eq. J4-4

Block shear	[Kip]	82.21	30.00	DL	0.36	Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 1$[in] $+ 1/16$ [in] $=$ **1.06**[in] Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25$[in] $+ (1 - 1)*3$[in] $- (1 - 0.5)*$
1.06[in]$)*0.313$[in] $=$ **0.225**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] $+ (4 - 1)*3$[in]$)*0.313$[in] $=$ **3.2**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25$[in] $+ (4 - 1)*(3$[in] $- 0.875$[in]$) -$
0.875[in]$/2)*0.313$[in] $=$ **2.25**[in2] Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*$
$A_{nt})) = 2 * (0.5*\min(0.6*58000$[lb/in2]$*2.25$[in2] $+ 1*58000$[lb/in2]$*0.225$[in2]$, 0.6*36000$[lb/in2]$*$
3.2[in2] $+ 1*58000$[lb/in2]$*0.225$[in2]$)) =$ **82.21**[kip] Eq. J4-5

Angle (Support side)

Weld capacity	[Kip]	53.28	30.00	DL	0.56	p. 10-11

$(1/\Omega)R_n = (1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*D/16$ [in]$*L/(1 + 12.96*e^2/L^2)^{1/2} = 0.5*2*0.6*$
70000[lb/in2]$*(2)^{1/2}/2*4/16$ [in]$*11.5$[in]$/(1 + 12.96*4$[in]$^2/11.5$[in]$^2)^{1/2} =$ **53.28**[kip] p. 10-11

Shear yielding	[Kip]	103.50	30.00	DL	0.29	Eq. J4-3

$A_g = L_p*t_p = 11.5$[in]$*0.313$[in] $=$ **3.59**[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*3.59$[in2]$) =$ **103.5**[kip] Eq. J4-3

Beam

Bolt bearing under shear load	[Kip]	53.82	30.00	DL	0.56	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 2.35$[in] $- 0.813$[in]$/2) =$ **1.94**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*$
$F_u*n_c = 0.5*(\min(1.2*1.94$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(4 - 1))*$
0.23[in]$*65000$[lb/in2]$*1 =$ **53.82**[kip] Eq. J3-6

Shear yielding	[Kip]	63.02	30.00	DL	0.48	Eq. J4-3

$A_g = L_p*t_p = 13.7$[in]$*0.23$[in] $=$ **3.15**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000$[lb/in2]$*3.15$[in2] $=$ **63.02**[kip] Eq. J4-3

Support

Welds rupture	[Kip/ft]	136.19	50.16	DL	0.37	p. 9-5

R_n = 0.6*F_u*t_p = 0.6*65000[lb/in2]*0.291[in] = **11.35**[kip/in] p. 9-5

D_{min} = P*(1 + 12.96*e^2/L^2)$^{1/2}$*16/(1 [in])/((1/Ω)*2*0.6*F_{EXX}*(2)$^{1/2}$/2*L) = 30[kip]*(1 + 12.96*4[in]^2/11.5[in]^2)$^{1/2}$*16/(1 [in])/(0.5*2*0.6*70000[lb/in2]*(2)$^{1/2}$/2*11.5[in]) = **2.25** p. 10-11

HasWeldsOnBothSides → **False**

R_u = 0.6*F_{EXX}*(2)$^{1/2}$/2*D_{min}/16 [in] = 0.6*70000[lb/in2]*(2)$^{1/2}$/2*2.25/16 [in] = **4.18**[kip/in] p. 9-5

Global critical strength ratio **0.56**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Width of the leg of the connection angle attached to the support

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{max}: Maximum weld size required

w_{min}: Minimum weld size required

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Steel connections

Results

Connection name : DA BCF Weld support Bolt beam

Connection ID : SC-04-7

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W16x26

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	30.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	11.50	7.10	14.21	✔	p. 10-8
$L_{min} = T/2 = 14.21$[in]$/2 = \mathbf{7.1}$[in]						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 15.7$[in] $- \max(0.747$[in], 0[in]$) - \max(0.747$[in], 0[in]$) = \mathbf{14.21}$[in]						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.00	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

$IsCorrosionConsidered \rightarrow$ **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.25$[in], 12 [in]$) =$ **6**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Weld size	[1/16in]	4	3	4	✔	table J2.4, Sec. J2.2b

$w_{min} = w_{min} =$ **0.0156** — table J2.4

$t_p < 1/4$ [in] $\rightarrow 0.313$[in]$<1/4$ [in] $\rightarrow$ **False**

$w_{max} = t_p - 1/16$ [in] $= 0.313$[in] $- 1/16$ [in] $=$ **0.0208** — Sec. J2.2b

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	84.86	30.00	DL	0.35	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61$[kip]$) =$ **84.86**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	30.00	DL	0.26	Eq. J3-6

$L_{c-end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c-spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*(n - 1))*$
$t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in], $2.4*0.75$[in]$) + \min(1.2*2.19$[in], $2.4*$
0.75[in]$)*(4 - 1))*0.313$[in]$*58000$[lb/in2]$*1) =$ **116.23**[kip] — Eq. J3-6

Shear yielding	[Kip]	103.50	30.00	DL	0.29	Eq. J4-3

$A_g = L_p*t_p = 11.5$[in]$*0.313$[in] = **3.59**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*3.59$[in2]$)$ = **103.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	87.00	30.00	DL	0.34	Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h = 11.5$[in] $- 4*0.875$[in] = **8**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8$[in]$*0.313$[in] = **2.5**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*2.5$[in2]$)$ = **87**[kip] — Eq. J4-4

Block shear	[Kip]	82.21	30.00	DL	0.36	Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 1$[in] $+ 1/16$ [in] = **1.06**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25$[in] $+ (1 - 1)*3$[in] $- (1 - 0.5)*1.06$[in]$)*0.313$[in] = **0.225**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] $+ (4 - 1)*3$[in]$)*0.313$[in] = **3.2**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25$[in] $+ (4 - 1)*(3$[in] $- 0.875$[in]$) - 0.875$[in]$/2)*0.313$[in] = **2.25**[in2] — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000$[lb/in2]$*2.25$[in2] $+ 1*58000$[lb/in2]$*0.225$[in2], $0.6*36000$[lb/in2]$*3.2$[in2] $+ 1*58000$[lb/in2]$*0.225$[in2]$))$ = **82.21**[kip] — Eq. J4-5

Angle (Support side)

Weld capacity	[Kip]	53.28	30.00	DL	0.56	p. 10-11

$(1/\Omega)R_n = (1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*D/16$ [in]$*L/(1 + 12.96*e^2/L^2)^{1/2} = 0.5*2*0.6*70000$[lb/in2]$*(2)^{1/2}/2*4/16$ [in]$*11.5$[in]$/(1 + 12.96*4$[in]$^2/11.5$[in]$^2)^{1/2}$ = **53.28**[kip] — p. 10-11

Shear yielding	[Kip]	103.50	30.00	DL	0.29	Eq. J4-3

$A_g = L_p*t_p = 11.5$[in]$*0.313$[in] = **3.59**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*3.59$[in2]$)$ = **103.5**[kip] — Eq. J4-3

Beam

Bolt bearing under shear load	[Kip]	58.50	30.00	DL	0.51	Eq. J3-6

$L_{c\text{-}end} = Max(0.0, L_e - d_h/2) = Max(0.0, 3.35$[in] $- 0.813$[in]$/2)$ = **2.94**[in] — Sec. J4.10

$L_{c\text{-}spa} = Max(0.0, s - d_h) = Max(0.0, 3$[in] $- 0.813$[in]$)$ = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*2.94$[in], $2.4*0.75$[in]$) + \min(1.2*2.19$[in], $2.4*0.75$[in]$)*(4 - 1))*0.25$[in]$*65000$[lb/in2]$*1$ = **58.5**[kip] — Eq. J3-6

Shear yielding	[Kip]	78.50	30.00	DL	0.38	Eq. J4-3

$A_g = L_p*t_p = 15.7$[in]$*0.25$[in] = **3.93**[in2] — Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000$[lb/in2]$*3.93$[in2] = **78.5**[kip] — Eq. J4-3

Support

Welds rupture	[Kip/ft]	136.19	50.16	DL	0.37	p. 9-5

R_n = 0.6*F_u*t_p = 0.6*65000[lb/in2]*0.291[in] = **11.35**[kip/in] p. 9-5

D_{min} = P*(1 + 12.96*e^2/L^2)$^{1/2}$*16/(1 [in])/((1/Ω)*2*0.6*F_{EXX}*(2)$^{1/2}$/2*L) = 30[kip]*(1 + 12.96*4[in]^2/11.5[in]^2)$^{1/2}$*16/(1 [in])/(0.5*2*0.6*70000[lb/in2]*(2)$^{1/2}$/2*11.5[in]) = **2.25** p. 10-11

HasWeldsOnBothSides → **False**

R_u = 0.6*F_{EXX}*(2)$^{1/2}$/2*D_{min}/16 [in] = 0.6*70000[lb/in2]*(2)$^{1/2}$/2*2.25/16 [in] = **4.18**[kip/in] p. 9-5

Global critical strength ratio **0.56**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Width of the leg of the connection angle attached to the support

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{max}: Maximum weld size required

w_{min}: Minimum weld size required

Current Date: 2016-05-06 4:51 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-04 Beam to Embed Plate Double Angle Weld_Bolt Shear Connection\B2W2.cnx\

Steel connections

Results

Connection name : DA BCF Weld support Bolt beam

Connection ID : SC-04-8

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W16x31

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	25.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	11.50	7.11	14.22	✔	p. 10-8
$L_{min} = T/2 = 14.22$[in]$/2 = \mathbf{7.11}$[in]						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 15.9$[in] $- \max(0.842$[in], 0[in]$) - \max(0.842$[in], 0[in]$) = \mathbf{14.22}$[in]						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.60	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.275$[in]$, 12$ [in]$) =$ **6.6**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Weld size	[1/16in]	4	3	4	✔	table J2.4, Sec. J2.2b

$w_{min} = w_{min} =$ **0.0156** — table J2.4

$t_p < 1/4$ [in] → 0.313[in]$<1/4$ [in] → **False**

$w_{max} = t_p - 1/16$ [in] $= 0.313$[in] $- 1/16$ [in] $=$ **0.0208** — Sec. J2.2b

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	84.86	25.00	DL	0.29	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61$[kip]$) =$ **84.86**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	25.00	DL	0.22	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(4 - 1))*0.313$[in]$*58000$[lb/in2]$*1) =$ **116.23**[kip] — Eq. J3-6

Shear yielding	[Kip]	103.50	25.00	DL	0.24	Eq. J4-3

$A_g = L_p*t_p = 11.5\text{[in]}*0.313\text{[in]} = \mathbf{3.59}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*3.59\text{[in2]}) = \mathbf{103.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 87.00 25.00 DL 0.29 Eq. J4-4

$L_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 11.5\text{[in]} - 4*0.875\text{[in]} = \mathbf{8}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8\text{[in]}*0.313\text{[in]} = \mathbf{2.5}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*2.5\text{[in2]}) = \mathbf{87}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 82.21 25.00 DL 0.30 Eq. J4-5

$dh_h = d_h + 1/16\ \text{[in]} = 1\text{[in]} + 1/16\ \text{[in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.225}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (4 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{3.2}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (4 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{2.25}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*2.25\text{[in2]} + 1*58000\text{[lb/in2]}*0.225\text{[in2]}, 0.6*36000\text{[lb/in2]}*3.2\text{[in2]} + 1*58000\text{[lb/in2]}*0.225\text{[in2]})) = \mathbf{82.21}\text{[kip]}$ Eq. J4-5

Angle (Support side)

Weld capacity [Kip] 53.28 25.00 DL 0.47 p. 10-11

$(1/\Omega)R_n = (1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*D/16\ \text{[in]}*L/(1 + 12.96*e^2/L^2)^{1/2} = 0.5*2*0.6*70000\text{[lb/in2]}*(2)^{1/2}/2*4/16\ \text{[in]}*11.5\text{[in]}/(1 + 12.96*4\text{[in]}^2/11.5\text{[in]}^2)^{1/2} = \mathbf{53.28}\text{[kip]}$ p. 10-11

Shear yielding [Kip] 103.50 25.00 DL 0.24 Eq. J4-3

$A_g = L_p*t_p = 11.5\text{[in]}*0.313\text{[in]} = \mathbf{3.59}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*3.59\text{[in2]}) = \mathbf{103.5}\text{[kip]}$ Eq. J4-3

Beam

Bolt bearing under shear load [Kip] 64.35 25.00 DL 0.39 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 3.45\text{[in]} - 0.813\text{[in]}/2) = \mathbf{3.04}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*3.04\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(4 - 1))*0.275\text{[in]}*65000\text{[lb/in2]}*1 = \mathbf{64.35}\text{[kip]}$ Eq. J3-6

Shear yielding [Kip] 87.45 25.00 DL 0.29 Eq. J4-3

$A_g = L_p*t_p = 15.9\text{[in]}*0.275\text{[in]} = \mathbf{4.37}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000\text{[lb/in2]}*4.37\text{[in2]} = \mathbf{87.45}\text{[kip]}$ Eq. J4-3

Support

Welds rupture [Kip/ft] 136.19 41.80 DL 0.31 p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000$[lb/in2]$*0.291$[in] = **11.35**[kip/in] p. 9-5

$D_{min} = P*(1 + 12.96*e^2/L^2)^{1/2}*16/(1$ [in]$)/((1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*L) = 25$[kip]$*(1 + 12.96*4$[in]$^2/11.5$[in]$^2)^{1/2}*16/(1$ [in]$)/(0.5*2*0.6*70000$[lb/in2]$*(2)^{1/2}/2*11.5$[in]$)$ = **1.88** p. 10-11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] $= 0.6*70000$[lb/in2]$*(2)^{1/2}/2*1.88/16$ [in] = **3.48**[kip/in] p. 9-5

Global critical strength ratio **0.47**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Width of the leg of the connection angle attached to the support

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{max}: Maximum weld size required

w_{min}: Minimum weld size required

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Steel connections

Results

Connection name : DA BCF Weld support Bolt beam

Connection ID : SC-04-9

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W18x35

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	35.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	11.50	8.02	16.05	✔	p. 10-8
$L_{min} = T/2 = 16.05$[in]$/2 =$ **8.02**[in]						p. 10-8
$L_{max} = d$ - max(k, d_{ct}) - max(k, d_{cb}) = 17.7[in] - max(0.827[in], 0[in]) - max(0.827[in], 0[in]) = **16.05**[in]						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in]						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.20	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.3$[in], 12 [in]$) =$ **7.2**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Weld size	[1/16in]	4	3	4	✔	table J2.4, Sec. J2.2b

$w_{min} = w_{min} =$ **0.0156** — table J2.4

t_p<1/4 [in] → 0.313[in]<1/4 [in] → **False**

$w_{max} = t_p - 1/16$ [in] $= 0.313$[in] $- 1/16$ [in] $=$ **0.0208** — Sec. J2.2b

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	84.86	35.00	DL	0.41	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61$[kip]$) =$ **84.86**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	35.00	DL	0.30	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*$
$t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in], $2.4*0.75$[in]$) + \min(1.2*2.19$[in], $2.4*$
0.75[in]$)*(4 - 1))*0.313$[in]$*58000$[lb/in2]$*1) =$ **116.23**[kip] — Eq. J3-6

Shear yielding	[Kip]	103.50	35.00	DL	0.34	Eq. J4-3

$A_g = L_p*t_p = 11.5\text{[in]}*0.313\text{[in]} = \mathbf{3.59}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*3.59\text{[in2]}) = \mathbf{103.5}\text{[kip]}$ Eq. J4-3

Shear rupture	[Kip]	87.00	35.00	DL	0.40	Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 11.5\text{[in]} - 4*0.875\text{[in]} = \mathbf{8}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8\text{[in]}*0.313\text{[in]} = \mathbf{2.5}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*2.5\text{[in2]}) = \mathbf{87}\text{[kip]}$ Eq. J4-4

Block shear	[Kip]	82.21	35.00	DL	0.43	Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 1\text{[in]} + 1/16\text{ [in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.225}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (4 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{3.2}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (4 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{2.25}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*2.25\text{[in2]} + 1*58000\text{[lb/in2]}*0.225\text{[in2]}, 0.6*36000\text{[lb/in2]}*3.2\text{[in2]} + 1*58000\text{[lb/in2]}*0.225\text{[in2]})) = \mathbf{82.21}\text{[kip]}$ Eq. J4-5

Angle (Support side)

Weld capacity	[Kip]	53.28	35.00	DL	0.66	p. 10-11

$(1/\Omega)R_n = (1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*D/16\text{ [in]}*L/(1 + 12.96*e^2/L^2)^{1/2} = 0.5*2*0.6*70000\text{[lb/in2]}*(2)^{1/2}/2*4/16\text{ [in]}*11.5\text{[in]}/(1 + 12.96*4\text{[in]}^2/11.5\text{[in]}^2)^{1/2} = \mathbf{53.28}\text{[kip]}$ p. 10-11

Shear yielding	[Kip]	103.50	35.00	DL	0.34	Eq. J4-3

$A_g = L_p*t_p = 11.5\text{[in]}*0.313\text{[in]} = \mathbf{3.59}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*3.59\text{[in2]}) = \mathbf{103.5}\text{[kip]}$ Eq. J4-3

Beam

Bolt bearing under shear load	[Kip]	70.20	35.00	DL	0.50	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 4.35\text{[in]} - 0.813\text{[in]}/2) = \mathbf{3.94}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*3.94\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(4 - 1))*0.3\text{[in]}*65000\text{[lb/in2]}*1 = \mathbf{70.2}\text{[kip]}$ Eq. J3-6

Shear yielding	[Kip]	106.20	35.00	DL	0.33	Eq. J4-3

$A_g = L_p*t_p = 17.7\text{[in]}*0.3\text{[in]} = \mathbf{5.31}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000\text{[lb/in2]}*5.31\text{[in2]} = \mathbf{106.2}\text{[kip]}$ Eq. J4-3

Support

Welds rupture	[Kip/ft]	136.19	58.53	DL	0.43	p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000$[lb/in2]$*0.291$[in] = **11.35**[kip/in] p. 9-5

$D_{min} = P*(1 + 12.96*e^2/L^2)^{1/2}*16/(1$ [in]$)/((1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*L) = 35$[kip]$*(1 + 12.96*4$[in]$^2/11.5$[in]$^2)^{1/2}*16/(1$ [in]$)/(0.5*2*0.6*70000$[lb/in2]$*(2)^{1/2}/2*11.5$[in]$)$ = **2.63** p. 10-11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] $= 0.6*70000$[lb/in2]$*(2)^{1/2}/2*2.63/16$ [in] = **4.88**[kip/in] p. 9-5

Global critical strength ratio **0.66**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Width of the leg of the connection angle attached to the support

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{max}: Maximum weld size required

w_{min}: Minimum weld size required

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Steel connections

Results

Connection name : DA BCF Weld support Bolt beam

Connection ID : SC-04-10

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W18x40

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	45.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	14.50	8.02	16.05	✔	p. 10-8
$L_{min} = T/2 = 16.05[in]/2 = \mathbf{8.02}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 17.9[in] - \max(0.927[in], 0[in]) - \max(0.927[in], 0[in]) = \mathbf{16.05}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.13	--	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0.125[in] = **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.313[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Weld size	[1/16in]	4	3	4	table J2.4, Sec. J2.2b

$w_{min} = w_{min} =$ **0.0156** — table J2.4

$t_p<1/4$ [in] → 0.313[in]<1/4 [in] → **False**

$w_{max} = t_p - 1/16$ [in] = 0.313[in] - 1/16 [in] = **0.0208** — Sec. J2.2b

Beam

Horizontal edge distance	[in]	2.25	1.00	--	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	106.08	45.00	DL	0.42	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (5*10.61$[kip]) = **106.08**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	148.85	45.00	DL	0.30	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c)$ = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.313[in]*58000[lb/in2]*1) = **148.85**[kip] — Eq. J3-6

Shear yielding	[Kip]	130.50	45.00	DL	0.34	Eq. J4-3

$A_g = L_p*t_p = 14.5\text{[in]}*0.313\text{[in]} = \mathbf{4.53}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*4.53\text{[in2]}) = \mathbf{130.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 110.11 45.00 DL 0.41 Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 14.5\text{[in]} - 5*0.875\text{[in]} = \mathbf{10.13}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 10.13\text{[in]}*0.313\text{[in]} = \mathbf{3.16}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*3.16\text{[in2]}) = \mathbf{110.11}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 102.46 45.00 DL 0.44 Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 1\text{[in]} + 1/16\text{ [in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.225}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (5 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{4.14}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (5 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{2.91}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*2.91\text{[in2]} + 1*58000\text{[lb/in2]}*0.225\text{[in2]}, 0.6*36000\text{[lb/in2]}*4.14\text{[in2]} + 1*58000\text{[lb/in2]}*0.225\text{[in2]})) = \mathbf{102.46}\text{[kip]}$ Eq. J4-5

Angle (Support side)

Weld capacity [Kip] 76.39 45.00 DL 0.59 p. 10-11

$(1/\Omega)R_n = (1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*D/16\text{ [in]}*L/(1 + 12.96*e^2/L^2)^{1/2} = 0.5*2*0.6*70000\text{[lb/in2]}*(2)^{1/2}/2*4/16\text{ [in]}*14.5\text{[in]}/(1 + 12.96*4\text{[in]}^2/14.5\text{[in]}^2)^{1/2} = \mathbf{76.39}\text{[kip]}$ p. 10-11

Shear yielding [Kip] 130.50 45.00 DL 0.34 Eq. J4-3

$A_g = L_p*t_p = 14.5\text{[in]}*0.313\text{[in]} = \mathbf{4.53}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*4.53\text{[in2]}) = \mathbf{130.5}\text{[kip]}$ Eq. J4-3

Beam

Bolt bearing under shear load [Kip] 92.14 45.00 DL 0.49 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 2.95\text{[in]} - 0.813\text{[in]}/2) = \mathbf{2.54}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*2.54\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(5 - 1))*0.315\text{[in]}*65000\text{[lb/in2]}*1 = \mathbf{92.14}\text{[kip]}$ Eq. J3-6

Shear yielding [Kip] 112.77 45.00 DL 0.40 Eq. J4-3

$A_g = L_p*t_p = 17.9\text{[in]}*0.315\text{[in]} = \mathbf{5.64}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000\text{[lb/in2]}*5.64\text{[in2]} = \mathbf{112.77}\text{[kip]}$ Eq. J4-3

Support

Welds rupture [Kip/ft] 81.43 52.49 DL 0.64 p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000$[lb/in2]$*0.174$[in] = **6.79**[kip/in] p. 9-5

$D_{min} = P*(1 + 12.96*e^2/L^2)^{1/2}*16/(1$ [in]$)/((1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*L) = 45$[kip]$*(1 + 12.96*4$[in]$^2/14.5$[in]$^2)^{1/2}*16/(1$ [in]$)/(0.5*2*0.6*70000$[lb/in2]$*(2)^{1/2}/2*14.5$[in]$)$ = **2.36** p. 10-11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] $= 0.6*70000$[lb/in2]$*(2)^{1/2}/2*2.36/16$ [in] = **4.37**[kip/in] p. 9-5

Global critical strength ratio **0.64**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Width of the leg of the connection angle attached to the support

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{max}: Maximum weld size required

w_{min}: Minimum weld size required

Current Date: 2016-05-06 4:46 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-04 Beam to Embed Plate Double Angle Weld_Bolt Shear Connection\B2W1.cnx\

Steel connections

Results

Connection name : **DA BCF Weld support Bolt beam**

Connection ID : **SC-04-11**

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W18x65

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	85.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	14.50	8.05	16.10	✔	p. 10-8
$L_{min} = T/2 = 16.1$[in]$/2 = \mathbf{8.05}$[in]						p. 10-8
$L_{max} = d$ - max(k, d_{ct}) - max(k, d_{cb}) = 18.4[in] - max(1.15[in], 0[in]) - max(1.15[in], 0[in]) = **16.1**[in]						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.13	--	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	10.80	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

$IsCorrosionConsidered \rightarrow$ **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.45$[in], 12 [in]$) =$ **10.8**[in] — Sec. J3.5

Thickness	[in]	0.50	--	0.63	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Weld size	[1/16in]	5	3	7	table J2.4, Sec. J2.2b

$w_{min} = w_{min} =$ **0.0156** — table J2.4

$t_p<1/4$ [in] $\rightarrow 0.5$[in]$<1/4$ [in] $\rightarrow$ **False**

$w_{max} = t_p - 1/16$ [in] $= 0.5$[in] $- 1/16$ [in] $=$ **0.0365** — Sec. J2.2b

Beam

Horizontal edge distance	[in]	2.25	1.00	--	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	106.08	85.00	DL	0.80	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (5*10.61$[kip]$) =$ **106.08**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	238.16	85.00	DL	0.36	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in], $2.4*0.75$[in]$) + \min(1.2*2.19$[in], $2.4*0.75$[in]$)*(5 - 1))*0.5$[in]$*58000$[lb/in2]$*1) =$ **238.16**[kip] — Eq. J3-6

Shear yielding	[Kip]	208.80	85.00	DL	0.41	Eq. J4-3

$A_g = L_p*t_p$ = 14.5[in]*0.5[in] = **7.25**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*7.25[in2]) = **208.8**[kip] Eq. J4-3

Shear rupture	[Kip]	176.18	85.00	DL	0.48	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$L_e = L - n*L_h$ = 14.5[in] - 5*0.875[in] = **10.13**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 10.13[in]*0.5[in] = **5.06**[in2] Sec. J4-2

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*5.06[in2]) = **176.18**[kip] Eq. J4-4

Block shear	[Kip]	163.94	85.00	DL	0.52	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*1.06[in])*0.5[in] = **0.359**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (5 - 1)*3[in])*0.5[in] = **6.63**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (5 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.5[in] = **4.66**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*min(0.6*58000[lb/in2]*4.66[in2] + 1*58000[lb/in2]*0.359[in2], 0.6*36000[lb/in2]*6.63[in2] + 1*58000[lb/in2]*0.359[in2])) = **163.94**[kip] Eq. J4-5

Angle (Support side)

Weld capacity	[Kip]	95.48	85.00	DL	0.89	p. 10-11

$(1/\Omega)R_n = (1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*D/16$ [in]$*L/(1 + 12.96*e^2/L^2)^{1/2}$ = 0.5*2*0.6*70000[lb/in2]*$(2)^{1/2}$/2*5/16 [in]*14.5[in]/(1 + 12.96*4[in]^2/14.5[in]^2)$^{1/2}$ = **95.48**[kip] p. 10-11

Shear yielding	[Kip]	208.80	85.00	DL	0.41	Eq. J4-3

$A_g = L_p*t_p$ = 14.5[in]*0.5[in] = **7.25**[in2] Sec. D3-1

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*7.25[in2]) = **208.8**[kip] Eq. J4-3

Beam

Bolt bearing under shear load	[Kip]	131.63	85.00	DL	0.65	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, $L_e - d_h/2$) = Max(0.0, 3.2[in] - 0.813[in]/2) = **2.79**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, $s - d_h$) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(min(1.2*2.79[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.45[in]*65000[lb/in2]*1 = **131.63**[kip] Eq. J3-6

Shear yielding	[Kip]	165.60	85.00	DL	0.51	Eq. J4-3

$A_g = L_p*t_p$ = 18.4[in]*0.45[in] = **8.28**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*8.28[in2] = **165.6**[kip] Eq. J4-3

Support

Welds rupture	[Kip/ft]	271.91	99.14	DL	0.36	p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000$[lb/in2]$*0.581$[in] = **22.66**[kip/in] p. 9-5

$D_{min} = P*(1 + 12.96*e^2/L^2)^{1/2}*16/(1$ [in]$)/((1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*L) = 85$[kip]$*(1 + 12.96*4$[in]$^2/14.5$[in]$^2)^{1/2}*16/(1$ [in]$)/(0.5*2*0.6*70000$[lb/in2]$*(2)^{1/2}/2*14.5$[in]$)$ = **4.45** p. 10-11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] $= 0.6*70000$[lb/in2]$*(2)^{1/2}/2*4.45/16$ [in] = **8.26**[kip/in] p. 9-5

Global critical strength ratio **0.89**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Width of the leg of the connection angle attached to the support

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

L_{c-end}: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{max}: Maximum weld size required

w_{min}: Minimum weld size required

Current Date: 2016-05-06 4:44 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-04 Beam to Embed Plate Double Angle Weld_Bolt Shear Connection\B2W1.cnx\

Steel connections

Results

Connection name : DA BCF Weld support Bolt beam

Connection ID : SC-04-12

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W21x44

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	45.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	14.50	9.40	18.80	✔	p. 10-8

$L_{min} = T/2 = 18.8\text{[in]}/2 = \mathbf{9.4}\text{[in]}$ p. 10-8

$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 20.7\text{[in]} - \max(0.95\text{[in]}, 0\text{[in]}) - \max(0.95\text{[in]}, 0\text{[in]}) = \mathbf{18.8}\text{[in]}$ p. 10-8

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$ Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $=$ **1.13**[in] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8$ [in] — p. 10-9

Angle (Support side)

Weld size	[1/16in]	4	3	4	✔	table J2.4, Sec. J2.2b

$w_{min} = w_{min} =$ **0.0156** — table J2.4

$t_p<1/4$ [in] $\rightarrow 0.313$[in]$<1/4$ [in] → **False**

$w_{max} = t_p - 1/16$ [in] $= 0.313$[in] $- 1/16$ [in] $=$ **0.0208** — Sec. J2.2b

Beam

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Angle (Beam side)

Bolts shear	[Kip]	106.08	45.00	DL	0.42	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (5*10.61$[kip]$) =$ **106.08**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	148.85	45.00	DL	0.30	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in], $2.4*0.75$[in]$) + \min(1.2*2.19$[in], $2.4*0.75$[in]$)*(5 - 1))*0.313$[in]$*58000$[lb/in2]$*1) =$ **148.85**[kip] — Eq. J3-6

Shear yielding	[Kip]	130.50	45.00	DL	0.34	Eq. J4-3

$A_g = L_p*t_p$ = 14.5[in]*0.313[in] = **4.53**[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g)$ = 2 * (0.667*0.60*36000[lb/in2]*4.53[in2]) = **130.5**[kip] Eq. J4-3

Shear rupture	[Kip]	110.11	45.00	DL	0.41	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$L_e = L - n*L_h$ = 14.5[in] - 5*0.875[in] = **10.13**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 10.13[in]*0.313[in] = **3.16**[in2] Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv})$ = 2 * (0.5*0.60*58000[lb/in2]*3.16[in2]) = **110.11**[kip] Eq. J4-4

Block shear	[Kip]	102.46	45.00	DL	0.44	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.225**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (5 - 1)*3[in])*0.313[in] = **4.14**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (5 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.91**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}))$ = 2 * (0.5*min(0.6*58000[lb/in2]*2.91[in2] + 1*58000[lb/in2]*0.225[in2], 0.6*36000[lb/in2]*4.14[in2] + 1*58000[lb/in2]*0.225[in2])) = **102.46**[kip] Eq. J4-5

Angle (Support side)

Weld capacity	[Kip]	76.39	45.00	DL	0.59	p. 10-11

$(1/\Omega)R_n = (1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*D/16 \text{ [in]}*L/(1 + 12.96*e^2/L^2)^{1/2}$ = 0.5*2*0.6*70000[lb/in2]*$(2)^{1/2}$/2*4/16 [in]*14.5[in]/(1 + 12.96*4[in]^2/14.5[in]^2)$^{1/2}$ = **76.39**[kip] p. 10-11

Shear yielding	[Kip]	130.50	45.00	DL	0.34	Eq. J4-3

$A_g = L_p*t_p$ = 14.5[in]*0.313[in] = **4.53**[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g)$ = 2 * (0.667*0.60*36000[lb/in2]*4.53[in2]) = **130.5**[kip] Eq. J4-3

Beam

Bolt bearing under shear load	[Kip]	102.38	45.00	DL	0.44	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 4.35[in] - 0.813[in]/2) = **3.94**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(min(1.2*3.94[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.35[in]*65000[lb/in2]*1 = **102.38**[kip] Eq. J3-6

Shear yielding	[Kip]	144.90	45.00	DL	0.31	Eq. J4-3

$A_g = L_p*t_p$ = 20.7[in]*0.35[in] = **7.25**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*7.25[in2] = **144.9**[kip] Eq. J4-3

Support

Welds rupture	[Kip/ft]	136.19	52.49	DL	0.39	p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000$[lb/in2]$*0.291$[in] = **11.35**[kip/in] p. 9-5

$D_{min} = P*(1 + 12.96*e^2/L^2)^{1/2}*16/(1$ [in]$)/((1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*L) = 45$[kip]$*(1 + 12.96*4$[in]$^2/14.5$[in]$^2)^{1/2}*16/(1$ [in]$)/(0.5*2*0.6*70000$[lb/in2]$*(2)^{1/2}/2*14.5$[in]$)$ = **2.36** p. 10-11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] $= 0.6*70000$[lb/in2]$*(2)^{1/2}/2*2.36/16$ [in] = **4.37**[kip/in] p. 9-5

Global critical strength ratio **0.59**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Width of the leg of the connection angle attached to the support

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

L_{c-end}: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{max}: Maximum weld size required

w_{min}: Minimum weld size required

Current Date: 2016-05-06 4:54 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\SC-04 Beam to Embed Plate Double Angle Weld_Bolt Shear Connection\B2W2.cnx\

Steel connections

Results

Connection name : **DA BCF Weld support Bolt beam**

Connection ID : **SC-04-13**

Family: Beam - Column flange (BCF)

Type: Angle(s)

Description: B:W24x55

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	50.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	17.50	10.79	21.58	✔	p. 10-8

$L_{min} = T/2 = 21.58[in]/2 = \mathbf{10.79}[in]$ p. 10-8

$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 23.6[in] - \max(1.01[in], 0[in]) - \max(1.01[in], 0[in]) = \mathbf{21.58}[in]$ p. 10-8

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ Tables J3.4, J3.5

Horizontal edge distance	[in]	1.25	1.13	--		Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0.125[in] = \mathbf{1.13}[in]$ — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50		Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$ — Sec. J3.3

$IsCorrosionConsidered \rightarrow \mathbf{False}$

$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.313[in], 12\ [in]) = \mathbf{7.5}[in]$ — Sec. J3.5

Thickness	[in]	0.31	--	0.63		p. 10-9

$t_{pmax} = 5/8\ [in]$ — p. 10-9

Angle (Support side)

Weld size	[1/16in]	4	3	4		table J2.4, Sec. J2.2b

$w_{min} = w_{min} = \mathbf{0.0156}$ — table J2.4

$t_p<1/4\ [in] \rightarrow 0.313[in]<1/4\ [in] \rightarrow \mathbf{False}$

$w_{max} = t_p - 1/16\ [in] = 0.313[in] - 1/16\ [in] = \mathbf{0.0208}$ — Sec. J2.2b

Beam

Horizontal edge distance	[in]	2.25	1.00	--		Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	127.30	50.00	DL	0.39	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (6*10.61[kip]) = \mathbf{127.3}[kip]$ — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	181.48	50.00	DL	0.28	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4* 0.75[in])*(6 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{181.48}[kip]$ — Eq. J3-6

Shear yielding	[Kip]	157.50	50.00	DL	0.32	Eq. J4-3

$A_g = L_p * t_p = 17.5\text{[in]}*0.313\text{[in]} = \mathbf{5.47}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*5.47\text{[in2]}) = \mathbf{157.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 133.22 50.00 DL 0.38 Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 17.5\text{[in]} - 6*0.875\text{[in]} = \mathbf{12.25}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 12.25\text{[in]}*0.313\text{[in]} = \mathbf{3.83}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*3.83\text{[in2]}) = \mathbf{133.22}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 122.71 50.00 DL 0.41 Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 1\text{[in]} + 1/16\text{ [in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.225}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (6 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{5.08}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (6 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{3.57}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*3.57\text{[in2]} + 1*58000\text{[lb/in2]}*0.225\text{[in2]}, 0.6*36000\text{[lb/in2]}*5.08\text{[in2]} + 1*58000\text{[lb/in2]}*0.225\text{[in2]})) = \mathbf{122.71}\text{[kip]}$ Eq. J4-5

Angle (Support side)

Weld capacity [Kip] 100.33 50.00 DL 0.50 p. 10-11

$(1/\Omega)R_n = (1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*D/16\text{ [in]}*L/(1 + 12.96*e^2/L^2)^{1/2} = 0.5*2*0.6*70000\text{[lb/in2]}*(2)^{1/2}/2*4/16\text{ [in]}*17.5\text{[in]}/(1 + 12.96*4\text{[in]}^2/17.5\text{[in]}^2)^{1/2} = \mathbf{100.33}\text{[kip]}$ p. 10-11

Shear yielding [Kip] 157.50 50.00 DL 0.32 Eq. J4-3

$A_g = L_p*t_p = 17.5\text{[in]}*0.313\text{[in]} = \mathbf{5.47}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*5.47\text{[in2]}) = \mathbf{157.5}\text{[kip]}$ Eq. J4-3

Beam

Bolt bearing under shear load [Kip] 138.65 50.00 DL 0.36 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 4.3\text{[in]} - 0.813\text{[in]}/2) = \mathbf{3.89}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*3.89\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(6 - 1))*0.395\text{[in]}*65000\text{[lb/in2]}*1 = \mathbf{138.65}\text{[kip]}$ Eq. J3-6

Shear yielding [Kip] 186.44 50.00 DL 0.27 Eq. J4-3

$A_g = L_p*t_p = 23.6\text{[in]}*0.395\text{[in]} = \mathbf{9.32}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000\text{[lb/in2]}*9.32\text{[in2]} = \mathbf{186.44}\text{[kip]}$ Eq. J4-3

Support

Welds rupture [Kip/ft] 136.19 44.40 DL 0.33 p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000$[lb/in2]$*0.291$[in] = **11.35**[kip/in] p. 9-5

$D_{min} = P*(1 + 12.96*e^2/L^2)^{1/2}*16/(1$ [in]$)/((1/\Omega)*2*0.6*F_{EXX}*(2)^{1/2}/2*L) = 50$[kip]$*(1 + 12.96*4$[in]$^2/17.5$[in]$^2)^{1/2}*16/(1$ [in]$)/(0.5*2*0.6*70000$[lb/in2]$*(2)^{1/2}/2*17.5$[in]$)$ = **1.99** p. 10-11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] $= 0.6*70000$[lb/in2]$*(2)^{1/2}/2*1.99/16$ [in] = **3.7**[kip/in] p. 9-5

Global critical strength ratio **0.50**

NOTATION

A_b: Nominal bolt area

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

C: Bolt group coefficient

C_2: Edge distance increment

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

e: Width of the leg of the connection angle attached to the support

F_{EXX}: Electrode classification number

F_{nv}: Nominal shear stress

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

L: Length

L: Angle length

L_{c-end}: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

e_{dmin}: Minimum edge distance

n: Bolts rows number

n_c: Number of bolt columns

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

U_{bs}: Stress index

w_{max}: Maximum weld size required

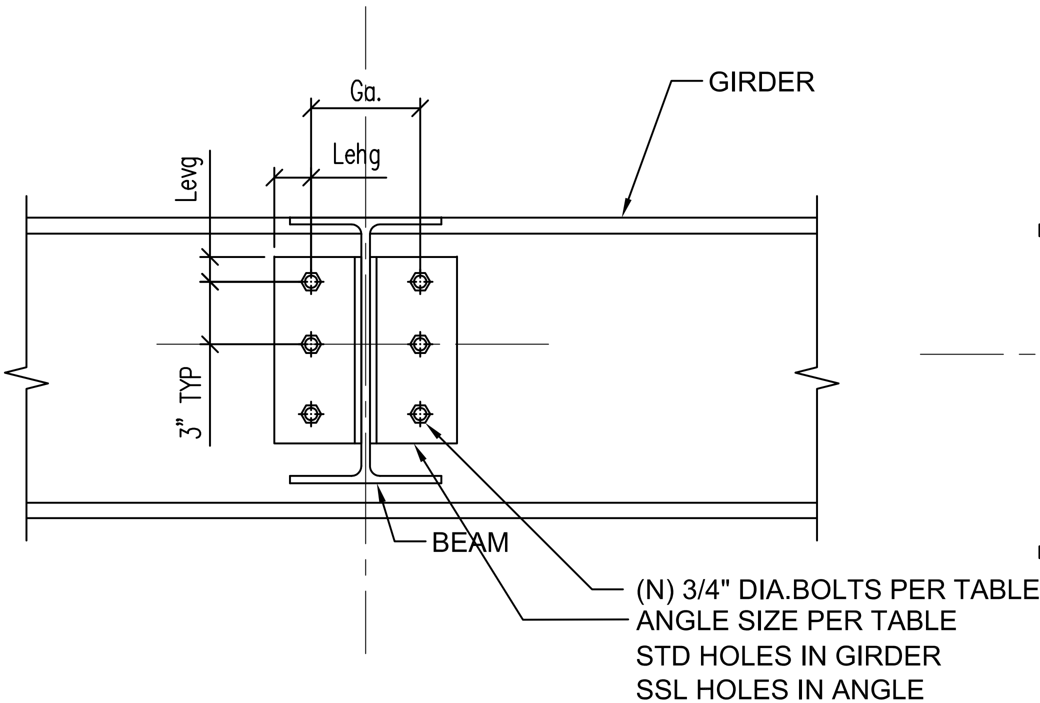
w_{min}: Minimum weld size required

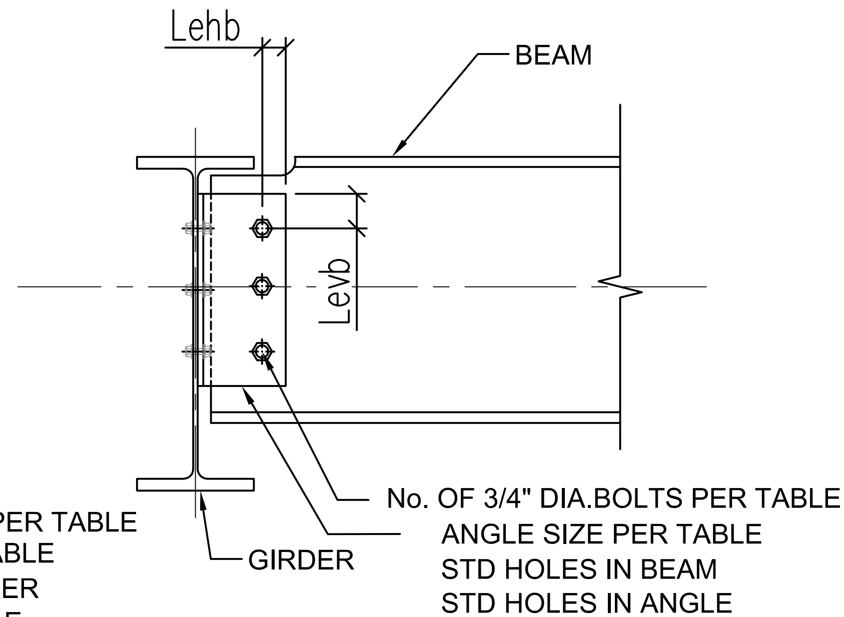
SC-06 BEAM TO GIRDER WEB DOUBLE ANGLE CONNECTION (ALL BOLTED)

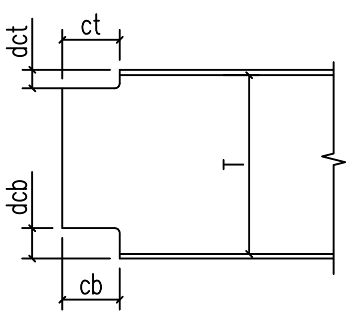
Connection ID	Beam Size	Beam Web Thickness "t_w" (inch)	Design Reaction (kip)	Double Angle Size	3/4" Dia. A325N Bolt Rows	Bolt Spacing （inch） "Spa."	Bolt Gage on Column Flange (inch) "Ga."	Beam Side Bolt Edge Distance （inch）		Girder Side Bolt Edge （inch）		Max. Cope Value (inch)				
								Vertical "L_{evb}"	Horizontal "L_{ehb}"	Vertical "L_{evg}"	Horizontal "L_{ehg}"	Cope	"d_{ct}"	"c_t"	"d_{cb}"	"c_b"
SC-06-01	W10X17	1/4	≤15	(2)L4x4x5/16	2	3	6	1.25	1.125	1.25	≥1.125	Top Cope Only	1.5	5	0	0
												Top & Bottom Cope	0.75	1.5	0.75	1.5
SC-06-02	W10X33	5/16	≤25	(2)L4x4x5/16	2	3	6	1.25	1.125	1.25	≥1.125	Top Cope Only	1.5	5	0	0
SC-06-03	W12X14	3/16	≤10	(2)L4x4x5/16	3	3	6	1.25	1.125	1.25	≥1.125	Top & Bottom Cope	1	3	1	3
SC-06-04	W12X19	1/4	≤20	(2)L4x4x5/16	3	3	6	1.25	1.125	1.25	≥1.125	Top & Bottom Cope	1.25	4	1.25	4
SC-06-05	W12X22	1/4	≤10	(2)L4x4x5/16	3	3	6	1.25	1.125	1.25	≥1.125	Top Cope Only	1	3	0	0
SC-06-06	W12X26	1/4	≤15	(2)L4x4x5/16	3	3	6	1.25	1.125	1.25	≥1.125	Top Cope Only	1.25	5	0	0
SC-06-07	W14X22	1/4	≤30	(2)L4x4x5/16	3	3	6	1.25	1.125	1.25	≥1.125	Top Cope Only	1.5	5	0	0
SC-06-08	W14X26	1/4	≤20	(2)L4x4x5/16	3	3	6	1.25	1.125	1.25	≥1.125	Top Cope Only	1.5	5	0	0
SC-06-09	W16X26	1/4	≤30	(2)L4x4x5/16	3	3	6	1.25	1.125	1.25	≥1.125	Top & Bottom Cope	1.5	5	1.5	5
SC-06-10	W16X31	1/4	≤30	(2)L4x4x5/16	3	3	6	1.25	1.125	1.25	≥1.125	Top & Bottom Cope	1.5	5	1.5	5
SC-06-11	W18X35	5/16	≤40	(2)L4x4x5/16	4	3	6	1.25	1.125	1.25	≥1.125	Top & Bottom Cope	1.5	5	3	5
SC-06-12	W18X40	5/16	≤45	(2)L4x4x5/16	4	3	6	1.25	1.125	1.25	≥1.125	Top & Bottom Cope	1.5	4	1.5	4
SC-06-13	W18X65	7/16	≤45	(2)L4x4x5/16	4	3	6.25	1.25	1.125	1.25	≥1.125	Top & Bottom Cope	1.5	4	1.5	4
SC-06-14	W21X44	3/8	≤55	(2)L4x4x5/16	5	3	6	1.25	1.125	1.25	≥1.125	Top & Bottom Cope	1.25	4	4	4
SC-06-15	W24x68	7/16	≤35	(2)L4x4x5/16	4	3	6.25	1.25	1.125	1.25	≥1.125	Top Cope Only	2.8	8	0	0
SC-06-16	W24x62	7/16	≤70	(2)L4x4x5/16	5	3	6.25	1.25	1.125	1.25	≥1.125	Top Cope Only	2.8	8	0	0

** SSL on outstanding legs against girder web. Other holes are standard.
See attached files for beam to girder erection sequence. Please distinguish the shop bolts and field bolts per erection sequence.
If the cope values required are greated than values in the table, please point out.
Stagger (P=1.5 inch) bolts when beam of gage 6.25 inch frames into girder with beam of gage=6 inch framing into from the other side. Use gage=6 inch

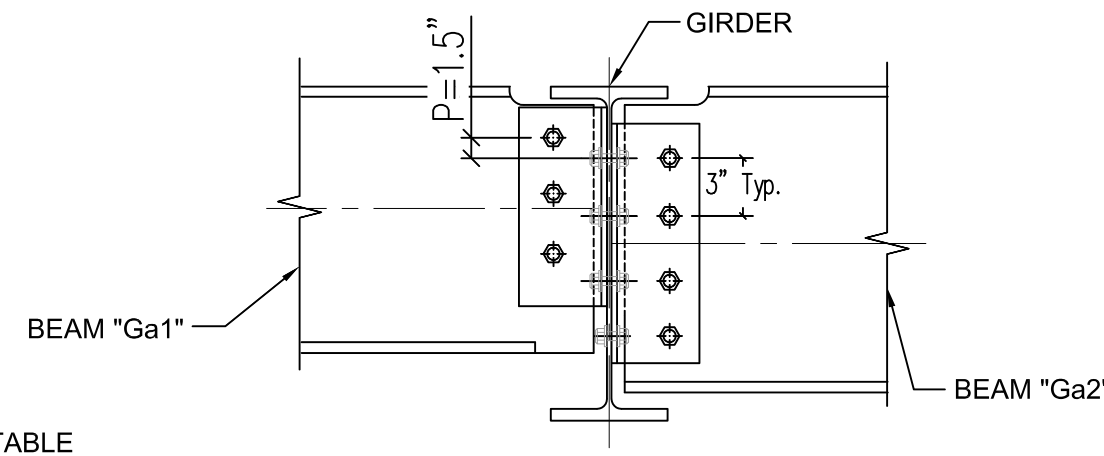
SC-06 Beam-Girder Double-Angle Connection







MAX. TOP & BOTTOM COPE VALUES PER TABLE



Stagger Bolt Pattern, P=1.5 inch, Use Gage=min(Ga1, Ga2)

Current Date: 2016-05-06 11:16 AM
Units system: English
File name:

Steel connections

Results

Connection name	:	**DA BG All bolted**
Connection ID	:	**SC-06-01**

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W10X17

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	15.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	5.50	4.42	7.97	✓	p. 10-8
$L_{min} = T/2 = 8.84[in]/2 = \mathbf{4.42}[in]$						p. 10-8
$L_{max} = d$ - max(k, d_{ct}) - max(k, d_{cb}) = 10.1[in] - max(0.63[in], 1.5[in]) - max(0.63[in], 0[in]) = **7.97**[in]						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✓	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✓	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0.125[in] = \mathbf{1.13}[in]$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.76	✓	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.24[in], 12\ [in]) = \mathbf{5.76}[in]$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✓	p. 10-9
$t_{pmax} = 5/8\ [in]$						p. 10-9
Angle (Support side)						
Vertical edge distance	[in]	1.25	1.00	--	✓	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✓	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0.125[in] = \mathbf{1.13}[in]$						Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Beam

Top cope length	[in]	5.00	--	20.20	✔	

$c_{max} = 2*d = 2*10.1$[in] $=$ **20.2**[in]

Bottom cope length	[in]	0.00	--	20.20	✔	

$c_{max} = 2*d = 2*10.1$[in] $=$ **20.2**[in]

Top cope depth	[in]	1.50	--	2.30	✔	

$d_{ctmax} = \min(d/2, d_{top} - w) = \min(10.1$[in]$/2, 2.3$[in] $- 0$[in]$) =$ **2.3**[in]

Bottom cope depth	[in]	0.00	--	2.30	✔	

$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(10.1$[in]$/2, 10.1$[in] $- 5.5$[in] $- 2.3$[in] $- 0$[in]$) =$ **2.3**[in]

Vertical edge distance	[in]	2.05	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.38	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Angle (Beam side)

Bolts shear	[Kip]	42.43	15.00	DL	0.35	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (2*10.61$[kip]$) =$ **42.43**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	50.98	15.00	DL	0.29	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in], $2.4*0.75$[in]$) + \min(1.2*2.19$[in], $2.4*0.75$[in]$)*(2 - 1))*0.313$[in]$*58000$[lb/in2]$*1) =$ **50.98**[kip] — Eq. J3-6

Shear yielding	[Kip]	49.50	15.00	DL	0.30	Eq. J4-3

$A_g = L_p*t_p = 5.5$[in]$*0.313$[in] $=$ **1.72**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*1.72$[in2]$) =$ **49.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	40.78	15.00	DL	0.37	Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h = 5.5$[in] $- 2*0.875$[in] $=$ **3.75**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 3.75$[in]$*0.313$[in] $=$ **1.17**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*1.17$[in2]$) =$ **40.78**[kip] — Eq. J4-4

Block shear	[Kip]	39.45	15.00	DL	0.38	Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 1$[in] $+ 1/16$ [in] $=$ **1.06**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13$[in] $+ (1 - 1)*3$[in] $- (1 - 0.5)* 1.06$[in]$)*0.313$[in] $=$ **0.186**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] $+ (2 - 1)*3$[in]$)*0.313$[in] $=$ **1.33**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25$[in] $+ (2 - 1)*(3$[in] $- 0.875$[in]$) -$

0.875[in]$/2)*0.313$[in] $=$ **0.918**[in2] — Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000$[lb/in2]$*0.918$[in2] $+ 1*58000$[lb/in2]$*0.186$[in2]$, 0.6*36000$[lb/in2]$*1.33$[in2] $+ 1*58000$[lb/in2]$*0.186$[in2]$))$ $=$ **39.45**[kip] — Eq. J4-5

Angle (Support side)

Bolts shear	[Kip]	42.43	15.00	DL	0.35	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (2*10.61$[kip]$)$ $=$ **42.43**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	50.98	15.00	DL	0.29	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2)$ $=$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$)$ $=$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(2/(1*2))*(\min(1.2*0.844$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4*0.75$[in]$)*(2 - 1))*0.313$[in]$*58000$[lb/in2]$*1)$ $=$ **50.98**[kip] — p. 7-18, Sec. J3.10

Shear yielding	[Kip]	49.50	15.00	DL	0.30	Eq. J4-3

$A_g = L_p*t_p = 5.5$[in]$*0.313$[in] $=$ **1.72**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*1.72$[in2]$)$ $=$ **49.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	40.78	15.00	DL	0.37	Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h = 5.5$[in] $- 2*0.875$[in] $=$ **3.75**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 3.75$[in]$*0.313$[in] $=$ **1.17**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*1.17$[in2]$)$ $=$ **40.78**[kip] — Eq. J4-4

Block shear	[Kip]	39.45	15.00	DL	0.38	Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 1$[in] $+ 1/16$ [in] $=$ **1.06**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13$[in] $+ (1 - 1)*5.5$[in] $- (1 - 0.5)*1.06$[in]$)*0.313$[in] $=$ **0.186**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] $+ (2 - 1)*3$[in]$)*0.313$[in] $=$ **1.33**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25$[in] $+ (2 - 1)*(3$[in] $- 0.875$[in]$) - 0.875$[in]$/2)*0.313$[in] $=$ **0.918**[in2] — Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ — Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000$[lb/in2]$*0.918$[in2] $+ 1*58000$[lb/in2]$*0.186$[in2]$, 0.6*36000$[lb/in2]$*1.33$[in2] $+ 1*58000$[lb/in2]$*0.186$[in2]$))$ $=$ **39.45**[kip] — Eq. J4-5

Resulting tension capacity due prying action	[Kip]	6.80	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 15$[kip]$/(0.442$[in2]$*4)$ $=$ **8484.16**[lb/in2] — Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000$[lb/in2] $- 90000$[lb/in2]$*8484.16$[lb/in2]$/(0.5*48000$[lb/in2]$), 0.0), 90000$[lb/in2]$)$ $=$ **85184.39**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*85184.39$[lb/in2]$*0.442$[in2] $=$ **18.83**[kip] — Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 15$[kip]$/(0.442$[in2]$*4)$ $=$ **8484.16**[lb/in2] — Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000$[lb/in2] $- 90000$[lb/in2]$*8484.16$[lb/in2]$/(0.5*48000$[lb/in2]$), 0.0), 90000$[lb/in2]$)$ $=$ **85184.39**[lb/in2] — Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*85184.39$[lb/in2]$*0.442$[in2] $=$ **18.83**[kip] — Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13$[in] $+ 0.75$[in]$/2, 1.25*2.72$[in] $+ 0.75$[in]$/2)$ $=$ **1.5**[in] — p. 9-12

$b' = b - d/2 = 2.72$[in] $- 0.75$[in]$/2$ $=$ **2.34**[in] — p. 9-12

$\rho = b'/a' = 2.34$[in]$/1.5$[in] $=$ **1.56** — p. 9-12

$\delta = 1 - d'/p = 1 - 0.813$[in]$/3$[in] $=$ **0.729** — p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*18.83$[kip]$*2.34$[in]$)/(0.5*3$[in]$*58000$[lb/in2]$))^{0.5}$ $=$ **1.3**[in] — p. 9-12

$\alpha' = (1/(\delta*(1+\rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1+1.56)))*((1.3\text{[in]}/0.313\text{[in]})^2 - 1) =$ **8.72** p. 9-13

$Q = (t_p/t_c)^2*(1+\delta) = (0.313\text{[in]}/1.3\text{[in]})^2*(1+0.729) =$ **0.1** p. 9-13

$a' = \text{Min}(a + d/2, 1.25*b + d/2) = \text{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) =$ **1.5**[in] p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 =$ **2.34**[in] p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} =$ **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/2.75\text{[in]} =$ **0.705** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*18.83\text{[kip]}*2.34\text{[in]})/(0.5*2.75\text{[in]}*58000\text{[lb/in2]}))^{0.5} =$ **1.36**[in] p. 9-12

$\alpha' = (1/(\delta*(1+\rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1+1.56)))*((1.36\text{[in]}/0.313\text{[in]})^2 - 1) =$ **9.9** p. 9-13

$Q = (t_p/t_c)^2*(1+\delta) = (0.313\text{[in]}/1.36\text{[in]})^2*(1+0.705) =$ **0.0904** p. 9-13

$HasEqualLengths \rightarrow$ **False**

$Q = (2*Q_{ext} + (n-2)*Q_{int})/n = (2*0.0904 + (2-2)*0.1)/2 =$ **0.0904** p. 9-13

$T_{avail} = 4*(B*Q) = 4*(18.83\text{[kip]}*0.0904) =$ **6.8**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	28.08	15.00	DL	0.53	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 2.05\text{[in]} - 0.813\text{[in]}/2) =$ **1.64**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n-1))*t_p*F_u*n_c = 0.5*(\min(1.2*1.64\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(2-1))*0.24\text{[in]}*65000\text{[lb/in2]}*1 =$ **28.08**[kip] Eq. J3-6

Shear yielding	[Kip]	41.28	15.00	DL	0.36	Eq. J4-3

$A_g = L_p*t_p = 8.6\text{[in]}*0.24\text{[in]} =$ **2.06**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000\text{[lb/in2]}*2.06\text{[in2]} =$ **41.28**[kip] Eq. J4-3

Shear rupture	[Kip]	32.06	15.00	DL	0.47	Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} =$ **0.875**[in] Sec. D3-2

$L_e = L - n*L_h = 8.6\text{[in]} - 2*0.875\text{[in]} =$ **6.85**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 6.85\text{[in]}*0.24\text{[in]} =$ **1.64**[in2] Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000\text{[lb/in2]}*1.64\text{[in2]} =$ **32.06**[kip] Eq. J4-4

Block shear	[Kip]	32.60	15.00	DL	0.46	Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} =$ **0.875**[in] Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} =$ **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.38\text{[in]} + (1-1)*3\text{[in]} - (1-0.5)*0.875\text{[in]})*0.24\text{[in]} =$ **0.465**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n-1)*s)*t_p = (2.05\text{[in]} + (2-1)*3\text{[in]})*0.24\text{[in]} =$ **1.21**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n-1)*(s - dh_v) - dh_v/2)*t_p = (2.05\text{[in]} + (2-1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.24\text{[in]} =$ **0.897**[in2] Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*65000\text{[lb/in2]}*0.897\text{[in2]} + 1*65000\text{[lb/in2]}*0.465\text{[in2]}, 0.6*50000\text{[lb/in2]}*1.21\text{[in2]} + 1*65000\text{[lb/in2]}*0.465\text{[in2]}) =$ **32.6**[kip] Eq. J4-5

Flexural yielding	[Kip]	24.28	15.00	DL	0.62	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000\text{[lb/in2]}*4.46\text{[in3]}/5.5\text{[in]} =$ **24.28**[kip] p. 9-6

Flexural rupture	[Kip]	26.36	15.00	DL	0.57	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000\text{[lb/in2]}*4.46\text{[in3]}/5.5\text{[in]} =$ **26.36**[kip] p. 9-6

Local web buckling	[Kip]	24.28	15.00	DL	0.62	p. 9-7

$h_o = d - d_c = 10.1\text{[in]} - 1.5\text{[in]} =$ **8.6**[in] p. 9-7

$IsTopFlangeBeamCoped = (c<=2*d) \text{ and } (d_c<=d/2) = (5\text{[in]}<=2*10.1\text{[in]}) \text{ and } (1.5\text{[in]}<=10.1\text{[in]}/2) =$ **True** p. 9-7

$c/d<=1 \rightarrow 5\text{[in]}/10.1\text{[in]}<=1 \rightarrow$ **True**

$f = 2*c/d = 2*5\text{[in]}/10.1\text{[in]} =$ **0.99** p. 9-7

$c/h_o<=1 \rightarrow 5\text{[in]}/8.6\text{[in]}<=1 \rightarrow$ **True**

$k = 2.2*(h_o/c)^{1.65} = 2.2*(8.6[in]/5[in])^{1.65} = \mathbf{5.38}$ p. 9-7

$F_{cr} = \pi^2*E/(12*(1 - \nu^2))*(t_w/h_o)^2*f*k = \pi^2*2.90E+07[lb/in2]/(12*(1 - 0.3^2))*$
$(0.24[in]/8.6[in])^2*0.99*5.38 = \mathbf{1.09E+05}[lb/in2]$ p. 9-7

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e = 0.599*\min(50000[lb/in2], 1.09E+05[lb/in2])*4.46[in3]/$
$5.5[in] = \mathbf{24.28}[kip]$ p. 9-7

Support

Bolt bearing under shear load	[Kip]	109.98	15.00	DL	0.14	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.20E+31[in] - 0.813[in]/2) = \mathbf{1.20E+31}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*$
$t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*$
$0.75[in])*(2 - 1))*0.47[in]*65000[lb/in2]*1) = \mathbf{109.98}[kip]$ Eq. J3-6

Global critical strength ratio **0.62**

NOTATION

a: Plate depth
A_b: Nominal bolt area
A_g: Gross area
A_{gv}: Gross area subject to shear
A_{nt}: Net area subject to tension
A_{nv}: Net area subjected to shear
a': Distance for prying action
α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
B: Available tensile strength per bolt
B: Available strength of all bolts
b': Distance for prying action
b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
C: Bolt group coefficient
c: Coped length
C_2: Edge distance increment
c_{max}: Maximum coped length
d: Nominal bolt diameter
d_c: Coped depth
d_{cb}: Bottom cope depth
d_{cbmax}: Maximum bottom coped depth
d_{ct}: Top cope depth
d_{ctmax}: Maximum top coped depth
d_h: Nominal hole dimension
d_{top}: Beam top edge distance
d': Width of the hole along the length of the fitting
δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
d: Beam depth
dh_h: Horizontal hole dimension
dh_v: Vertical hole dimension
e: Load eccentricity
E: Elastic modulus
f: Plate buckling model adjustment factor
F: Required shear force for combined tension and shear
F_{cr}: Critical stress, flexural stress buckling
F_{nt}: Nominal tensile stress
F_{nv}: Nominal shear stress
F_u: Specified minimum tensile strength
f_v: Required shear stress
F_y: Specified minimum yield stress
F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
h_o: Reduced beam depth
HasEqualLengths: Has equal tributary length for interior and exterior bolts
IsCorrosionConsidered: Is corrosion considered
IsStressUniform: Is the stress uniform
IsTopFlangeBeamCoped: Is the top beam flange coped
k: Plate buckling coefficient
k_1: Bearing factor
k_2: Bearing factor
k: Outside corner radius
L: Length
L: Angle length
$L_{c\text{-}end}$: Clear distance
L_e: Effective length
L_e: Edge distance

L_{eh}: Horizontal edge distance
L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
ν: Poisson's ratio
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
L_{c-spa}: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

Current Date: 2016-05-06 11:57 AM
Units system: English
File name:

Steel connections

Results

Connection name	**: DA BG All bolted**
Connection ID	**: SC-06-02**

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W10X33

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	25.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	5.50	3.93	7.30	✔	p. 10-8
$L_{min} = T/2 = 7.86[in]/2 = \mathbf{3.93}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 9.73[in] - \max(0.935[in], 1.5[in]) - \max(0.935[in], 0[in]) = \mathbf{7.3}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.96	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.29[in], 12\ [in]) = \mathbf{6.96}[in]$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8\ [in]$						p. 10-9
Angle (Support side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0.125[in] = \mathbf{1.13}[in]$						Tables J3.4,

					J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$					Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**					
$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.313[in], 12\ [in]) = \mathbf{7.5}[in]$					Sec. J3.5
<u>Beam</u>					
Top cope length	[in]	5.00	--	19.46	
$c_{max} = 2*d = 2*9.73[in] = \mathbf{19.46}[in]$					
Bottom cope length	[in]	0.00	--	19.46	
$c_{max} = 2*d = 2*9.73[in] = \mathbf{19.46}[in]$					
Top cope depth	[in]	1.50	--	2.11	
$d_{ctmax} = \min(d/2, d_{top} - w) = \min(9.73[in]/2, 2.12[in] - 0[in]) = \mathbf{2.12}[in]$					
Bottom cope depth	[in]	0.00	--	2.11	
$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(9.73[in]/2, 9.73[in] - 5.5[in] - 2.12[in] - 0[in]) = \mathbf{2.12}[in]$					
Vertical edge distance	[in]	1.86	1.00	--	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$					Tables J3.4, J3.5
Horizontal edge distance	[in]	2.38	1.00	--	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$					Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Angle (Beam side)</u>						
Bolts shear	[Kip]	42.43	25.00	DL	0.59	Tables (7-1..14)
$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$						Eq. J3-1
$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (2*10.61[kip]) = \mathbf{42.43}[kip]$						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	50.98	25.00	DL	0.49	Eq. J3-6
$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$						Sec. J4.10
$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$						Sec. J4.10
$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(2 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{50.98}[kip]$						Eq. J3-6
Shear yielding	[Kip]	49.50	25.00	DL	0.51	Eq. J4-3
$A_g = L_p*t_p = 5.5[in]*0.313[in] = \mathbf{1.72}[in2]$						Sec. D3-1
$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*1.72[in2]) = \mathbf{49.5}[kip]$						Eq. J4-3
Shear rupture	[Kip]	40.78	25.00	DL	0.61	Eq. J4-4
$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$						Sec. D3-2
$L_e = L - n*L_h = 5.5[in] - 2*0.875[in] = \mathbf{3.75}[in]$						DG4 Eq. 3-13
$A_{nv} = L_e*t_p = 3.75[in]*0.313[in] = \mathbf{1.17}[in2]$						Sec. J4-2
$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.17[in2]) = \mathbf{40.78}[kip]$						Eq. J4-4
Block shear	[Kip]	41.15	25.00	DL	0.61	Eq. J4-5
$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$						Sec. D3-2
$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$						Sec. D3-2
$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*3[in] - (1 - 0.5)*$						

$0.875[in])*0.313[in] = \mathbf{0.215}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (2 - 1)*3[in])*0.313[in] = \mathbf{1.33}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (2 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{0.918}[in2]$ Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*0.918[in2] + 1*58000[lb/in2]*0.215[in2], 0.6*36000[lb/in2]*1.33[in2] + 1*58000[lb/in2]*0.215[in2])) = \mathbf{41.15}[kip]$ Eq. J4-5

Angle (Support side)

Bolts shear [Kip] 42.43 25.00 DL 0.59 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (2*10.61[kip]) = \mathbf{42.43}[kip]$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 50.98 25.00 DL 0.49 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(2/(1*2))*(\min(1.2*0.844[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(2 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{50.98}[kip]$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 49.50 25.00 DL 0.51 Eq. J4-3

$A_g = L_p*t_p = 5.5[in]*0.313[in] = \mathbf{1.72}[in2]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*1.72[in2]) = \mathbf{49.5}[kip]$ Eq. J4-3

Shear rupture [Kip] 40.78 25.00 DL 0.61 Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 5.5[in] - 2*0.875[in] = \mathbf{3.75}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 3.75[in]*0.313[in] = \mathbf{1.17}[in2]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.17[in2]) = \mathbf{40.78}[kip]$ Eq. J4-4

Block shear [Kip] 39.45 25.00 DL 0.63 Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 1[in] + 1/16\ [in] = \mathbf{1.06}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = \mathbf{0.186}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (2 - 1)*3[in])*0.313[in] = \mathbf{1.33}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (2 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{0.918}[in2]$ Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*0.918[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*1.33[in2] + 1*58000[lb/in2]*0.186[in2])) = \mathbf{39.45}[kip]$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 6.80 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 25[kip]/(0.442[in2]*4) = \mathbf{14140.27}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*14140.27[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{63973.98}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*63973.98[lb/in2]*0.442[in2] = \mathbf{14.14}[kip]$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 25[kip]/(0.442[in2]*4) = \mathbf{14140.27}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*14140.27[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{63973.98}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*63973.98[lb/in2]*0.442[in2] = \mathbf{14.14}[kip]$ Eq. J3-2

$a' = \text{Min}(a + d/2, 1.25*b + d/2) = \text{Min}(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/3[in] = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*14.14[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))^{0.5} = \mathbf{1.13}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.13[in]/0.313[in])^2 - 1) = \mathbf{6.42}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.13[in])^2*(1 + 0.729) = \mathbf{0.133}$ p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*14.14[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} = \mathbf{1.18}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.18[in]/0.313[in])^2 - 1) = \mathbf{7.29}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.18[in])^2*(1 + 0.705) = \mathbf{0.12}$ p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.12 + (2 - 2)*0.133)/2 = \mathbf{0.12}$ p. 9-13

$T_{avail} = 4 * (B*Q) = 4 * (14.14[kip]*0.12) = \mathbf{6.8}[kip]$ p. 9-10

Beam

Bolt bearing under shear load	[Kip]	33.46	25.00	DL	0.75	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.87[in] - 0.813[in]/2) = \mathbf{1.46}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*1.46[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(2 - 1))*0.29[in]*65000[lb/in2]*1 = \mathbf{33.46}[kip]$ Eq. J3-6

Shear yielding	[Kip]	47.73	25.00	DL	0.52	Eq. J4-3

$A_g = L_p*t_p = 8.23[in]*0.29[in] = \mathbf{2.39}[in2]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*2.39[in2] = \mathbf{47.73}[kip]$ Eq. J4-3

Shear rupture	[Kip]	36.64	25.00	DL	0.68	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 8.23[in] - 2*0.875[in] = \mathbf{6.48}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 6.48[in]*0.29[in] = \mathbf{1.88}[in2]$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000[lb/in2]*1.88[in2] = \mathbf{36.64}[kip]$ Eq. J4-4

Block shear	[Kip]	38.35	25.00	DL	0.65	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.38[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.29[in] = \mathbf{0.562}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.87[in] + (2 - 1)*3[in])*0.29[in] = \mathbf{1.41}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.87[in] + (2 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.29[in] = \mathbf{1.03}[in2]$ Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*65000[lb/in2]*1.03[in2] + 1*65000[lb/in2]*0.562[in2], 0.6*50000[lb/in2]*1.41[in2] + 1*65000[lb/in2]*0.562[in2]) = \mathbf{38.35}[kip]$ Eq. J4-5

Flexural yielding	[Kip]	29.59	25.00	DL	0.84	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000[lb/in2]*5.43[in3]/5.5[in] = \mathbf{29.59}[kip]$ p. 9-6

Flexural rupture	[Kip]	32.12	25.00	DL	0.78	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000[lb/in2]*5.43[in3]/5.5[in] = \mathbf{32.12}[kip]$ p. 9-6

Local web buckling	[Kip]	29.59	25.00	DL	0.84	p. 9-7

$h_o = d - d_c = 9.73[in] - 1.5[in] = \mathbf{8.23}[in]$ p. 9-7

$IsTopFlangeBeamCoped = (c<=2*d)\ \text{and}\ (d_c<=d/2) = (5[in]<=2*9.73[in])\ \text{and}\ (1.5[in]<=9.73[in]/2) = \mathbf{True}$ p. 9-7

c/d<=1 → 5[in]/9.73[in]<=1 → **True**

$f = 2*c/d = 2*5$[in]$/9.73$[in] = **1.03** p. 9-7

c/h_o<=1 → 5[in]/8.23[in]<=1 → **True**

$k = 2.2*(h_o/c)^{1.65} = 2.2*(8.23$[in]$/5$[in]$)^{1.65}$ = **5.01** p. 9-7

$F_{cr} = \pi^2*E/(12*(1 - \nu^2))*(t_w/h_o)^2*f*k = \pi^2*2.90E+07$[lb/in2]$/(12*(1 - 0.3^2))*$
$(0.29$[in]$/8.23$[in]$)^2*1.03*5.01$ = **1.67E+05**[lb/in2] p. 9-7

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e$ = 0.599*min(50000[lb/in2], 1.67E+05[lb/in2])*5.43[in3]/
5.5[in] = **29.59**[kip] p. 9-7

Support

Bolt bearing under shear load	[Kip]	107.64	25.00	DL	0.23	Eq. J3-6

$L_{c-end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c-spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*(n - 1))*$
$t_p*F_u*n_c)$ = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*
0.75[in])*(2 - 1))*0.46[in]*65000[lb/in2]*1) = **107.64**[kip] Eq. J3-6

Global critical strength ratio **0.84**

NOTATION

a: Plate depth
A_b: Nominal bolt area
A_g: Gross area
A_{gv}: Gross area subject to shear
A_{nt}: Net area subject to tension
A_{nv}: Net area subjected to shear
a': Distance for prying action
α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
B: Available tensile strength per bolt
B: Available strength of all bolts
b': Distance for prying action
b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
C: Bolt group coefficient
c: Coped length
C_2: Edge distance increment
c_{max}: Maximum coped length
d: Nominal bolt diameter
d_c: Coped depth
d_{cb}: Bottom cope depth
d_{cbmax}: Maximum bottom coped depth
d_{ct}: Top cope depth
d_{ctmax}: Maximum top coped depth
d_h: Nominal hole dimension
d_{top}: Beam top edge distance
d': Width of the hole along the length of the fitting
δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
d: Beam depth
dh_h: Horizontal hole dimension
dh_v: Vertical hole dimension
e: Load eccentricity
E: Elastic modulus
f: Plate buckling model adjustment factor
F: Required shear force for combined tension and shear
F_{cr}: Critical stress, flexural stress buckling
F_{nt}: Nominal tensile stress
F_{nv}: Nominal shear stress
F_u: Specified minimum tensile strength
f_v: Required shear stress
F_y: Specified minimum yield stress
F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
h_o: Reduced beam depth
HasEqualLengths: Has equal tributary length for interior and exterior bolts
IsCorrosionConsidered: Is corrosion considered
IsStressUniform: Is the stress uniform
IsTopFlangeBeamCoped: Is the top beam flange coped
k: Plate buckling coefficient
k_1: Bearing factor
k_2: Bearing factor
k: Outside corner radius
L: Length

L: Angle length
$L_{c\text{-}end}$: Clear distance
L_e: Effective length
L_e: Edge distance
L_{eh}: Horizontal edge distance
L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
ν: Poisson's ratio
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
$L_{c\text{-}spa}$: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

Current Date: 2016-05-06 1:40 PM
Units system: English
File name:

Steel connections

Results

Connection name	:	**DA BG All bolted**
Connection ID	:	**SC-06-03**

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W12X14

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	10.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	8.50	5.43	9.90	✔	p. 10-8
$L_{min} = T/2 = 10.85[in]/2 = \mathbf{5.43}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 11.9[in] - \max(0.525[in], 1[in]) - \max(0.525[in], 1[in]) = \mathbf{9.9}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	4.80	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$						Sec. J3.3
$IsCorrosionConsidered \rightarrow \mathbf{False}$						
$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.2[in], 12\ [in]) = \mathbf{4.8}[in]$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8\ [in]$						p. 10-9
Angle (Support side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0.125[in] = \mathbf{1.13}[in]$						Tables J3.4,

J3.5

Verification	Unit	Value	Min	Max		References
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.00	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.25$[in], 12 [in]$) =$ **6**[in] — Sec. J3.5

Beam

Verification	Unit	Value	Min	Max		References
Top cope length	[in]	3.00	--	23.80	✔	

$c_{max} = 2*d = 2*11.9$[in] $=$ **23.8**[in]

Verification	Unit	Value	Min	Max		References
Bottom cope length	[in]	3.00	--	23.80	✔	

$c_{max} = 2*d = 2*11.9$[in] $=$ **23.8**[in]

Verification	Unit	Value	Min	Max		References
Top cope depth	[in]	1.00	--	1.70	✔	

$d_{ctmax} = \min(d/2, d_{top} - w) = \min(11.9$[in]$/2, 1.7$[in] $- 0$[in]$) =$ **1.7**[in]

Verification	Unit	Value	Min	Max		References
Bottom cope depth	[in]	1.00	--	1.70	✔	

$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(11.9$[in]$/2, 11.9$[in] $- 8.5$[in] $- 1.7$[in] $- 0$[in]$) =$ **1.7**[in]

Verification	Unit	Value	Min	Max		References
Vertical edge distance	[in]	1.95	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Verification	Unit	Value	Min	Max		References
Horizontal edge distance	[in]	2.38	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	63.65	10.00	DL	0.16	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61$[kip]$) =$ **63.65**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	83.60	10.00	DL	0.12	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in], $2.4*0.75$[in]$) + \min(1.2*2.19$[in], $2.4*0.75$[in]$)*(3 - 1))*0.313$[in]$*58000$[lb/in2]$*1) =$ **83.6**[kip] — Eq. J3-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Kip]	76.50	10.00	DL	0.13	Eq. J4-3

$A_g = L_p*t_p = 8.5$[in]$*0.313$[in] $=$ **2.66**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*2.66$[in2]$) =$ **76.5**[kip] — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear rupture	[Kip]	63.89	10.00	DL	0.16	Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h = 8.5$[in] $- 3*0.875$[in] $=$ **5.88**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88$[in]$*0.313$[in] $=$ **1.84**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*1.84$[in2]$) =$ **63.89**[kip] — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear	[Kip]	61.40	10.00	DL	0.16	Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13$[in] $+ (1 - 1)*3$[in] $- (1 - 0.5)*$

$0.875\text{[in]})*0.313\text{[in]} = \mathbf{0.215}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (3 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{2.27}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (3 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{1.58}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*1.58\text{[in2]} + 1*58000\text{[lb/in2]}*0.215\text{[in2]}, 0.6*36000\text{[lb/in2]}*2.27\text{[in2]} + 1*58000\text{[lb/in2]}*0.215\text{[in2]})) = \mathbf{61.4}\text{[kip]}$ Eq. J4-5

Angle (Support side)

Bolts shear [Kip] 63.65 10.00 DL 0.16 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61\text{[kip]}) = \mathbf{63.65}\text{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 83.60 10.00 DL 0.12 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(3 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{83.6}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 76.50 10.00 DL 0.13 Eq. J4-3

$A_g = L_p*t_p = 8.5\text{[in]}*0.313\text{[in]} = \mathbf{2.66}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*2.66\text{[in2]}) = \mathbf{76.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 63.89 10.00 DL 0.16 Eq. J4-4

$L_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 8.5\text{[in]} - 3*0.875\text{[in]} = \mathbf{5.88}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88\text{[in]}*0.313\text{[in]} = \mathbf{1.84}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*1.84\text{[in2]}) = \mathbf{63.89}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 59.70 10.00 DL 0.17 Eq. J4-5

$dh_h = d_h + 1/16\ \text{[in]} = 1\text{[in]} + 1/16\ \text{[in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13\text{[in]} + (1 - 1)*5.5\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.186}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (3 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{2.27}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (3 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{1.58}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*1.58\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]}, 0.6*36000\text{[lb/in2]}*2.27\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]})) = \mathbf{59.7}\text{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 10.57 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 10\text{[kip]}/(0.442\text{[in2]}*6) = \mathbf{3770.74}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*3770.74\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{90000}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*90000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{19.89}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 10\text{[kip]}/(0.442\text{[in2]}*6) = \mathbf{3770.74}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*3770.74\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{90000}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*90000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{19.89}\text{[kip]}$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\,[\mathrm{in}]/3\,[\mathrm{in}] = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*19.89\,[\mathrm{kip}]*2.34\,[\mathrm{in}])/(0.5*3\,[\mathrm{in}]*58000\,[\mathrm{lb/in2}]))^{0.5} = \mathbf{1.34}\,[\mathrm{in}]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.34\,[\mathrm{in}]/0.313\,[\mathrm{in}])^2 - 1) = \mathbf{9.24}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313\,[\mathrm{in}]/1.34\,[\mathrm{in}])^2*(1 + 0.729) = \mathbf{0.0946}$ p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13\,[\mathrm{in}] + 0.75\,[\mathrm{in}]/2, 1.25*2.72\,[\mathrm{in}] + 0.75\,[\mathrm{in}]/2) = \mathbf{1.5}\,[\mathrm{in}]$ p. 9-12

$b' = b - d/2 = 2.72\,[\mathrm{in}] - 0.75\,[\mathrm{in}]/2 = \mathbf{2.34}\,[\mathrm{in}]$ p. 9-12

$\rho = b'/a' = 2.34\,[\mathrm{in}]/1.5\,[\mathrm{in}] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\,[\mathrm{in}]/2.75\,[\mathrm{in}] = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*19.89\,[\mathrm{kip}]*2.34\,[\mathrm{in}])/(0.5*2.75\,[\mathrm{in}]*58000\,[\mathrm{lb/in2}]))^{0.5} = \mathbf{1.4}\,[\mathrm{in}]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.4\,[\mathrm{in}]/0.313\,[\mathrm{in}])^2 - 1) = \mathbf{10.49}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313\,[\mathrm{in}]/1.4\,[\mathrm{in}])^2*(1 + 0.705) = \mathbf{0.0855}$ p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.0855 + (3 - 2)*0.0946)/3 = \mathbf{0.0886}$ p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (19.89\,[\mathrm{kip}]*0.0886) = \mathbf{10.57}\,[\mathrm{kip}]$ p. 9-10

<u>Beam</u>

Bolt bearing under shear load [Kip] 35.10 10.00 DL 0.28 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.95\,[\mathrm{in}] - 0.813\,[\mathrm{in}]/2) = \mathbf{1.54}\,[\mathrm{in}]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\,[\mathrm{in}] - 0.813\,[\mathrm{in}]) = \mathbf{2.19}\,[\mathrm{in}]$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*1.54\,[\mathrm{in}], 2.4*0.75\,[\mathrm{in}]) + \min(1.2*2.19\,[\mathrm{in}], 2.4*0.75\,[\mathrm{in}])*(3 - 1))*0.2\,[\mathrm{in}]*65000\,[\mathrm{lb/in2}]*1 = \mathbf{35.1}\,[\mathrm{kip}]$ Eq. J3-6

Shear yielding [Kip] 39.60 10.00 DL 0.25 Eq. J4-3

$A_g = L_p*t_p = 9.9\,[\mathrm{in}]*0.2\,[\mathrm{in}] = \mathbf{1.98}\,[\mathrm{in2}]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000\,[\mathrm{lb/in2}]*1.98\,[\mathrm{in2}] = \mathbf{39.6}\,[\mathrm{kip}]$ Eq. J4-3

Shear rupture [Kip] 28.37 10.00 DL 0.35 Eq. J4-4

$L_h = d_h + 1/16\,[\mathrm{in}] = 0.813\,[\mathrm{in}] + 1/16\,[\mathrm{in}] = \mathbf{0.875}\,[\mathrm{in}]$ Sec. D3-2

$L_e = L - n*L_h = 9.9\,[\mathrm{in}] - 3*0.875\,[\mathrm{in}] = \mathbf{7.28}\,[\mathrm{in}]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 7.28\,[\mathrm{in}]*0.2\,[\mathrm{in}] = \mathbf{1.46}\,[\mathrm{in2}]$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000\,[\mathrm{lb/in2}]*1.46\,[\mathrm{in2}] = \mathbf{28.37}\,[\mathrm{kip}]$ Eq. J4-4

Block shear [Kip] 35.07 10.00 DL 0.29 Eq. J4-5

$dh_h = d_h + 1/16\,[\mathrm{in}] = 0.813\,[\mathrm{in}] + 1/16\,[\mathrm{in}] = \mathbf{0.875}\,[\mathrm{in}]$ Sec. D3-2

$dh_v = d_h + 1/16\,[\mathrm{in}] = 0.813\,[\mathrm{in}] + 1/16\,[\mathrm{in}] = \mathbf{0.875}\,[\mathrm{in}]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.38\,[\mathrm{in}] + (1 - 1)*3\,[\mathrm{in}] - (1 - 0.5)*0.875\,[\mathrm{in}])*0.2\,[\mathrm{in}] = \mathbf{0.388}\,[\mathrm{in2}]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.95\,[\mathrm{in}] + (3 - 1)*3\,[\mathrm{in}])*0.2\,[\mathrm{in}] = \mathbf{1.59}\,[\mathrm{in2}]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.95\,[\mathrm{in}] + (3 - 1)*(3\,[\mathrm{in}] - 0.875\,[\mathrm{in}]) - 0.875\,[\mathrm{in}]/2)*0.2\,[\mathrm{in}] = \mathbf{1.15}\,[\mathrm{in2}]$ Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*65000\,[\mathrm{lb/in2}]*1.15\,[\mathrm{in2}] + 1*65000\,[\mathrm{lb/in2}]*0.388\,[\mathrm{in2}], 0.6*50000\,[\mathrm{lb/in2}]*1.59\,[\mathrm{in2}] + 1*65000\,[\mathrm{lb/in2}]*0.388\,[\mathrm{in2}]) = \mathbf{35.07}\,[\mathrm{kip}]$ Eq. J4-5

Flexural yielding [Kip] 27.95 10.00 DL 0.36 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000\,[\mathrm{lb/in2}]*3.27\,[\mathrm{in3}]/3.5\,[\mathrm{in}] = \mathbf{27.95}\,[\mathrm{kip}]$ p. 9-6

Flexural rupture [Kip] 30.34 10.00 DL 0.33 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000\,[\mathrm{lb/in2}]*3.27\,[\mathrm{in3}]/3.5\,[\mathrm{in}] = \mathbf{30.34}\,[\mathrm{kip}]$ p. 9-6

Local web buckling [Kip] 27.95 10.00 DL 0.36 p. 9-8, p. 9-7

$h_o = d - d_c = 11.9\,[\mathrm{in}] - 2\,[\mathrm{in}] = \mathbf{9.9}\,[\mathrm{in}]$ p. 9-7

$IsBeamCopedAtBothFlanges = (c_t<=2*d) \text{ and } (d_{ct}<=0.2*d) \text{ and } (c_b<=2*d) \text{ and } (d_{cb}<=0.2*d) = (3\,[\mathrm{in}]<=2*11.9\,[\mathrm{in}]) \text{ and } (1\,[\mathrm{in}]<=0.2*11.9\,[\mathrm{in}]) \text{ and } (3\,[\mathrm{in}]<=2*11.9\,[\mathrm{in}]) \text{ and } (1\,[\mathrm{in}]<=0.2*$

$11.9\text{[in]}) =$ **True** p. 9-8

$f_d = 3.5 - 7.5*(d_c/d) = 3.5 - 7.5*(1\text{[in]}/11.9\text{[in]}) = \mathbf{2.87}$ p. 9-8

$F_{cr} = 0.62*\pi*E*t_w^2/(c*h_o)*f_d = 0.62*\pi*2.90E+07\text{[lb/in2]}*0.2\text{[in]}^2/(3\text{[in]}*9.9\text{[in]})*2.87 = \mathbf{2.18E+05}\text{[lb/in2]}$ p. 9-8

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e = 0.599*\min(50000\text{[lb/in2]}, 2.18E+05\text{[lb/in2]})*3.27\text{[in3]}/3.5\text{[in]} = \mathbf{27.95}\text{[kip]}$ p. 9-7

Support

Bolt bearing under shear load	[Kip]	87.75	10.00	DL	0.11	Eq. J3-6

$L_{c-end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.20E+31\text{[in]} - 0.813\text{[in]}/2) = \mathbf{1.20E+31}\text{[in]}$ Sec. J4.10

$L_{c-spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(3 - 1))*0.25\text{[in]}*65000\text{[lb/in2]}*1) = \mathbf{87.75}\text{[kip]}$ Eq. J3-6

Global critical strength ratio **0.36**

NOTATION

a: Plate depth
A_b: Nominal bolt area
A_g: Gross area
A_{gv}: Gross area subject to shear
A_{nt}: Net area subject to tension
A_{nv}: Net area subjected to shear
a': Distance for prying action
α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
B: Available tensile strength per bolt
B: Available strength of all bolts
b': Distance for prying action
b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
C: Bolt group coefficient
c: Coped length
C_2: Edge distance increment
c_b: Bottom cope length
c_t: Top cope length
c_{max}: Maximum coped length
d: Nominal bolt diameter
d_c: Coped depth
d_{cb}: Bottom cope depth
d_{cbmax}: Maximum bottom coped depth
d_{ct}: Top cope depth
d_{ctmax}: Maximum top coped depth
d_h: Nominal hole dimension
d_{top}: Beam top edge distance
d': Width of the hole along the length of the fitting
δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
d: Beam depth
dh_h: Horizontal hole dimension
dh_v: Vertical hole dimension
e: Load eccentricity
E: Elastic modulus
F: Required shear force for combined tension and shear
F_{cr}: Critical stress, flexural stress buckling
f_d: Plate buckling model adjustment factor for beam coped at both flanges
F_{nt}: Nominal tensile stress
F_{nv}: Nominal shear stress
F_u: Specified minimum tensile strength
f_v: Required shear stress
F_y: Specified minimum yield stress
F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
h_o: Reduced beam depth
HasEqualLengths: Has equal tributary length for interior and exterior bolts
IsBeamCopedAtBothFlanges: Is beam coped at both flanges
IsCorrosionConsidered: Is corrosion considered
IsStressUniform: Is the stress uniform
k_1: Bearing factor
k_2: Bearing factor
k: Outside corner radius
L: Length
L: Angle length
L_{c-end}: Clear distance

L_e: Effective length
L_e: Edge distance
L_{eh}: Horizontal edge distance
L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
$L_{c\text{-}spa}$: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

Bentley

Current Date: 2016-05-06 1:17 PM
Units system: English
File name:

Steel connections

Results

Connection name : **DA BG All bolted**
Connection ID : **SC-06-04**

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W12X19
Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	20.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	8.50	5.45	9.70	✔	p. 10-8
$L_{min} = T/2 = 10.9\text{[in]}/2 = \mathbf{5.45}\text{[in]}$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 12.2\text{[in]} - \max(0.65\text{[in]}, 1.25\text{[in]}) - \max(0.65\text{[in]}, 1.25\text{[in]}) = \mathbf{9.7}\text{[in]}$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.64	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75\text{[in]} = \mathbf{2}\text{[in]}$						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12\ \text{[in]}) = \min(24*0.235\text{[in]}, 12\ \text{[in]}) = \mathbf{5.64}\text{[in]}$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8\ \text{[in]}$						p. 10-9
Angle (Support side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0\text{[in]} = \mathbf{1}\text{[in]}$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1\text{[in]} + 0.125\text{[in]} = \mathbf{1.13}\text{[in]}$						Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.64	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$ — Sec. J3.3

$IsCorrosionConsidered \rightarrow$ **False**

$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.235[in], 12\ [in]) = \mathbf{5.64}[in]$ — Sec. J3.5

Beam

Top cope length	[in]	4.00	--	24.40	✔	

$c_{max} = 2*d = 2*12.2[in] = \mathbf{24.4}[in]$

Bottom cope length	[in]	4.00	--	24.40	✔	

$c_{max} = 2*d = 2*12.2[in] = \mathbf{24.4}[in]$

Top cope depth	[in]	1.25	--	1.85	✔	

$d_{ctmax} = \min(d/2, d_{top} - w) = \min(12.2[in]/2, 1.85[in] - 0[in]) = \mathbf{1.85}[in]$

Bottom cope depth	[in]	1.25	--	1.85	✔	

$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(12.2[in]/2, 12.2[in] - 8.5[in] - 1.85[in] - 0[in]) = \mathbf{1.85}[in]$

Vertical edge distance	[in]	1.85	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.38	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Angle (Beam side)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	63.65	20.00	DL	0.31	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61[kip]) = \mathbf{63.65}[kip]$ — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	83.60	20.00	DL	0.24	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4* 0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{83.6}[kip]$ — Eq. J3-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Kip]	76.50	20.00	DL	0.26	Eq. J4-3

$A_g = L_p*t_p = 8.5[in]*0.313[in] = \mathbf{2.66}[in2]$ — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = \mathbf{76.5}[kip]$ — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear rupture	[Kip]	63.89	20.00	DL	0.31	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ — Sec. D3-2

$L_e = L - n*L_h = 8.5[in] - 3*0.875[in] = \mathbf{5.88}[in]$ — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88[in]*0.313[in] = \mathbf{1.84}[in2]$ — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = \mathbf{63.89}[kip]$ — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear	[Kip]	61.40	20.00	DL	0.33	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ — Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*3[in] - (1 - 0.5)* 0.875[in])*0.313[in] = \mathbf{0.215}[in2]$ — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (3 - 1)*3[in])*0.313[in] = \mathbf{2.27}[in2]$ — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{1.58}[in2]$ — Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.215[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.215[in2])) = \mathbf{61.4}[kip]$ Eq. J4-5

<u>Angle (Support side)</u>

Bolts shear [Kip] 63.65 20.00 DL 0.31 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61[kip]) = \mathbf{63.65}[kip]$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 83.60 20.00 DL 0.24 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(\min(1.2*0.844[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{83.6}[kip]$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 76.50 20.00 DL 0.26 Eq. J4-3

$A_g = L_p*t_p = 8.5[in]*0.313[in] = \mathbf{2.66}[in2]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = \mathbf{76.5}[kip]$ Eq. J4-3

Shear rupture [Kip] 63.89 20.00 DL 0.31 Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 8.5[in] - 3*0.875[in] = \mathbf{5.88}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88[in]*0.313[in] = \mathbf{1.84}[in2]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = \mathbf{63.89}[kip]$ Eq. J4-4

Block shear [Kip] 59.70 20.00 DL 0.34 Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 1[in] + 1/16\ [in] = \mathbf{1.06}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = \mathbf{0.186}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (3 - 1)*3[in])*0.313[in] = \mathbf{2.27}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{1.58}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.186[in2])) = \mathbf{59.7}[kip]$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 10.57 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 20[kip]/(0.442[in2]*6) = \mathbf{7541.48}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*7541.48[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{88719.46}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*88719.46[lb/in2]*0.442[in2] = \mathbf{19.61}[kip]$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 20[kip]/(0.442[in2]*6) = \mathbf{7541.48}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*7541.48[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{88719.46}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*88719.46[lb/in2]*0.442[in2] = \mathbf{19.61}[kip]$ Eq. J3-2

$a' = \text{Min}(a + d/2, 1.25*b + d/2) = \text{Min}(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/3[in] = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*19.61[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))^{0.5} = \mathbf{1.33}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.33[in]/0.313[in])^2 - 1) =$

9.1 p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.33[in])^2*(1 + 0.729) =$ **0.096** p. 9-13

$a' = \text{Min}(a + d/2, 1.25*b + d/2) = \text{Min}(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) =$ **1.5**[in] p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 =$ **2.34**[in] p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] =$ **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] =$ **0.705** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*19.61[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} =$ **1.39**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.39[in]/0.313[in])^2 - 1) =$ **10.33** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.39[in])^2*(1 + 0.705) =$ **0.0868** p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.0868 + (3 - 2)*0.096)/3 =$ **0.0898** p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (19.61[kip]*0.0898) =$ **10.57**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	40.73	20.00	DL	0.49	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.85[in] - 0.813[in]/2) =$ **1.44**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3[in] - 0.813[in]) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*1.44[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.235[in]*65000[lb/in2]*1 =$ **40.73**[kip] Eq. J3-6

Shear yielding	[Kip]	45.59	20.00	DL	0.44	Eq. J4-3

$A_g = L_p*t_p = 9.7[in]*0.235[in] =$ **2.28**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*2.28[in2] =$ **45.59**[kip] Eq. J4-3

Shear rupture	[Kip]	32.42	20.00	DL	0.62	Eq. J4-4

$L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] =$ **0.875**[in] Sec. D3-2

$L_e = L - n*L_h = 9.7[in] - 3*0.875[in] =$ **7.08**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 7.08[in]*0.235[in] =$ **1.66**[in2] Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000[lb/in2]*1.66[in2] =$ **32.42**[kip] Eq. J4-4

Block shear	[Kip]	40.75	20.00	DL	0.49	Eq. J4-5

$dh_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] =$ **0.875**[in] Sec. D3-2

$dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] =$ **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.38[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.235[in] =$ **0.455**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.85[in] + (3 - 1)*3[in])*0.235[in] =$ **1.84**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.85[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.235[in] =$ **1.33**[in2] Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*65000[lb/in2]*1.33[in2] + 1*65000[lb/in2]*0.455[in2], 0.6*50000[lb/in2]*1.84[in2] + 1*65000[lb/in2]*0.455[in2]) =$ **40.75**[kip] Eq. J4-5

Flexural yielding	[Kip]	24.52	20.00	DL	0.82	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000[lb/in2]*3.69[in3]/4.5[in] =$ **24.52**[kip] p. 9-6

Flexural rupture	[Kip]	26.62	20.00	DL	0.75	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000[lb/in2]*3.69[in3]/4.5[in] =$ **26.62**[kip] p. 9-6

Local web buckling	[Kip]	24.52	20.00	DL	0.82	p. 9-8, p. 9-7

$h_o = d - d_c = 12.2[in] - 2.5[in] =$ **9.7**[in] p. 9-7

$IsBeamCopedAtBothFlanges = (c_t<=2*d) \text{ and } (d_{ct}<=0.2*d) \text{ and } (c_b<=2*d) \text{ and } (d_{cb}<=0.2*d) = (4[in]<=2*12.2[in]) \text{ and } (1.25[in]<=0.2*12.2[in]) \text{ and } (4[in]<=2*12.2[in]) \text{ and } (1.25[in]<=0.2*12.2[in]) =$ **True** p. 9-8

$f_d = 3.5 - 7.5*(d_c/d) = 3.5 - 7.5*(1.25[in]/12.2[in]) =$ **2.73** p. 9-8

$F_{cr} = 0.62*\pi*E*t_w^2/(c*h_o)*f_d = 0.62*\pi*2.90E+07[lb/in2]*0.235[in]^2/(4[in]*9.7[in])*2.73 =$ **2.20E+05**[lb/in2] p. 9-8

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e = 0.599*\min(50000[lb/in2], 2.20E+05[lb/in2])*3.69[in3]/ 4.5[in] = \mathbf{24.52}[kip]$ p. 9-7

Support

Bolt bearing under shear load	[Kip]	82.48	20.00	DL	0.24	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.20E+31[in] - 0.813[in]/2) = \mathbf{1.20E+31}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4* 0.75[in])*(3 - 1))*0.235[in]*65000[lb/in2]*1) = \mathbf{82.49}[kip]$ Eq. J3-6

Global critical strength ratio **0.82**

NOTATION

a: Plate depth
A_b: Nominal bolt area
A_g: Gross area
A_{gv}: Gross area subject to shear
A_{nt}: Net area subject to tension
A_{nv}: Net area subjected to shear
a': Distance for prying action
α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
B: Available tensile strength per bolt
B: Available strength of all bolts
b': Distance for prying action
b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
C: Bolt group coefficient
c: Coped length
C_2: Edge distance increment
c_b: Bottom cope length
c_t: Top cope length
c_{max}: Maximum coped length
d: Nominal bolt diameter
d_c: Coped depth
d_{cb}: Bottom cope depth
d_{cbmax}: Maximum bottom coped depth
d_{ct}: Top cope depth
d_{ctmax}: Maximum top coped depth
d_h: Nominal hole dimension
d_{top}: Beam top edge distance
d': Width of the hole along the length of the fitting
δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
d: Beam depth
dh_h: Horizontal hole dimension
dh_v: Vertical hole dimension
e: Load eccentricity
E: Elastic modulus
F: Required shear force for combined tension and shear
F_{cr}: Critical stress, flexural stress buckling
f_d: Plate buckling model adjustment factor for beam coped at both flanges
F_{nt}: Nominal tensile stress
F_{nv}: Nominal shear stress
F_u: Specified minimum tensile strength
f_v: Required shear stress
F_y: Specified minimum yield stress
F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
h_o: Reduced beam depth
HasEqualLengths: Has equal tributary length for interior and exterior bolts
IsBeamCopedAtBothFlanges: Is beam coped at both flanges
IsCorrosionConsidered: Is corrosion considered
IsStressUniform: Is the stress uniform
k_1: Bearing factor
k_2: Bearing factor
k: Outside corner radius
L: Length
L: Angle length
$L_{c\text{-}end}$: Clear distance
L_e: Effective length
L_e: Edge distance
L_{eh}: Horizontal edge distance
L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
$L_{c\text{-}spa}$: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

Current Date: 2016-05-06 1:45 PM
Units system: English
File name:

Steel connections

Results

Connection name : DA BG All bolted
Connection ID : SC-06-05

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W12X22

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	10.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	8.50	5.42	10.57	✔	p. 10-8
$L_{min} = T/2 = 10.85[in]/2 = \mathbf{5.43}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 12.3[in] - \max(0.725[in], 1[in]) - \max(0.725[in], 0[in]) = \mathbf{10.58}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.24	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.26[in], 12\ [in]) = \mathbf{6.24}[in]$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8\ [in]$						p. 10-9
Angle (Support side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0.125[in] = \mathbf{1.13}[in]$						Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.20		Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $= \mathbf{2}$[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.3$[in]$, 12$ [in]$) = \mathbf{7.2}$[in] — Sec. J3.5

Beam

Top cope length	[in]	3.00	--	24.60		

$c_{max} = 2*d = 2*12.3$[in] $= \mathbf{24.6}$[in]

Bottom cope length	[in]	0.00	--	24.60		

$c_{max} = 2*d = 2*12.3$[in] $= \mathbf{24.6}$[in]

Top cope depth	[in]	1.00	--	1.90		

$d_{ctmax} = \min(d/2, d_{top} - w) = \min(12.3$[in]$/2, 1.9$[in] $- 0$[in]$) = \mathbf{1.9}$[in]

Bottom cope depth	[in]	0.00	--	1.90		

$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(12.3$[in]$/2, 12.3$[in] $- 8.5$[in] $- 1.9$[in] $- 0$[in]$) = \mathbf{1.9}$[in]

Vertical edge distance	[in]	2.15	1.00	--		Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.38	1.00	--		Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	63.65	10.00	DL	0.16	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $= \mathbf{10.61}$[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61$[kip]$) = \mathbf{63.65}$[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	10.00	DL	0.12	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) = \mathbf{0.844}$[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) = \mathbf{2.19}$[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4* 0.75$[in]$)*(3 - 1))*0.313$[in]$*58000$[lb/in2]$*1) = \mathbf{83.6}$[kip] — Eq. J3-6

Shear yielding	[Kip]	76.50	10.00	DL	0.13	Eq. J4-3

$A_g = L_p*t_p = 8.5$[in]$*0.313$[in] $= \mathbf{2.66}$[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*2.66$[in2]$) = \mathbf{76.5}$[kip] — Eq. J4-3

Shear rupture	[Kip]	63.89	10.00	DL	0.16	Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $= \mathbf{0.875}$[in] — Sec. D3-2

$L_e = L - n*L_h = 8.5$[in] $- 3*0.875$[in] $= \mathbf{5.88}$[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88$[in]$*0.313$[in] $= \mathbf{1.84}$[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*1.84$[in2]$) = \mathbf{63.89}$[kip] — Eq. J4-4

Block shear	[Kip]	61.40	10.00	DL	0.16	Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $= \mathbf{0.875}$[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $= \mathbf{0.875}$[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13$[in] $+ (1 - 1)*3$[in] $- (1 - 0.5)* 0.875$[in]$)*0.313$[in] $= \mathbf{0.215}$[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] $+ (3 - 1)*3$[in]$)*0.313$[in] $= \mathbf{2.27}$[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (3 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{1.58}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*1.58\text{[in2]} + 1*58000\text{[lb/in2]}*0.215\text{[in2]}, 0.6*36000\text{[lb/in2]}*2.27\text{[in2]} + 1*58000\text{[lb/in2]}*0.215\text{[in2]})) = \mathbf{61.4}\text{[kip]}$ Eq. J4-5

<u>Angle (Support side)</u>

Bolts shear [Kip] 63.65 10.00 DL 0.16 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61\text{[kip]}) = \mathbf{63.65}\text{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 83.60 10.00 DL 0.12 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(3 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{83.6}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 76.50 10.00 DL 0.13 Eq. J4-3

$A_g = L_p*t_p = 8.5\text{[in]}*0.313\text{[in]} = \mathbf{2.66}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*2.66\text{[in2]}) = \mathbf{76.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 63.89 10.00 DL 0.16 Eq. J4-4

$L_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 8.5\text{[in]} - 3*0.875\text{[in]} = \mathbf{5.88}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88\text{[in]}*0.313\text{[in]} = \mathbf{1.84}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*1.84\text{[in2]}) = \mathbf{63.89}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 59.70 10.00 DL 0.17 Eq. J4-5

$dh_h = d_h + 1/16\ \text{[in]} = 1\text{[in]} + 1/16\ \text{[in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13\text{[in]} + (1 - 1)*5.5\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.186}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (3 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{2.27}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (3 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{1.58}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*1.58\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]}, 0.6*36000\text{[lb/in2]}*2.27\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]})) = \mathbf{59.7}\text{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 10.57 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 10\text{[kip]}/(0.442\text{[in2]}*6) = \mathbf{3770.74}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*3770.74\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{90000}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*90000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{19.89}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 10\text{[kip]}/(0.442\text{[in2]}*6) = \mathbf{3770.74}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*3770.74\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{90000}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*90000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{19.89}\text{[kip]}$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*19.89\text{[kip]}*2.34\text{[in]})/(0.5*3\text{[in]}*58000\text{[lb/}$

in2]))$^{0.5}$ = **1.34**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.34[in]/0.313[in])^2 - 1) =$ **9.24** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.34[in])^2*(1 + 0.729) =$ **0.0946** p. 9-13

$a' = \text{Min}(a + d/2, 1.25*b + d/2) = \text{Min}(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) =$ **1.5**[in] p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 =$ **2.34**[in] p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] =$ **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] =$ **0.705** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*19.89[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} =$ **1.4**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.4[in]/0.313[in])^2 - 1) =$ **10.49** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.4[in])^2*(1 + 0.705) =$ **0.0855** p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.0855 + (3 - 2)*0.0946)/3 =$ **0.0886** p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (19.89[kip]*0.0886) =$ **10.57**[kip] p. 9-10

Beam

Bolt bearing under shear load [Kip] 45.63 10.00 DL 0.22 Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 2.15[in] - 0.813[in]/2) =$ **1.74**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3[in] - 0.813[in]) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*1.74[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.26[in]*65000[lb/in2]*1 =$ **45.63**[kip] Eq. J3-6

Shear yielding [Kip] 58.76 10.00 DL 0.17 Eq. J4-3

$A_g = L_p*t_p = 11.3[in]*0.26[in] =$ **2.94**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*2.94[in2] =$ **58.76**[kip] Eq. J4-3

Shear rupture [Kip] 43.98 10.00 DL 0.23 Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] =$ **0.875**[in] Sec. D3-2

$L_e = L - n*L_h = 11.3[in] - 3*0.875[in] =$ **8.68**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8.68[in]*0.26[in] =$ **2.26**[in2] Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000[lb/in2]*2.26[in2] =$ **43.98**[kip] Eq. J4-4

Block shear [Kip] 46.60 10.00 DL 0.21 Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] =$ **0.875**[in] Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] =$ **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.38[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.26[in] =$ **0.504**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (2.15[in] + (3 - 1)*3[in])*0.26[in] =$ **2.12**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (2.15[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.26[in] =$ **1.55**[in2] Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*65000[lb/in2]*1.55[in2] + 1*65000[lb/in2]*0.504[in2], 0.6*50000[lb/in2]*2.12[in2] + 1*65000[lb/in2]*0.504[in2]) =$ **46.6**[kip] Eq. J4-5

Flexural yielding [Kip] 70.34 10.00 DL 0.14 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000[lb/in2]*8.22[in3]/3.5[in] =$ **70.34**[kip] p. 9-6

Flexural rupture [Kip] 76.36 10.00 DL 0.13 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000[lb/in2]*8.22[in3]/3.5[in] =$ **76.36**[kip] p. 9-6

Local web buckling [Kip] 70.34 10.00 DL 0.14 p. 9-7

$h_o = d - d_c = 12.3[in] - 1[in] =$ **11.3**[in] p. 9-7

IsTopFlangeBeamCoped $= (c<=2*d)$ and $(d_c<=d/2) = (3[in]<=2*12.3[in])$ and $(1[in]<=12.3[in]/2) =$ **True** p. 9-7

$c/d<=1 \rightarrow 3[in]/12.3[in]<=1 \rightarrow$ **True**

$f = 2*c/d = 2*3[in]/12.3[in] =$ **0.488** p. 9-7

$c/h_o<=1 \rightarrow 3[in]/11.3[in]<=1 \rightarrow$ **True**

$k = 2.2*(h_o/c)^{1.65} = 2.2*(11.3[in]/3[in])^{1.65} = \mathbf{19.62}$ p. 9-7

$F_{cr} = \pi^2*E/(12*(1 - \nu^2))*(t_w/h_o)^2*f*k = \pi^2*2.90E+07[lb/in2]/(12*(1 - 0.3^2))*$
$(0.26[in]/11.3[in])^2*0.488*19.62 = \mathbf{1.33E+05}[lb/in2]$ p. 9-7

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e = 0.599*\min(50000[lb/in2], 1.33E+05[lb/in2])*8.22[in3]/$
$3.5[in] = \mathbf{70.34}[kip]$ p. 9-7

Support

Bolt bearing under shear load	[Kip]	105.30	10.00	DL	0.09	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.20E+31[in] - 0.813[in]/2) = \mathbf{1.20E+31}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*$
$t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*$
$0.75[in])*(3 - 1))*0.3[in]*65000[lb/in2]*1) = \mathbf{105.3}[kip]$ Eq. J3-6

Global critical strength ratio **0.23**

NOTATION

a: Plate depth
A_b: Nominal bolt area
A_g: Gross area
A_{gv}: Gross area subject to shear
A_{nt}: Net area subject to tension
A_{nv}: Net area subjected to shear
a': Distance for prying action
α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
B: Available tensile strength per bolt
B: Available strength of all bolts
b': Distance for prying action
b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
C: Bolt group coefficient
c: Coped length
C_2: Edge distance increment
c_{max}: Maximum coped length
d: Nominal bolt diameter
d_c: Coped depth
d_{cb}: Bottom cope depth
d_{cbmax}: Maximum bottom coped depth
d_{ct}: Top cope depth
d_{ctmax}: Maximum top coped depth
d_h: Nominal hole dimension
d_{top}: Beam top edge distance
d': Width of the hole along the length of the fitting
δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
d: Beam depth
dh_h: Horizontal hole dimension
dh_v: Vertical hole dimension
e: Load eccentricity
E: Elastic modulus
f: Plate buckling model adjustment factor
F: Required shear force for combined tension and shear
F_{cr}: Critical stress, flexural stress buckling
F_{nt}: Nominal tensile stress
F_{nv}: Nominal shear stress
F_u: Specified minimum tensile strength
f_v: Required shear stress
F_y: Specified minimum yield stress
F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
h_o: Reduced beam depth
HasEqualLengths: Has equal tributary length for interior and exterior bolts
IsCorrosionConsidered: Is corrosion considered
IsStressUniform: Is the stress uniform
IsTopFlangeBeamCoped: Is the top beam flange coped
k: Plate buckling coefficient
k_1: Bearing factor
k_2: Bearing factor
k: Outside corner radius
L: Length
L: Angle length
$L_{c\text{-}end}$: Clear distance
L_e: Effective length
L_e: Edge distance

L_{eh}: Horizontal edge distance
L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
ν: Poisson's ratio
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
$L_{c\text{-}spa}$: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

Current Date: 2016-05-06 1:47 PM
Units system: English
File name:

Steel connections

Results

Connection name : DA BG All bolted
Connection ID : SC-06-06

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W12X26

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	15.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	5.50	5.42	10.27	✔	p. 10-8
$L_{min} = T/2 = 10.84[in]/2 = \mathbf{5.42}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 12.2[in] - \max(0.68[in], 1.25[in]) - \max(0.68[in], 0[in]) = \mathbf{10.27}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.52	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.23[in], 12\ [in]) = \mathbf{5.52}[in]$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8\ [in]$						p. 10-9
Angle (Support side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0.125[in] = \mathbf{1.13}[in]$						Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.52	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.23$[in], 12 [in]) = **5.52**[in] — Sec. J3.5

Beam

Top cope length	[in]	5.00	--	24.40	✔	

$c_{max} = 2*d = 2*12.2$[in] = **24.4**[in]

Bottom cope length	[in]	0.00	--	24.40	✔	

$c_{max} = 2*d = 2*12.2$[in] = **24.4**[in]

Top cope depth	[in]	1.25	--	1.75	✔	

$d_{ctmax} = \min(d/2, d_{top} - w) = \min(12.2$[in]/2, 1.75[in] - 0[in]) = **1.75**[in]

Bottom cope depth	[in]	0.00	--	4.95	✔	

$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(12.2$[in]/2, 12.2[in] - 5.5[in] - 1.75[in] - 0[in]) = **4.95**[in]

Vertical edge distance	[in]	1.63	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Angle (Beam side)

Bolts shear	[Kip]	42.43	15.00	DL	0.35	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (2*10.61$[kip]) = **42.43**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	48.26	15.00	DL	0.31	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.13$[in] - 0.813[in]/2) = **0.719**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.719$[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4* 0.75[in])*(2 - 1))*0.313[in]*58000[lb/in2]*1) = **48.26**[kip] — Eq. J3-6

Shear yielding	[Kip]	49.50	15.00	DL	0.30	Eq. J4-3

$A_g = L_p*t_p = 5.5$[in]*0.313[in] = **1.72**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]*1.72[in2]) = **49.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	40.78	15.00	DL	0.37	Eq. J4-4

$L_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h = 5.5$[in] - 2*0.875[in] = **3.75**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 3.75$[in]*0.313[in] = **1.17**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]*1.17[in2]) = **40.78**[kip] — Eq. J4-4

Block shear	[Kip]	42.57	15.00	DL	0.35	Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25$[in] + (1 - 1)*3[in] - (1 - 0.5)* 0.875[in])*0.313[in] = **0.254**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.13$[in] + (2 - 1)*3[in])*0.313[in] = **1.29**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.13$[in] + (2 - 1)*(3[in] - 0.875[in]) -

$0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{0.879}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*0.879\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]}, 0.6*36000\text{[lb/in2]}*1.29\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]})) = \mathbf{42.57}\text{[kip]}$ Eq. J4-5

<u>Angle (Support side)</u>

Bolts shear [Kip] 42.43 15.00 DL 0.35 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (2*10.61\text{[kip]}) = \mathbf{42.43}\text{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 50.98 15.00 DL 0.29 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(2/(1*2))*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(2 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{50.98}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 49.50 15.00 DL 0.30 Eq. J4-3

$A_g = L_p*t_p = 5.5\text{[in]}*0.313\text{[in]} = \mathbf{1.72}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*1.72\text{[in2]}) = \mathbf{49.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 40.78 15.00 DL 0.37 Eq. J4-4

$L_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 5.5\text{[in]} - 2*0.875\text{[in]} = \mathbf{3.75}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 3.75\text{[in]}*0.313\text{[in]} = \mathbf{1.17}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*1.17\text{[in2]}) = \mathbf{40.78}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 39.45 15.00 DL 0.38 Eq. J4-5

$dh_h = d_h + 1/16\ \text{[in]} = 1\text{[in]} + 1/16\ \text{[in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13\text{[in]} + (1 - 1)*5.5\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.186}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (2 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{1.33}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (2 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{0.918}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*0.918\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]}, 0.6*36000\text{[lb/in2]}*1.33\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]})) = \mathbf{39.45}\text{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 6.80 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 15\text{[kip]}/(0.442\text{[in2]}*4) = \mathbf{8484.16}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*8484.16\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{85184.39}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*85184.39\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{18.83}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 15\text{[kip]}/(0.442\text{[in2]}*4) = \mathbf{8484.16}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*8484.16\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{85184.39}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*85184.39\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{18.83}\text{[kip]}$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*18.83\text{[kip]}*2.34\text{[in]})/(0.5*3\text{[in]}*58000\text{[lb/in2]}))^{0.5} = \mathbf{1.3}\text{[in]}$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.3[in]/0.313[in])^2 - 1) = \mathbf{8.72}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.3[in])^2*(1 + 0.729) = \mathbf{0.1}$ p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*18.83[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} = \mathbf{1.36}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.36[in]/0.313[in])^2 - 1) = \mathbf{9.9}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.36[in])^2*(1 + 0.705) = \mathbf{0.0904}$ p. 9-13

$HasEqualLengths \rightarrow$ **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.0904 + (2 - 2)*0.1)/2 = \mathbf{0.0904}$ p. 9-13

$T_{avail} = 4 * (B*Q) = 4 * (18.83[kip]*0.0904) = \mathbf{6.8}[kip]$ p. 9-10

Beam

Bolt bearing under shear load [Kip] 24.39 15.00 DL 0.62 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.63[in] - 0.813[in]/2) = \mathbf{1.22}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*1.22[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(2 - 1))*0.23[in]*65000[lb/in2]*1 = \mathbf{24.39}[kip]$ Eq. J3-6

Shear yielding [Kip] 50.37 15.00 DL 0.30 Eq. J4-3

$A_g = L_p*t_p = 10.95[in]*0.23[in] = \mathbf{2.52}[in2]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*2.52[in2] = \mathbf{50.37}[kip]$ Eq. J4-3

Shear rupture [Kip] 41.26 15.00 DL 0.36 Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 10.95[in] - 2*0.875[in] = \mathbf{9.2}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 9.2[in]*0.23[in] = \mathbf{2.12}[in2]$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000[lb/in2]*2.12[in2] = \mathbf{41.26}[kip]$ Eq. J4-4

Block shear [Kip] 28.41 15.00 DL 0.53 Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.25[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.23[in] = \mathbf{0.417}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.63[in] + (2 - 1)*3[in])*0.23[in] = \mathbf{1.06}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.63[in] + (2 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.23[in] = \mathbf{0.762}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*65000[lb/in2]*0.762[in2] + 1*65000[lb/in2]*0.417[in2], 0.6*50000[lb/in2]*1.06[in2] + 1*65000[lb/in2]*0.417[in2]) = \mathbf{28.41}[kip]$ Eq. J4-5

Flexural yielding [Kip] 40.27 15.00 DL 0.37 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000[lb/in2]*7.4[in3]/5.5[in] = \mathbf{40.27}[kip]$ p. 9-6

Flexural rupture [Kip] 43.71 15.00 DL 0.34 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000[lb/in2]*7.4[in3]/5.5[in] = \mathbf{43.71}[kip]$ p. 9-6

Local web buckling [Kip] 40.27 15.00 DL 0.37 p. 9-7

$h_o = d - d_c = 12.2[in] - 1.25[in] = \mathbf{10.95}[in]$ p. 9-7

$IsTopFlangeBeamCoped = (c<=2*d)$ and $(d_c<=d/2) = (5[in]<=2*12.2[in])$ and $(1.25[in]<=12.2[in]/2) =$ **True** p. 9-7

$c/d<=1 \rightarrow 5[in]/12.2[in]<=1 \rightarrow$ **True**

$f = 2*c/d = 2*5[in]/12.2[in] = \mathbf{0.82}$ p. 9-7

$c/h_o<=1 \rightarrow 5[in]/10.95[in]<=1 \rightarrow$ **True**

$k = 2.2*(h_o/c)^{1.65} = 2.2*(10.95[in]/5[in])^{1.65} = \mathbf{8.02}$ p. 9-7

$F_{cr} = \pi^2*E/(12*(1 - \nu^2))*(t_w/h_o)^2*f*k = \pi^2*2.90E+07[lb/in2]/(12*(1 - 0.3^2))*$
$(0.23[in]/10.95[in])^2*0.82*8.02 = \mathbf{76014.8}[lb/in2]$ p. 9-7

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e = 0.599*\min(50000[lb/in2], 76014.8[lb/in2])*7.4[in3]/$
$5.5[in] = \mathbf{40.27}[kip]$ p. 9-7

Support

Bolt bearing under shear load	[Kip]	53.82	15.00	DL	0.28	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.20E+31[in] - 0.813[in]/2) = \mathbf{1.20E+31}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*$
$t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*$
$0.75[in])*(2 - 1))*0.23[in]*65000[lb/in2]*1) = \mathbf{53.82}[kip]$ Eq. J3-6

Global critical strength ratio **0.62**

NOTATION

a: Plate depth
A_b: Nominal bolt area
A_g: Gross area
A_{gv}: Gross area subject to shear
A_{nt}: Net area subject to tension
A_{nv}: Net area subjected to shear
a': Distance for prying action
α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
B: Available tensile strength per bolt
B: Available strength of all bolts
b': Distance for prying action
b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
C: Bolt group coefficient
c: Coped length
C_2: Edge distance increment
c_{max}: Maximum coped length
d: Nominal bolt diameter
d_c: Coped depth
d_{cb}: Bottom cope depth
d_{cbmax}: Maximum bottom coped depth
d_{ct}: Top cope depth
d_{ctmax}: Maximum top coped depth
d_h: Nominal hole dimension
d_{top}: Beam top edge distance
d': Width of the hole along the length of the fitting
δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
d: Beam depth
dh_h: Horizontal hole dimension
dh_v: Vertical hole dimension
e: Load eccentricity
E: Elastic modulus
f: Plate buckling model adjustment factor
F: Required shear force for combined tension and shear
F_{cr}: Critical stress, flexural stress buckling
F_{nt}: Nominal tensile stress
F_{nv}: Nominal shear stress
F_u: Specified minimum tensile strength
f_v: Required shear stress
F_y: Specified minimum yield stress
F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
h_o: Reduced beam depth
HasEqualLengths: Has equal tributary length for interior and exterior bolts
IsCorrosionConsidered: Is corrosion considered
IsStressUniform: Is the stress uniform
IsTopFlangeBeamCoped: Is the top beam flange coped
k: Plate buckling coefficient
k_1: Bearing factor
k_2: Bearing factor
k: Outside corner radius
L: Length
L: Angle length
$L_{c\text{-}end}$: Clear distance
L_e: Effective length
L_e: Edge distance

L_{eh}: Horizontal edge distance
L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
ν: Poisson's ratio
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
$L_{c\text{-}spa}$: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

Current Date: 2016-05-06 11:27 AM
Units system: English
File name:

Steel connections

Results

Connection name	:	**DA BG All bolted**
Connection ID	:	**SC-06-07**

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W14X22

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	30.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	8.50	6.11	11.47	✔	p. 10-8
$L_{min} = T/2 = 12.23[in]/2 = \mathbf{6.12}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 13.7[in] - \max(0.735[in], 1.5[in]) - \max(0.735[in], 0[in]) = \mathbf{11.47}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	5.52	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.23[in], 12\ [in]) = \mathbf{5.52}[in]$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8\ [in]$						p. 10-9
Angle (Support side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.25	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0.125[in] = \mathbf{1.13}[in]$						Tables J3.4,

J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Beam

Top cope length	[in]	5.00	--	27.40	✔

$c_{max} = 2*d = 2*13.7$[in] $=$ **27.4**[in]

Bottom cope length	[in]	0.00	--	27.40	✔

$c_{max} = 2*d = 2*13.7$[in] $=$ **27.4**[in]

Top cope depth	[in]	1.50	--	1.75	✔

$d_{ctmax} = \min(d/2, d_{top} - w) = \min(13.7$[in]$/2, 1.75$[in] $- 0$[in]$) =$ **1.75**[in]

Bottom cope depth	[in]	0.00	--	3.45	✔

$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(13.7$[in]$/2, 13.7$[in] $- 8.5$[in] $- 1.75$[in] $- 0$[in]$) =$ **3.45**[in]

Vertical edge distance	[in]	1.50	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	63.65	30.00	DL	0.47	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61$[kip]$) =$ **63.65**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	30.00	DL	0.36	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in], $2.4*0.75$[in]$) + \min(1.2*2.19$[in], $2.4*0.75$[in]$)*(3 - 1))*0.313$[in]$*58000$[lb/in2]$*1) =$ **83.6**[kip] — Eq. J3-6

Shear yielding	[Kip]	76.50	30.00	DL	0.39	Eq. J4-3

$A_g = L_p*t_p = 8.5$[in]$*0.313$[in] $=$ **2.66**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*2.66$[in2]$) =$ **76.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	63.89	30.00	DL	0.47	Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h = 8.5$[in] $- 3*0.875$[in] $=$ **5.88**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88$[in]$*0.313$[in] $=$ **1.84**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*1.84$[in2]$) =$ **63.89**[kip] — Eq. J4-4

Block shear	[Kip]	63.66	30.00	DL	0.47	Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25$[in] $+ (1 - 1)*3$[in] $- (1 - 0.5)*$

$0.875\text{[in]})*0.313\text{[in]} = \mathbf{0.254}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (3 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{2.27}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (3 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{1.58}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*1.58\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]}, 0.6*36000\text{[lb/in2]}*2.27\text{[in2]} + 1*58000\text{[lb/in2]}*0.254\text{[in2]})) = \mathbf{63.66}\text{[kip]}$ Eq. J4-5

Angle (Support side)

Bolts shear [Kip] 63.65 30.00 DL 0.47 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61\text{[kip]}) = \mathbf{63.65}\text{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 83.60 30.00 DL 0.36 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(3 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{83.6}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 76.50 30.00 DL 0.39 Eq. J4-3

$A_g = L_p*t_p = 8.5\text{[in]}*0.313\text{[in]} = \mathbf{2.66}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*2.66\text{[in2]}) = \mathbf{76.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 63.89 30.00 DL 0.47 Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 8.5\text{[in]} - 3*0.875\text{[in]} = \mathbf{5.88}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88\text{[in]}*0.313\text{[in]} = \mathbf{1.84}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*1.84\text{[in2]}) = \mathbf{63.89}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 61.96 30.00 DL 0.48 Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 1\text{[in]} + 1/16\text{ [in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25\text{[in]} + (1 - 1)*5.5\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.225}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (3 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{2.27}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (3 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{1.58}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*1.58\text{[in2]} + 1*58000\text{[lb/in2]}*0.225\text{[in2]}, 0.6*36000\text{[lb/in2]}*2.27\text{[in2]} + 1*58000\text{[lb/in2]}*0.225\text{[in2]})) = \mathbf{61.96}\text{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 11.16 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 30\text{[kip]}/(0.442\text{[in2]}*6) = \mathbf{11312.22}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*11312.22\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{74579.19}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*74579.19\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{16.48}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 30\text{[kip]}/(0.442\text{[in2]}*6) = \mathbf{11312.22}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*11312.22\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{74579.19}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*74579.19\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{16.48}\text{[kip]}$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.25\text{[in]} + 0.75\text{[in]}/2, 1.25*2.59\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.63}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.59\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.22}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.22\text{[in]}/1.63\text{[in]} = \mathbf{1.37}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/3[in] = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*16.48[kip]*2.22[in])/(0.5*3[in]*58000[lb/in2]))^{0.5} = \mathbf{1.18}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.37)))*((1.18[in]/0.313[in])^2 - 1) = \mathbf{7.73}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.18[in])^2*(1 + 0.729) = \mathbf{0.121}$ p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.25[in] + 0.75[in]/2, 1.25*2.59[in] + 0.75[in]/2) = \mathbf{1.63}[in]$ p. 9-12

$b' = b - d/2 = 2.59[in] - 0.75[in]/2 = \mathbf{2.22}[in]$ p. 9-12

$\rho = b'/a' = 2.22[in]/1.63[in] = \mathbf{1.37}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*16.48[kip]*2.22[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} = \mathbf{1.24}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.37)))*((1.24[in]/0.313[in])^2 - 1) = \mathbf{8.78}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.24[in])^2*(1 + 0.705) = \mathbf{0.109}$ p. 9-13

$HasEqualLengths \rightarrow$ **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.109 + (3 - 2)*0.121)/3 = \mathbf{0.113}$ p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (16.48[kip]*0.113) = \mathbf{11.16}[kip]$ p. 9-10

Beam

Bolt bearing under shear load [Kip] 36.72 30.00 DL 0.82 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.5[in] - 0.813[in]/2) = \mathbf{1.09}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*1.09[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.23[in]*65000[lb/in2]*1 = \mathbf{36.72}[kip]$ Eq. J3-6

Shear yielding [Kip] 56.12 30.00 DL 0.53 Eq. J4-3

$A_g = L_p*t_p = 12.2[in]*0.23[in] = \mathbf{2.81}[in2]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*2.81[in2] = \mathbf{56.12}[kip]$ Eq. J4-3

Shear rupture [Kip] 42.94 30.00 DL 0.70 Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 12.2[in] - 3*0.875[in] = \mathbf{9.58}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 9.58[in]*0.23[in] = \mathbf{2.2}[in2]$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000[lb/in2]*2.2[in2] = \mathbf{42.94}[kip]$ Eq. J4-4

Block shear [Kip] 37.38 30.00 DL 0.80 Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.25[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.23[in] = \mathbf{0.417}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.5[in] + (3 - 1)*3[in])*0.23[in] = \mathbf{1.73}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.5[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.23[in] = \mathbf{1.22}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*65000[lb/in2]*1.22[in2] + 1*65000[lb/in2]*0.417[in2], 0.6*50000[lb/in2]*1.73[in2] + 1*65000[lb/in2]*0.417[in2]) = \mathbf{37.38}[kip]$ Eq. J4-5

Flexural yielding [Kip] 46.77 30.00 DL 0.64 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000[lb/in2]*8.59[in3]/5.5[in] = \mathbf{46.77}[kip]$ p. 9-6

Flexural rupture [Kip] 50.77 30.00 DL 0.59 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000[lb/in2]*8.59[in3]/5.5[in] = \mathbf{50.77}[kip]$ p. 9-6

Local web buckling [Kip] 46.77 30.00 DL 0.64 p. 9-7

$h_o = d - d_c = 13.7[in] - 1.5[in] = \mathbf{12.2}[in]$ p. 9-7

$IsTopFlangeBeamCoped = (c<=2*d) \text{ and } (d_c<=d/2) = (5[in]<=2*13.7[in]) \text{ and } (1.5[in]<=13.7[in]/2) =$

True p. 9-7

$c/d <= 1 \rightarrow 5$[in]$/13.7$[in]$<=1 \rightarrow$ **True**

$f = 2*c/d = 2*5$[in]$/13.7$[in] $=$ **0.73** p. 9-7

$c/h_o <= 1 \rightarrow 5$[in]$/12.2$[in]$<=1 \rightarrow$ **True**

$k = 2.2*(h_o/c)^{1.65} = 2.2*(12.2$[in]$/5$[in]$)^{1.65} =$ **9.59** p. 9-7

$F_{cr} = \pi^2*E/(12*(1 - \nu^2))*(t_w/h_o)^2*f*k = \pi^2*2.90E+07$[lb/in2]$/(12*(1 - 0.3^2))*$
$(0.23$[in]$/12.2$[in]$)^2*0.73*9.59 =$ **65178.81**[lb/in2] p. 9-7

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e = 0.599*\min(50000$[lb/in2], 65178.81[lb/in2]$)*8.59$[in3]/
5.5[in] $=$ **46.77**[kip] p. 9-7

Support

Bolt bearing under shear load	[Kip]	171.99	30.00	DL	0.17	Eq. J3-6

$L_{c-end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.20E+31$[in] $- 0.813$[in]$/2) =$ **1.20E+31**[in] Sec. J4.10

$L_{c-spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*(n - 1))*$
$t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31$[in], $2.4*0.75$[in]$) + \min(1.2*2.19$[in], $2.4*$
0.75[in]$)*(3 - 1))*0.49$[in]$*65000$[lb/in2]$*1) =$ **171.99**[kip] Eq. J3-6

Global critical strength ratio **0.82**

NOTATION

a: Plate depth
A_b: Nominal bolt area
A_g: Gross area
A_{gv}: Gross area subject to shear
A_{nt}: Net area subject to tension
A_{nv}: Net area subjected to shear
a': Distance for prying action
α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
B: Available tensile strength per bolt
B: Available strength of all bolts
b': Distance for prying action
b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
C: Bolt group coefficient
c: Coped length
C_2: Edge distance increment
c_{max}: Maximum coped length
d: Nominal bolt diameter
d_c: Coped depth
d_{cb}: Bottom cope depth
d_{cbmax}: Maximum bottom coped depth
d_{ct}: Top cope depth
d_{ctmax}: Maximum top coped depth
d_h: Nominal hole dimension
d_{top}: Beam top edge distance
d': Width of the hole along the length of the fitting
δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
d: Beam depth
dh_h: Horizontal hole dimension
dh_v: Vertical hole dimension
e: Load eccentricity
E: Elastic modulus
f: Plate buckling model adjustment factor
F: Required shear force for combined tension and shear
F_{cr}: Critical stress, flexural stress buckling
F_{nt}: Nominal tensile stress
F_{nv}: Nominal shear stress
F_u: Specified minimum tensile strength
f_v: Required shear stress
F_y: Specified minimum yield stress
F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
h_o: Reduced beam depth
HasEqualLengths: Has equal tributary length for interior and exterior bolts
IsCorrosionConsidered: Is corrosion considered
IsStressUniform: Is the stress uniform
IsTopFlangeBeamCoped: Is the top beam flange coped
k: Plate buckling coefficient
k_1: Bearing factor
k_2: Bearing factor
k: Outside corner radius

L: Length
L: Angle length
$L_{c\text{-}end}$: Clear distance
L_e: Effective length
L_e: Edge distance
L_{eh}: Horizontal edge distance
L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
ν: Poisson's ratio
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
$L_{c\text{-}spa}$: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

Current Date: 2016-05-06 2:03 PM
Units system: English
File name:

Steel connections

Results

Connection name : DA BG All bolted
Connection ID : SC-06-08

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W14X26

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	20.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	8.50	6.13	11.58	✔	p. 10-8
$L_{min} = T/2 = 12.26$[in]$/2 = \mathbf{6.13}$[in]						p. 10-8
$L_{max} = d$ - max(k, d_{ct}) - max(k, d_{cb}) = 13.9[in] - max(0.82[in], 1.5[in]) - max(0.82[in], 0[in]) = **11.58**[in]						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.12	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $= \mathbf{2}$[in]						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
s_{max} = min(24*t_p, 12 [in]) = min(24*0.255[in], 12 [in]) = **6.12**[in]						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8$ [in]						p. 10-9
Angle (Support side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $= \mathbf{1.13}$[in]						Tables J3.4,

J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

Beam

Top cope length	[in]	5.00	--	27.80	✔	

$c_{max} = 2*d = 2*13.9$[in] $=$ **27.8**[in]

Bottom cope length	[in]	0.00	--	27.80	✔	

$c_{max} = 2*d = 2*13.9$[in] $=$ **27.8**[in]

Top cope depth	[in]	1.50	--	2.70	✔	

$d_{ctmax} = \min(d/2, d_{top} - w) = \min(13.9$[in]$/2, 2.7$[in] $- 0$[in]$) =$ **2.7**[in]

Bottom cope depth	[in]	0.00	--	2.70	✔	

$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(13.9$[in]$/2, 13.9$[in] $- 8.5$[in] $- 2.7$[in] $- 0$[in]$) =$ **2.7**[in]

Vertical edge distance	[in]	2.45	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.38	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	63.65	20.00	DL	0.31	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61$[kip]$) =$ **63.65**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	20.00	DL	0.24	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in], $2.4*0.75$[in]$) + \min(1.2*2.19$[in], $2.4* 0.75$[in]$)*(3 - 1))*0.313$[in]$*58000$[lb/in2]$*1) =$ **83.6**[kip] — Eq. J3-6

Shear yielding	[Kip]	76.50	20.00	DL	0.26	Eq. J4-3

$A_g = L_p*t_p = 8.5$[in]$*0.313$[in] $=$ **2.66**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*2.66$[in2]$) =$ **76.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	63.89	20.00	DL	0.31	Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h = 8.5$[in] $- 3*0.875$[in] $=$ **5.88**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88$[in]$*0.313$[in] $=$ **1.84**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*1.84$[in2]$) =$ **63.89**[kip] — Eq. J4-4

Block shear	[Kip]	61.40	20.00	DL	0.33	Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13$[in] $+ (1 - 1)*3$[in] $- (1 - 0.5)*$

$0.875[\mathrm{in}])*0.313[\mathrm{in}] = \mathbf{0.215}[\mathrm{in2}]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[\mathrm{in}] + (3 - 1)*3[\mathrm{in}])*0.313[\mathrm{in}] = \mathbf{2.27}[\mathrm{in2}]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[\mathrm{in}] + (3 - 1)*(3[\mathrm{in}] - 0.875[\mathrm{in}]) - 0.875[\mathrm{in}]/2)*0.313[\mathrm{in}] = \mathbf{1.58}[\mathrm{in2}]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[\mathrm{lb/in2}]*1.58[\mathrm{in2}] + 1*58000[\mathrm{lb/in2}]*0.215[\mathrm{in2}], 0.6*36000[\mathrm{lb/in2}]*2.27[\mathrm{in2}] + 1*58000[\mathrm{lb/in2}]*0.215[\mathrm{in2}])) = \mathbf{61.4}[\mathrm{kip}]$ Eq. J4-5

Angle (Support side)

Bolts shear [Kip] 63.65 20.00 DL 0.31 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[\mathrm{lb/in2}]*0.442[\mathrm{in2}] = \mathbf{10.61}[\mathrm{kip}]$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61[\mathrm{kip}]) = \mathbf{63.65}[\mathrm{kip}]$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 83.60 20.00 DL 0.24 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[\mathrm{in}] - 0.813[\mathrm{in}]/2) = \mathbf{0.844}[\mathrm{in}]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[\mathrm{in}] - 0.813[\mathrm{in}]) = \mathbf{2.19}[\mathrm{in}]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(\min(1.2*0.844[\mathrm{in}], 2.4*0.75[\mathrm{in}]) + \min(1.2*2.19[\mathrm{in}], 2.4*0.75[\mathrm{in}])*(3 - 1))*0.313[\mathrm{in}]*58000[\mathrm{lb/in2}]*1) = \mathbf{83.6}[\mathrm{kip}]$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 76.50 20.00 DL 0.26 Eq. J4-3

$A_g = L_p*t_p = 8.5[\mathrm{in}]*0.313[\mathrm{in}] = \mathbf{2.66}[\mathrm{in2}]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[\mathrm{lb/in2}]*2.66[\mathrm{in2}]) = \mathbf{76.5}[\mathrm{kip}]$ Eq. J4-3

Shear rupture [Kip] 63.89 20.00 DL 0.31 Eq. J4-4

$L_h = d_h + 1/16\ [\mathrm{in}] = 0.813[\mathrm{in}] + 1/16\ [\mathrm{in}] = \mathbf{0.875}[\mathrm{in}]$ Sec. D3-2

$L_e = L - n*L_h = 8.5[\mathrm{in}] - 3*0.875[\mathrm{in}] = \mathbf{5.88}[\mathrm{in}]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88[\mathrm{in}]*0.313[\mathrm{in}] = \mathbf{1.84}[\mathrm{in2}]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[\mathrm{lb/in2}]*1.84[\mathrm{in2}]) = \mathbf{63.89}[\mathrm{kip}]$ Eq. J4-4

Block shear [Kip] 59.70 20.00 DL 0.34 Eq. J4-5

$dh_h = d_h + 1/16\ [\mathrm{in}] = 1[\mathrm{in}] + 1/16\ [\mathrm{in}] = \mathbf{1.06}[\mathrm{in}]$ Sec. D3-2

$dh_v = d_h + 1/16\ [\mathrm{in}] = 0.813[\mathrm{in}] + 1/16\ [\mathrm{in}] = \mathbf{0.875}[\mathrm{in}]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[\mathrm{in}] + (1 - 1)*5.5[\mathrm{in}] - (1 - 0.5)*1.06[\mathrm{in}])*0.313[\mathrm{in}] = \mathbf{0.186}[\mathrm{in2}]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[\mathrm{in}] + (3 - 1)*3[\mathrm{in}])*0.313[\mathrm{in}] = \mathbf{2.27}[\mathrm{in2}]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[\mathrm{in}] + (3 - 1)*(3[\mathrm{in}] - 0.875[\mathrm{in}]) - 0.875[\mathrm{in}]/2)*0.313[\mathrm{in}] = \mathbf{1.58}[\mathrm{in2}]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[\mathrm{lb/in2}]*1.58[\mathrm{in2}] + 1*58000[\mathrm{lb/in2}]*0.186[\mathrm{in2}], 0.6*36000[\mathrm{lb/in2}]*2.27[\mathrm{in2}] + 1*58000[\mathrm{lb/in2}]*0.186[\mathrm{in2}])) = \mathbf{59.7}[\mathrm{kip}]$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 10.57 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 20[\mathrm{kip}]/(0.442[\mathrm{in2}]*6) = \mathbf{7541.48}[\mathrm{lb/in2}]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[\mathrm{lb/in2}] - 90000[\mathrm{lb/in2}]*7541.48[\mathrm{lb/in2}]/(0.5*48000[\mathrm{lb/in2}]), 0.0), 90000[\mathrm{lb/in2}]) = \mathbf{88719.46}[\mathrm{lb/in2}]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*88719.46[\mathrm{lb/in2}]*0.442[\mathrm{in2}] = \mathbf{19.61}[\mathrm{kip}]$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 20[\mathrm{kip}]/(0.442[\mathrm{in2}]*6) = \mathbf{7541.48}[\mathrm{lb/in2}]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[\mathrm{lb/in2}] - 90000[\mathrm{lb/in2}]*7541.48[\mathrm{lb/in2}]/(0.5*48000[\mathrm{lb/in2}]), 0.0), 90000[\mathrm{lb/in2}]) = \mathbf{88719.46}[\mathrm{lb/in2}]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*88719.46[\mathrm{lb/in2}]*0.442[\mathrm{in2}] = \mathbf{19.61}[\mathrm{kip}]$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[\mathrm{in}] + 0.75[\mathrm{in}]/2, 1.25*2.72[\mathrm{in}] + 0.75[\mathrm{in}]/2) = \mathbf{1.5}[\mathrm{in}]$ p. 9-12

$b' = b - d/2 = 2.72[\mathrm{in}] - 0.75[\mathrm{in}]/2 = \mathbf{2.34}[\mathrm{in}]$ p. 9-12

$\rho = b'/a' = 2.34[\mathrm{in}]/1.5[\mathrm{in}] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\,[in]/3\,[in] = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*19.61\,[kip]*2.34\,[in])/(0.5*3\,[in]*58000\,[lb/in2]))^{0.5} = \mathbf{1.33}\,[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.33\,[in]/0.313\,[in])^2 - 1) = \mathbf{9.1}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313\,[in]/1.33\,[in])^2*(1 + 0.729) = \mathbf{0.096}$ p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13\,[in] + 0.75\,[in]/2, 1.25*2.72\,[in] + 0.75\,[in]/2) = \mathbf{1.5}\,[in]$ p. 9-12

$b' = b - d/2 = 2.72\,[in] - 0.75\,[in]/2 = \mathbf{2.34}\,[in]$ p. 9-12

$\rho = b'/a' = 2.34\,[in]/1.5\,[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\,[in]/2.75\,[in] = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*19.61\,[kip]*2.34\,[in])/(0.5*2.75\,[in]*58000\,[lb/in2]))^{0.5} = \mathbf{1.39}\,[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.39\,[in]/0.313\,[in])^2 - 1) = \mathbf{10.33}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313\,[in]/1.39\,[in])^2*(1 + 0.705) = \mathbf{0.0868}$ p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.0868 + (3 - 2)*0.096)/3 = \mathbf{0.0898}$ p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (19.61\,[kip]*0.0898) = \mathbf{10.57}\,[kip]$ p. 9-10

<u>Beam</u>

Bolt bearing under shear load [Kip] 44.75 20.00 DL 0.45 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 2.45\,[in] - 0.813\,[in]/2) = \mathbf{2.04}\,[in]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\,[in] - 0.813\,[in]) = \mathbf{2.19}\,[in]$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*2.04\,[in], 2.4*0.75\,[in]) + \min(1.2*2.19\,[in], 2.4*0.75\,[in])*(3 - 1))*0.255\,[in]*65000\,[lb/in2]*1 = \mathbf{44.75}\,[kip]$ Eq. J3-6

Shear yielding [Kip] 63.24 20.00 DL 0.32 Eq. J4-3

$A_g = L_p*t_p = 12.4\,[in]*0.255\,[in] = \mathbf{3.16}\,[in2]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000\,[lb/in2]*3.16\,[in2] = \mathbf{63.24}\,[kip]$ Eq. J4-3

Shear rupture [Kip] 48.61 20.00 DL 0.41 Eq. J4-4

$L_h = d_h + 1/16\,[in] = 0.813\,[in] + 1/16\,[in] = \mathbf{0.875}\,[in]$ Sec. D3-2

$L_e = L - n*L_h = 12.4\,[in] - 3*0.875\,[in] = \mathbf{9.78}\,[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 9.78\,[in]*0.255\,[in] = \mathbf{2.49}\,[in2]$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000\,[lb/in2]*2.49\,[in2] = \mathbf{48.61}\,[kip]$ Eq. J4-4

Block shear [Kip] 47.20 20.00 DL 0.42 Eq. J4-5

$dh_h = d_h + 1/16\,[in] = 0.813\,[in] + 1/16\,[in] = \mathbf{0.875}\,[in]$ Sec. D3-2

$dh_v = d_h + 1/16\,[in] = 0.813\,[in] + 1/16\,[in] = \mathbf{0.875}\,[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.38\,[in] + (1 - 1)*3\,[in] - (1 - 0.5)*0.875\,[in])*0.255\,[in] = \mathbf{0.494}\,[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (2.45\,[in] + (3 - 1)*3\,[in])*0.255\,[in] = \mathbf{2.15}\,[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (2.45\,[in] + (3 - 1)*(3\,[in] - 0.875\,[in]) - 0.875\,[in]/2)*0.255\,[in] = \mathbf{1.6}\,[in2]$ Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*65000\,[lb/in2]*1.6\,[in2] + 1*65000\,[lb/in2]*0.494\,[in2], 0.6*50000\,[lb/in2]*2.15\,[in2] + 1*65000\,[lb/in2]*0.494\,[in2]) = \mathbf{47.2}\,[kip]$ Eq. J4-5

Flexural yielding [Kip] 54.21 20.00 DL 0.37 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000\,[lb/in2]*9.96\,[in3]/5.5\,[in] = \mathbf{54.21}\,[kip]$ p. 9-6

Flexural rupture [Kip] 58.84 20.00 DL 0.34 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000\,[lb/in2]*9.96\,[in3]/5.5\,[in] = \mathbf{58.84}\,[kip]$ p. 9-6

Local web buckling [Kip] 54.21 20.00 DL 0.37 p. 9-7

$h_o = d - d_c = 13.9\,[in] - 1.5\,[in] = \mathbf{12.4}\,[in]$ p. 9-7

$IsTopFlangeBeamCoped = (c<=2*d) \text{ and } (d_c<=d/2) = (5\,[in]<=2*13.9\,[in]) \text{ and } (1.5\,[in]<=13.9\,[in]/2) = \mathbf{True}$ p. 9-7

c/d<=1 → 5[in]/13.9[in]<=1 → **True**

f = 2*c/d = 2*5[in]/13.9[in] = **0.719** p. 9-7

c/h_o<=1 → 5[in]/12.4[in]<=1 → **True**

$k = 2.2*(h_o/c)^{1.65} = 2.2*(12.4\text{[in]}/5\text{[in]})^{1.65}$ = **9.85** p. 9-7

$F_{cr} = \pi^2*E/(12*(1 - \nu^2))*(t_w/h_o)^2*f*k = \pi^2*2.90E+07\text{[lb/in2]}/(12*(1 - 0.3^2))*$ $(0.255\text{[in]}/12.4\text{[in]})^2*0.719*9.85$ = **78517.28**[lb/in2] p. 9-7

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e$ = 0.599*min(50000[lb/in2], 78517.28[lb/in2])*9.96[in3]/ 5.5[in] = **54.21**[kip] p. 9-7

Support

Bolt bearing under shear load	[Kip]	161.46	20.00	DL	0.12	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*$ $t_p*F_u*n_c)$ = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4* 0.75[in])*(3 - 1))*0.46[in]*65000[lb/in2]*1) = **161.46**[kip] Eq. J3-6

Global critical strength ratio **0.45**

NOTATION

a: Plate depth
A_b: Nominal bolt area
A_g: Gross area
A_{gv}: Gross area subject to shear
A_{nt}: Net area subject to tension
A_{nv}: Net area subjected to shear
a': Distance for prying action
α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
B: Available tensile strength per bolt
B: Available strength of all bolts
b': Distance for prying action
b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
C: Bolt group coefficient
c: Coped length
C_2: Edge distance increment
c_{max}: Maximum coped length
d: Nominal bolt diameter
d_c: Coped depth
d_{cb}: Bottom cope depth
d_{cbmax}: Maximum bottom coped depth
d_{ct}: Top cope depth
d_{ctmax}: Maximum top coped depth
d_h: Nominal hole dimension
d_{top}: Beam top edge distance
d': Width of the hole along the length of the fitting
δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
d: Beam depth
dh_h: Horizontal hole dimension
dh_v: Vertical hole dimension
e: Load eccentricity
E: Elastic modulus
f: Plate buckling model adjustment factor
F: Required shear force for combined tension and shear
F_{cr}: Critical stress, flexural stress buckling
F_{nt}: Nominal tensile stress
F_{nv}: Nominal shear stress
F_u: Specified minimum tensile strength
f_v: Required shear stress
F_y: Specified minimum yield stress
F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
h_o: Reduced beam depth
HasEqualLengths: Has equal tributary length for interior and exterior bolts
IsCorrosionConsidered: Is corrosion considered
IsStressUniform: Is the stress uniform
IsTopFlangeBeamCoped: Is the top beam flange coped
k: Plate buckling coefficient
k_1: Bearing factor
k_2: Bearing factor
k: Outside corner radius
L: Length

L: Angle length
L_{c-end}: Clear distance
L_e: Effective length
L_e: Edge distance
L_{eh}: Horizontal edge distance
L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
ν: Poisson's ratio
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
L_{c-spa}: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

Current Date: 2016-05-06 11:26 AM
Units system: English
File name:

Steel connections

Results

Connection name	:	**DA BG All bolted**
Connection ID	:	**SC-06-09**

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W16X26

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	30.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	8.50	7.10	12.70	✔	p. 10-8
$L_{min} = T/2 = 14.21$[in]$/2 = \mathbf{7.1}$[in]						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 15.7$[in] $- \max(0.747$[in], 1.5[in]$) - \max(0.747$[in], 1.5[in]$) = \mathbf{12.7}$[in]						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.00	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.00	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $= \mathbf{2}$[in]						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.25$[in], 12 [in]$) = \mathbf{6}$[in]						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8$ [in]						p. 10-9
<u>Angle (Support side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $= \mathbf{1.13}$[in]						Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]) = **7.5**[in] — Sec. J3.5

Beam

Top cope length	[in]	5.00	--	31.40	✔	

$c_{max} = 2*d = 2*15.7$[in] = **31.4**[in]

Bottom cope length	[in]	5.00	--	31.40	✔	

$c_{max} = 2*d = 2*15.7$[in] = **31.4**[in]

Top cope depth	[in]	1.50	--	1.75	✔	

$d_{ctmax} = \min(d/2, d_{top} - w) = \min(15.7$[in]/2, 1.75[in] - 0[in]) = **1.75**[in]

Bottom cope depth	[in]	1.50	--	5.45	✔	

$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(15.7$[in]/2, 15.7[in] - 8.5[in] - 1.75[in] - 0[in]) = **5.45**[in]

Vertical edge distance	[in]	1.50	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.50	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] + 0[in] = **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	63.65	30.00	DL	0.47	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]*0.442[in2] = **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61$[kip]) = **63.65**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	30.00	DL	0.36	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] - 0.813[in]/2) = **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] - 0.813[in]) = **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4* 0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] — Eq. J3-6

Shear yielding	[Kip]	76.50	30.00	DL	0.39	Eq. J4-3

$A_g = L_p*t_p = 8.5$[in]*0.313[in] = **2.66**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]*2.66[in2]) = **76.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	63.89	30.00	DL	0.47	Eq. J4-4

$L_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h = 8.5$[in] - 3*0.875[in] = **5.88**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88$[in]*0.313[in] = **1.84**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]*1.84[in2]) = **63.89**[kip] — Eq. J4-4

Block shear	[Kip]	59.13	30.00	DL	0.51	Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1$[in] + (1 - 1)*3[in] - (1 - 0.5)* 0.875[in])*0.313[in] = **0.176**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25$[in] + (3 - 1)*(3[in] - 0.875[in]) -

$0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{1.58}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*1.58\text{[in2]} + 1*58000\text{[lb/in2]}*0.176\text{[in2]}, 0.6*36000\text{[lb/in2]}*2.27\text{[in2]} + 1*58000\text{[lb/in2]}*0.176\text{[in2]})) = \mathbf{59.13}\text{[kip]}$ Eq. J4-5

Angle (Support side)

Bolts shear [Kip] 63.65 30.00 DL 0.47 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (3*10.61\text{[kip]}) = \mathbf{63.65}\text{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 83.60 30.00 DL 0.36 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(3/(1*3))*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(3 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{83.6}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 76.50 30.00 DL 0.39 Eq. J4-3

$A_g = L_p*t_p = 8.5\text{[in]}*0.313\text{[in]} = \mathbf{2.66}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*2.66\text{[in2]}) = \mathbf{76.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 63.89 30.00 DL 0.47 Eq. J4-4

$L_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 8.5\text{[in]} - 3*0.875\text{[in]} = \mathbf{5.88}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 5.88\text{[in]}*0.313\text{[in]} = \mathbf{1.84}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*1.84\text{[in2]}) = \mathbf{63.89}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 59.70 30.00 DL 0.50 Eq. J4-5

$dh_h = d_h + 1/16\ \text{[in]} = 1\text{[in]} + 1/16\ \text{[in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13\text{[in]} + (1 - 1)*5.5\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.186}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (3 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{2.27}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (3 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{1.58}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*1.58\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]}, 0.6*36000\text{[lb/in2]}*2.27\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]})) = \mathbf{59.7}\text{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 10.57 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 30\text{[kip]}/(0.442\text{[in2]}*6) = \mathbf{11312.22}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*11312.22\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{74579.19}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*74579.19\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{16.48}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 30\text{[kip]}/(0.442\text{[in2]}*6) = \mathbf{11312.22}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*11312.22\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{74579.19}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*74579.19\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{16.48}\text{[kip]}$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*16.48\text{[kip]}*2.34\text{[in]})/(0.5*3\text{[in]}*58000\text{[lb/in2]}))^{0.5} = \mathbf{1.22}\text{[in]}$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.22[in]/0.313[in])^2 - 1) =$ **7.57** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.22[in])^2*(1 + 0.729) =$ **0.114** p. 9-13

$a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) =$ **1.5**[in] p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 =$ **2.34**[in] p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] =$ **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] =$ **0.705** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*16.48[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} =$ **1.27**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.27[in]/0.313[in])^2 - 1) =$ **8.59** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.27[in])^2*(1 + 0.705) =$ **0.103** p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.103 + (3 - 2)*0.114)/3 =$ **0.107** p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (16.48[kip]*0.107) =$ **10.57**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	39.91	30.00	DL	0.75	Eq. J3-6

$L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 1.5[in] - 0.813[in]/2) =$ **1.09**[in] Sec. J4.10

$L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*1.09[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.25[in]*65000[lb/in2]*1 =$ **39.91**[kip] Eq. J3-6

Shear yielding	[Kip]	63.50	30.00	DL	0.47	Eq. J4-3

$A_g = L_p*t_p = 12.7[in]*0.25[in] =$ **3.18**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*3.18[in2] =$ **63.5**[kip] Eq. J4-3

Shear rupture	[Kip]	49.12	30.00	DL	0.61	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] =$ **0.875**[in] Sec. D3-2

$L_e = L - n*L_h = 12.7[in] - 3*0.875[in] =$ **10.08**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 10.08[in]*0.25[in] =$ **2.52**[in2] Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000[lb/in2]*2.52[in2] =$ **49.12**[kip] Eq. J4-4

Block shear	[Kip]	42.66	30.00	DL	0.70	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] =$ **0.875**[in] Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] =$ **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.5[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.25[in] =$ **0.516**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.5[in] + (3 - 1)*3[in])*0.25[in] =$ **1.88**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.5[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.25[in] =$ **1.33**[in2] Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*min(0.6*65000[lb/in2]*1.33[in2] + 1*65000[lb/in2]*0.516[in2], 0.6*50000[lb/in2]*1.88[in2] + 1*65000[lb/in2]*0.516[in2]) =$ **42.66**[kip] Eq. J4-5

Flexural yielding	[Kip]	36.58	30.00	DL	0.82	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000[lb/in2]*6.72[in3]/5.5[in] =$ **36.58**[kip] p. 9-6

Flexural rupture	[Kip]	39.71	30.00	DL	0.76	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000[lb/in2]*6.72[in3]/5.5[in] =$ **39.71**[kip] p. 9-6

Local web buckling	[Kip]	36.58	30.00	DL	0.82	p. 9-8, p. 9-7

$h_o = d - d_c = 15.7[in] - 3[in] =$ **12.7**[in] p. 9-7

IsBeamCopedAtBothFlanges $= (c_t<=2*d)$ and $(d_{ct}<=0.2*d)$ and $(c_b<=2*d)$ and $(d_{cb}<=0.2*d) =$ (5[in]<=2*15.7[in]) and (1.5[in]<=0.2*15.7[in]) and (5[in]<=2*15.7[in]) and (1.5[in]<=0.2*15.7[in]) = **True** p. 9-8

$f_d = 3.5 - 7.5*(d_c/d) = 3.5 - 7.5*(1.5[in]/15.7[in]) =$ **2.78** p. 9-8

$F_{cr} = 0.62*\pi*E*t_w^2/(c*h_o)*f_d = 0.62*\pi*2.90E+07[lb/in2]*0.25[in]^2/(5[in]*12.7[in])*2.78 =$

1.55E+05[lb/in2] p. 9-8

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e$ = 0.599*min(50000[lb/in2], 1.55E+05[lb/in2])*6.72[in3]/ 5.5[in] = **36.58**[kip] p. 9-7

Support

Bolt bearing under shear load	[Kip]	164.97	30.00	DL	0.18	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c)$ = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4* 0.75[in])*(3 - 1))*0.47[in]*65000[lb/in2]*1) = **164.97**[kip] Eq. J3-6

Global critical strength ratio **0.82**

NOTATION

a: Plate depth
A_b: Nominal bolt area
A_g: Gross area
A_{gv}: Gross area subject to shear
A_{nt}: Net area subject to tension
A_{nv}: Net area subjected to shear
a': Distance for prying action
α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
B: Available tensile strength per bolt
B: Available strength of all bolts
b': Distance for prying action
b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
C: Bolt group coefficient
c: Coped length
C_2: Edge distance increment
c_b: Bottom cope length
c_t: Top cope length
c_{max}: Maximum coped length
d: Nominal bolt diameter
d_c: Coped depth
d_{cb}: Bottom cope depth
d_{cbmax}: Maximum bottom coped depth
d_{ct}: Top cope depth
d_{ctmax}: Maximum top coped depth
d_h: Nominal hole dimension
d_{top}: Beam top edge distance
d': Width of the hole along the length of the fitting
δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
d: Beam depth
dh_h: Horizontal hole dimension
dh_v: Vertical hole dimension
e: Load eccentricity
E: Elastic modulus
F: Required shear force for combined tension and shear
F_{cr}: Critical stress, flexural stress buckling
f_d: Plate buckling model adjustment factor for beam coped at both flanges
F_{nt}: Nominal tensile stress
F_{nv}: Nominal shear stress
F_u: Specified minimum tensile strength
f_v: Required shear stress
F_y: Specified minimum yield stress
F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
h_o: Reduced beam depth
HasEqualLengths: Has equal tributary length for interior and exterior bolts
IsBeamCopedAtBothFlanges: Is beam coped at both flanges
IsCorrosionConsidered: Is corrosion considered
IsStressUniform: Is the stress uniform
k_1: Bearing factor
k_2: Bearing factor
k: Outside corner radius
L: Length
L: Angle length
$L_{c\text{-}end}$: Clear distance
L_e: Effective length
L_e: Edge distance
L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
$L_{c\text{-}spa}$: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

Current Date: 2016-05-06 2:10 PM
Units system: English
File name:

Steel connections

Results

Connection name : DA BG All bolted
Connection ID : SC-06-10

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W16X31

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	30.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	8.50	7.11	12.90	✓	p. 10-8
$L_{min} = T/2 = 14.22[in]/2 = \mathbf{7.11}[in]$						p. 10-8
$L_{max} = d$ - max(k, d_{ct}) - max$(k, d_{cb}) = 15.9[in]$ - max$(0.842[in], 1.5[in])$ - max$(0.842[in], 1.5[in]) = \mathbf{12.9}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✓	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.00	--	✓	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.60	✓	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} =$ min$(24*t_p, 12\ [in]) =$ min$(24*0.275[in], 12\ [in]) = \mathbf{6.6}[in]$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✓	p. 10-9
$t_{pmax} = 5/8\ [in]$						p. 10-9
Angle (Support side)						
Vertical edge distance	[in]	1.25	1.00	--	✓	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✓	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0.125[in] = \mathbf{1.13}[in]$						Tables J3.4,

J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	6.60	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] = **2**[in] Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.275[in], 12 [in]) = **6.6**[in] Sec. J3.5

Beam

Top cope length	[in]	4.00	--	31.80	✔

$c_{max} = 2*d = 2*15.9$[in] = **31.8**[in]

Bottom cope length	[in]	4.00	--	31.80	✔

$c_{max} = 2*d = 2*15.9$[in] = **31.8**[in]

Top cope depth	[in]	1.50	--	3.70	✔

$d_{ctmax} = \min(d/2, d_{top} - w)$ = min(15.9[in]/2, 3.7[in] - 0[in]) = **3.7**[in]

Bottom cope depth	[in]	1.50	--	3.70	✔

$d_{cbmax} = \min(d/2, d - L - d_{top} - w)$ = min(15.9[in]/2, 15.9[in] - 8.5[in] - 3.7[in] - 0[in]) = **3.7**[in]

Vertical edge distance	[in]	3.45	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1[in] + 0[in] = **1**[in] Tables J3.4, J3.5

Horizontal edge distance	[in]	2.38	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1[in] + 0[in] = **1**[in] Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Angle (Beam side)

Bolts shear	[Kip]	63.65	30.00	DL	0.47	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n)$ = 2 * (3*10.61[kip]) = **63.65**[kip] Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	30.00	DL	0.36	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c)$ = 2 * (0.5*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] Eq. J3-6

Shear yielding	[Kip]	76.50	30.00	DL	0.39	Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g)$ = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] Eq. J4-3

Shear rupture	[Kip]	63.89	30.00	DL	0.47	Eq. J4-4

$L_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$L_e = L - n*L_h$ = 8.5[in] - 3*0.875[in] = **5.88**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 5.88[in]*0.313[in] = **1.84**[in2] Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv})$ = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] Eq. J4-4

Block shear	[Kip]	61.40	30.00	DL	0.49	Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.13[in] + (1 - 1)*3[in] - (1 - 0.5)*

0.875[in])*0.313[in] = **0.215**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}))$ = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.215[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.215[in2])) = **61.4**[kip] Eq. J4-5

Angle (Support side)

Bolts shear	[Kip]	63.65	30.00	DL	0.47		Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n)$ = 2 * (3*10.61[kip]) = **63.65**[kip] Tables (7-1..14)

Bolt bearing under shear load	[Kip]	83.60	30.00	DL	0.36		p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c)$ = 2 * (0.5*(3/(1*3))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.313[in]*58000[lb/in2]*1) = **83.6**[kip] p. 7-18, Sec. J3.10

Shear yielding	[Kip]	76.50	30.00	DL	0.39		Eq. J4-3

$A_g = L_p*t_p$ = 8.5[in]*0.313[in] = **2.66**[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g)$ = 2 * (0.667*0.60*36000[lb/in2]*2.66[in2]) = **76.5**[kip] Eq. J4-3

Shear rupture	[Kip]	63.89	30.00	DL	0.47		Eq. J4-4

$L_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$L_e = L - n*L_h$ = 8.5[in] - 3*0.875[in] = **5.88**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 5.88[in]*0.313[in] = **1.84**[in2] Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv})$ = 2 * (0.5*0.60*58000[lb/in2]*1.84[in2]) = **63.89**[kip] Eq. J4-4

Block shear	[Kip]	59.70	30.00	DL	0.50		Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (3 - 1)*3[in])*0.313[in] = **2.27**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (3 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **1.58**[in2] Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}))$ = 2 * (0.5*min(0.6*58000[lb/in2]*1.58[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*2.27[in2] + 1*58000[lb/in2]*0.186[in2])) = **59.7**[kip] Eq. J4-5

Resulting tension capacity due prying action	[Kip]	10.57	0.00	DL	0.00		p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts})$ = 30[kip]/(0.442[in2]*6) = **11312.22**[lb/in2] Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*11312.22[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **74579.19**[lb/in2] Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*74579.19[lb/in2]*0.442[in2] = **16.48**[kip] Eq. J3-2

$f_v = F/(A_b*N_{bolts})$ = 30[kip]/(0.442[in2]*6) = **11312.22**[lb/in2] Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*11312.22[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **74579.19**[lb/in2] Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*74579.19[lb/in2]*0.442[in2] = **16.48**[kip] Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2)$ = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

$\rho = b'/a'$ = 2.34[in]/1.5[in] = **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[\mathrm{in}]/3[\mathrm{in}] = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*16.48[\mathrm{kip}]*2.34[\mathrm{in}])/(0.5*3[\mathrm{in}]*58000[\mathrm{lb/in2}]))^{0.5} = \mathbf{1.22}[\mathrm{in}]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.22[\mathrm{in}]/0.313[\mathrm{in}])^2 - 1) = \mathbf{7.57}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[\mathrm{in}]/1.22[\mathrm{in}])^2*(1 + 0.729) = \mathbf{0.114}$ p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[\mathrm{in}] + 0.75[\mathrm{in}]/2, 1.25*2.72[\mathrm{in}] + 0.75[\mathrm{in}]/2) = \mathbf{1.5}[\mathrm{in}]$ p. 9-12

$b' = b - d/2 = 2.72[\mathrm{in}] - 0.75[\mathrm{in}]/2 = \mathbf{2.34}[\mathrm{in}]$ p. 9-12

$\rho = b'/a' = 2.34[\mathrm{in}]/1.5[\mathrm{in}] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[\mathrm{in}]/2.75[\mathrm{in}] = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*16.48[\mathrm{kip}]*2.34[\mathrm{in}])/(0.5*2.75[\mathrm{in}]*58000[\mathrm{lb/in2}]))^{0.5} = \mathbf{1.27}[\mathrm{in}]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.27[\mathrm{in}]/0.313[\mathrm{in}])^2 - 1) = \mathbf{8.59}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[\mathrm{in}]/1.27[\mathrm{in}])^2*(1 + 0.705) = \mathbf{0.103}$ p. 9-13

$HasEqualLengths \rightarrow$ **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.103 + (3 - 2)*0.114)/3 = \mathbf{0.107}$ p. 9-13

$T_{avail} = 6 * (B*Q) = 6 * (16.48[\mathrm{kip}]*0.107) = \mathbf{10.57}[\mathrm{kip}]$ p. 9-10

<u>Beam</u>

Bolt bearing under shear load [Kip] 48.26 30.00 DL 0.62 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 3.45[\mathrm{in}] - 0.813[\mathrm{in}]/2) = \mathbf{3.04}[\mathrm{in}]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[\mathrm{in}] - 0.813[\mathrm{in}]) = \mathbf{2.19}[\mathrm{in}]$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*3.04[\mathrm{in}], 2.4*0.75[\mathrm{in}]) + \min(1.2*2.19[\mathrm{in}], 2.4*0.75[\mathrm{in}])*(3 - 1))*0.275[\mathrm{in}]*65000[\mathrm{lb/in2}]*1 = \mathbf{48.26}[\mathrm{kip}]$ Eq. J3-6

Shear yielding [Kip] 70.95 30.00 DL 0.42 Eq. J4-3

$A_g = L_p*t_p = 12.9[\mathrm{in}]*0.275[\mathrm{in}] = \mathbf{3.55}[\mathrm{in2}]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[\mathrm{lb/in2}]*3.55[\mathrm{in2}] = \mathbf{70.95}[\mathrm{kip}]$ Eq. J4-3

Shear rupture [Kip] 55.10 30.00 DL 0.54 Eq. J4-4

$L_h = d_h + 1/16\ [\mathrm{in}] = 0.813[\mathrm{in}] + 1/16\ [\mathrm{in}] = \mathbf{0.875}[\mathrm{in}]$ Sec. D3-2

$L_e = L - n*L_h = 12.9[\mathrm{in}] - 3*0.875[\mathrm{in}] = \mathbf{10.28}[\mathrm{in}]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 10.28[\mathrm{in}]*0.275[\mathrm{in}] = \mathbf{2.83}[\mathrm{in2}]$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000[\mathrm{lb/in2}]*2.83[\mathrm{in2}] = \mathbf{55.1}[\mathrm{kip}]$ Eq. J4-4

Block shear [Kip] 56.26 30.00 DL 0.53 Eq. J4-5

$dh_h = d_h + 1/16\ [\mathrm{in}] = 0.813[\mathrm{in}] + 1/16\ [\mathrm{in}] = \mathbf{0.875}[\mathrm{in}]$ Sec. D3-2

$dh_v = d_h + 1/16\ [\mathrm{in}] = 0.813[\mathrm{in}] + 1/16\ [\mathrm{in}] = \mathbf{0.875}[\mathrm{in}]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.38[\mathrm{in}] + (1 - 1)*3[\mathrm{in}] - (1 - 0.5)*0.875[\mathrm{in}])*0.275[\mathrm{in}] = \mathbf{0.533}[\mathrm{in2}]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (3.45[\mathrm{in}] + (3 - 1)*3[\mathrm{in}])*0.275[\mathrm{in}] = \mathbf{2.6}[\mathrm{in2}]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (3.45[\mathrm{in}] + (3 - 1)*(3[\mathrm{in}] - 0.875[\mathrm{in}]) - 0.875[\mathrm{in}]/2)*0.275[\mathrm{in}] = \mathbf{2}[\mathrm{in2}]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*65000[\mathrm{lb/in2}]*2[\mathrm{in2}] + 1*65000[\mathrm{lb/in2}]*0.533[\mathrm{in2}], 0.6*50000[\mathrm{lb/in2}]*2.6[\mathrm{in2}] + 1*65000[\mathrm{lb/in2}]*0.533[\mathrm{in2}]) = \mathbf{56.26}[\mathrm{kip}]$ Eq. J4-5

Flexural yielding [Kip] 50.75 30.00 DL 0.59 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000[\mathrm{lb/in2}]*7.63[\mathrm{in3}]/4.5[\mathrm{in}] = \mathbf{50.75}[\mathrm{kip}]$ p. 9-6

Flexural rupture [Kip] 55.08 30.00 DL 0.54 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000[\mathrm{lb/in2}]*7.63[\mathrm{in3}]/4.5[\mathrm{in}] = \mathbf{55.08}[\mathrm{kip}]$ p. 9-6

Local web buckling [Kip] 50.75 30.00 DL 0.59 p. 9-8, p. 9-7

$h_o = d - d_c = 15.9[\mathrm{in}] - 3[\mathrm{in}] = \mathbf{12.9}[\mathrm{in}]$ p. 9-7

$IsBeamCopedAtBothFlanges = (c_t{<=}2*d)$ and $(d_{ct}{<=}0.2*d)$ and $(c_b{<=}2*d)$ and $(d_{cb}{<=}0.2*d) = (4[\mathrm{in}]{<=}2*15.9[\mathrm{in}])$ and $(1.5[\mathrm{in}]{<=}0.2*15.9[\mathrm{in}])$ and $(4[\mathrm{in}]{<=}2*15.9[\mathrm{in}])$ and $(1.5[\mathrm{in}]{<=}0.2*$

15.9[in]) = **True** p. 9-8

f_d = 3.5 - 7.5*(d_c/d) = 3.5 - 7.5*(1.5[in]/15.9[in]) = **2.79** p. 9-8

F_{cr} = 0.62*π*E*t_w^2/(c*h_o)*f_d = 0.62*π*2.90E+07[lb/in2]*0.275[in]^2/(4[in]*12.9[in])*2.79 = **2.31E+05**[lb/in2] p. 9-8

$(1/\Omega)R_n$ = $(1/\Omega)$*min(F_y, F_{cr})*S_{net}/e = 0.599*min(50000[lb/in2], 2.31E+05[lb/in2])*7.63[in3]/4.5[in] = **50.75**[kip] p. 9-7

Support

Bolt bearing under shear load	[Kip]	96.53	30.00	DL	0.31	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * (($1/\Omega$)*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(3 - 1))*0.275[in]*65000[lb/in2]*1) = **96.53**[kip] Eq. J3-6

Global critical strength ratio **0.62**

NOTATION

- a: Plate depth
- A_b: Nominal bolt area
- A_g: Gross area
- A_{gv}: Gross area subject to shear
- A_{nt}: Net area subject to tension
- A_{nv}: Net area subjected to shear
- a': Distance for prying action
- α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
- B: Available tensile strength per bolt
- B: Available strength of all bolts
- b': Distance for prying action
- b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
- C: Bolt group coefficient
- c: Coped length
- C_2: Edge distance increment
- c_b: Bottom cope length
- c_t: Top cope length
- c_{max}: Maximum coped length
- d: Nominal bolt diameter
- d_c: Coped depth
- d_{cb}: Bottom cope depth
- d_{cbmax}: Maximum bottom coped depth
- d_{ct}: Top cope depth
- d_{ctmax}: Maximum top coped depth
- d_h: Nominal hole dimension
- d_{top}: Beam top edge distance
- d': Width of the hole along the length of the fitting
- δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
- d: Beam depth
- dh_h: Horizontal hole dimension
- dh_v: Vertical hole dimension
- e: Load eccentricity
- E: Elastic modulus
- F: Required shear force for combined tension and shear
- F_{cr}: Critical stress, flexural stress buckling
- f_d: Plate buckling model adjustment factor for beam coped at both flanges
- F_{nt}: Nominal tensile stress
- F_{nv}: Nominal shear stress
- F_u: Specified minimum tensile strength
- f_v: Required shear stress
- F_y: Specified minimum yield stress
- F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
- h_o: Reduced beam depth
- *HasEqualLengths*: Has equal tributary length for interior and exterior bolts
- *IsBeamCopedAtBothFlanges*: Is beam coped at both flanges
- *IsCorrosionConsidered*: Is corrosion considered
- *IsStressUniform*: Is the stress uniform
- k_1: Bearing factor
- k_2: Bearing factor
- k: Outside corner radius
- L: Length
- L: Angle length
- $L_{c\text{-}end}$: Clear distance

L_e: Effective length
L_e: Edge distance
L_{eh}: Horizontal edge distance
L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
$L_{c\text{-}spa}$: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

Current Date: 2016-05-06 2:13 PM
Units system: English
File name:

Steel connections

Results

Connection name : DA BG All bolted
Connection ID : SC-06-11

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W18X35

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	40.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	11.50	8.02	13.20	✔	p. 10-8
$L_{min} = T/2 = 16.05$[in]$/2 = \mathbf{8.02}$[in]						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 17.7$[in] $- \max(0.827$[in]$, 1.5$[in]$) - \max(0.827$[in]$, 3$[in]$) = \mathbf{13.2}$[in]						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.20	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75$[in] $= \mathbf{2}$[in]						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.3$[in]$, 12$ [in]$) = \mathbf{7.2}$[in]						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8$ [in]						p. 10-9
<u>Angle (Support side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0.125$[in] $= \mathbf{1.13}$[in]						Tables J3.4, J3.5

Vertical center-to-center spacing (pitch) [in] 3.00 2.00 6.60 Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] Sec. J3.3

$IsCorrosionConsidered \rightarrow$ **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.275$[in], 12 [in]$) =$ **6.6**[in] Sec. J3.5

Beam

Top cope length [in] 5.00 -- 35.40

$c_{max} = 2*d = 2*17.7$[in] $=$ **35.4**[in]

Bottom cope length [in] 5.00 -- 35.40

$c_{max} = 2*d = 2*17.7$[in] $=$ **35.4**[in]

Top cope depth [in] 1.50 -- 2.50

$d_{ctmax} = \min(d/2, d_{top} - w) = \min(17.7$[in]$/2, 2.5$[in] $- 0$[in]$) =$ **2.5**[in]

Bottom cope depth [in] 3.00 -- 3.70

$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(17.7$[in]$/2, 17.7$[in] $- 11.5$[in] $- 2.5$[in] $- 0$[in]$) =$ **3.7**[in]

Vertical edge distance [in] 2.25 1.00 -- Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] Tables J3.4, J3.5

Horizontal edge distance [in] 2.38 1.00 -- Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Angle (Beam side)

Bolts shear [Kip] 84.86 40.00 DL 0.47 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61$[kip]$) =$ **84.86**[kip] Tables (7-1..14)

Bolt bearing under shear load [Kip] 116.23 40.00 DL 0.34 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in]$, 2.4*0.75$[in]$) + \min(1.2*2.19$[in]$, 2.4* 0.75$[in]$)*(4 - 1))*0.313$[in]$*58000$[lb/in2]$*1) =$ **116.23**[kip] Eq. J3-6

Shear yielding [Kip] 103.50 40.00 DL 0.39 Eq. J4-3

$A_g = L_p*t_p = 11.5$[in]$*0.313$[in] $=$ **3.59**[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*3.59$[in2]$) =$ **103.5**[kip] Eq. J4-3

Shear rupture [Kip] 87.00 40.00 DL 0.46 Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] Sec. D3-2

$L_e = L - n*L_h = 11.5$[in] $- 4*0.875$[in] $=$ **8**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8$[in]$*0.313$[in] $=$ **2.5**[in2] Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*2.5$[in2]$) =$ **87**[kip] Eq. J4-4

Block shear [Kip] 81.65 40.00 DL 0.49 Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13$[in] $+ (1 - 1)*3$[in] $- (1 - 0.5)* 0.875$[in]$)*0.313$[in] $=$ **0.215**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] $+ (4 - 1)*3$[in]$)*0.313$[in] $=$ **3.2**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25$[in] $+ (4 - 1)*(3$[in] $- 0.875$[in]$) -$

$0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{2.25}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*2.25\text{[in2]} + 1*58000\text{[lb/in2]}*0.215\text{[in2]}, 0.6*36000\text{[lb/in2]}*3.2\text{[in2]} + 1*58000\text{[lb/in2]}*0.215\text{[in2]})) = \mathbf{81.65}\text{[kip]}$ Eq. J4-5

<u>Angle (Support side)</u>

Bolts shear [Kip] 84.86 40.00 DL 0.47 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61\text{[kip]}) = \mathbf{84.86}\text{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load [Kip] 116.23 40.00 DL 0.34 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(4/(1*4))*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(4 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{116.23}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding [Kip] 103.50 40.00 DL 0.39 Eq. J4-3

$A_g = L_p*t_p = 11.5\text{[in]}*0.313\text{[in]} = \mathbf{3.59}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*3.59\text{[in2]}) = \mathbf{103.5}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 87.00 40.00 DL 0.46 Eq. J4-4

$L_h = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 11.5\text{[in]} - 4*0.875\text{[in]} = \mathbf{8}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8\text{[in]}*0.313\text{[in]} = \mathbf{2.5}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*2.5\text{[in2]}) = \mathbf{87}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 79.95 40.00 DL 0.50 Eq. J4-5

$dh_h = d_h + 1/16\ \text{[in]} = 1\text{[in]} + 1/16\ \text{[in]} = \mathbf{1.06}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \text{[in]} = 0.813\text{[in]} + 1/16\ \text{[in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13\text{[in]} + (1 - 1)*5.5\text{[in]} - (1 - 0.5)*1.06\text{[in]})*0.313\text{[in]} = \mathbf{0.186}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (4 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{3.2}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (4 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{2.25}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*2.25\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]}, 0.6*36000\text{[lb/in2]}*3.2\text{[in2]} + 1*58000\text{[lb/in2]}*0.186\text{[in2]})) = \mathbf{79.95}\text{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action [Kip] 14.33 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 40\text{[kip]}/(0.442\text{[in2]}*8) = \mathbf{11312.22}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*11312.22\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{74579.19}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*74579.19\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{16.48}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 40\text{[kip]}/(0.442\text{[in2]}*8) = \mathbf{11312.22}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*11312.22\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{74579.19}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*74579.19\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{16.48}\text{[kip]}$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*16.48\text{[kip]}*2.34\text{[in]})/(0.5*3\text{[in]}*58000\text{[lb/in2]}))^{0.5} = \mathbf{1.22}\text{[in]}$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.22[in]/0.313[in])^2 - 1) =$ **7.57** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.22[in])^2*(1 + 0.729) =$ **0.114** p. 9-13

$a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) =$ **1.5**[in] p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 =$ **2.34**[in] p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] =$ **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] =$ **0.705** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*16.48[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} =$ **1.27**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.27[in]/0.313[in])^2 - 1) =$ **8.59** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.27[in])^2*(1 + 0.705) =$ **0.103** p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.103 + (4 - 2)*0.114)/4 =$ **0.109** p. 9-13

$T_{avail} = 8 * (B*Q) = 8 * (16.48[kip]*0.109) =$ **14.33**[kip] p. 9-10

Beam

Bolt bearing under shear load	[Kip]	70.20	40.00	DL	0.57	Eq. J3-6

$L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 2.25[in] - 0.813[in]/2) =$ **1.84**[in] Sec. J4.10

$L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*1.84[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.3[in]*65000[lb/in2]*1 =$ **70.2**[kip] Eq. J3-6

Shear yielding	[Kip]	79.20	40.00	DL	0.51	Eq. J4-3

$A_g = L_p*t_p = 13.2[in]*0.3[in] =$ **3.96**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*3.96[in2] =$ **79.2**[kip] Eq. J4-3

Shear rupture	[Kip]	56.75	40.00	DL	0.70	Eq. J4-4

$L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] =$ **0.875**[in] Sec. D3-2

$L_e = L - n*L_h = 13.2[in] - 4*0.875[in] =$ **9.7**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 9.7[in]*0.3[in] =$ **2.91**[in2] Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000[lb/in2]*2.91[in2] =$ **56.75**[kip] Eq. J4-4

Block shear	[Kip]	66.79	40.00	DL	0.60	Eq. J4-5

$dh_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] =$ **0.875**[in] Sec. D3-2

$dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] =$ **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.38[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.3[in] =$ **0.581**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (2.25[in] + (4 - 1)*3[in])*0.3[in] =$ **3.38**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (2.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.3[in] =$ **2.46**[in2] Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*min(0.6*65000[lb/in2]*2.46[in2] + 1*65000[lb/in2]*0.581[in2], 0.6*50000[lb/in2]*3.38[in2] + 1*65000[lb/in2]*0.581[in2]) =$ **66.79**[kip] Eq. J4-5

Flexural yielding	[Kip]	47.43	40.00	DL	0.84	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000[lb/in2]*8.71[in3]/5.5[in] =$ **47.43**[kip] p. 9-6

Flexural rupture	[Kip]	51.48	40.00	DL	0.78	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000[lb/in2]*8.71[in3]/5.5[in] =$ **51.48**[kip] p. 9-6

Local web buckling	[Kip]	47.43	40.00	DL	0.84	p. 9-8, p. 9-7

$h_o = d - d_c = 17.7[in] - 4.5[in] =$ **13.2**[in] p. 9-7

IsBeamCopedAtBothFlanges $= (c_t<=2*d)$ and $(d_{ct}<=0.2*d)$ and $(c_b<=2*d)$ and $(d_{cb}<=0.2*d) = (5[in]<=2*17.7[in])$ and $(1.5[in]<=0.2*17.7[in])$ and $(5[in]<=2*17.7[in])$ and $(3[in]<=0.2*17.7[in]) =$ **True** p. 9-8

$f_d = 3.5 - 7.5*(d_c/d) = 3.5 - 7.5*(3[in]/17.7[in]) =$ **2.23** p. 9-8

$F_{cr} = 0.62*\pi*E*t_w^2/(c*h_o)*f_d = 0.62*\pi*2.90E+07[lb/in2]*0.3[in]^2/(5[in]*13.2[in])*2.23 =$

1.72E+05[lb/in2] p. 9-8

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e$ = 0.599*min(50000[lb/in2], 1.72E+05[lb/in2])*8.71[in3]/ 5.5[in] = **47.43**[kip] p. 9-7

Support

Bolt bearing under shear load	[Kip]	128.70	40.00	DL	0.31	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c)$ = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4* 0.75[in])*(4 - 1))*0.275[in]*65000[lb/in2]*1) = **128.7**[kip] Eq. J3-6

Global critical strength ratio **0.84**

NOTATION

- a: Plate depth
- A_b: Nominal bolt area
- A_g: Gross area
- A_{gv}: Gross area subject to shear
- A_{nt}: Net area subject to tension
- A_{nv}: Net area subjected to shear
- a': Distance for prying action
- α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
- B: Available tensile strength per bolt
- B: Available strength of all bolts
- b': Distance for prying action
- b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
- C: Bolt group coefficient
- c: Coped length
- C_2: Edge distance increment
- c_b: Bottom cope length
- c_t: Top cope length
- c_{max}: Maximum coped length
- d: Nominal bolt diameter
- d_c: Coped depth
- d_{cb}: Bottom cope depth
- d_{cbmax}: Maximum bottom coped depth
- d_{ct}: Top cope depth
- d_{ctmax}: Maximum top coped depth
- d_h: Nominal hole dimension
- d_{top}: Beam top edge distance
- d': Width of the hole along the length of the fitting
- δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
- d: Beam depth
- dh_h: Horizontal hole dimension
- dh_v: Vertical hole dimension
- e: Load eccentricity
- E: Elastic modulus
- F: Required shear force for combined tension and shear
- F_{cr}: Critical stress, flexural stress buckling
- f_d: Plate buckling model adjustment factor for beam coped at both flanges
- F_{nt}: Nominal tensile stress
- F_{nv}: Nominal shear stress
- F_u: Specified minimum tensile strength
- f_v: Required shear stress
- F_y: Specified minimum yield stress
- F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
- h_o: Reduced beam depth
- *HasEqualLengths*: Has equal tributary length for interior and exterior bolts
- *IsBeamCopedAtBothFlanges*: Is beam coped at both flanges
- *IsCorrosionConsidered*: Is corrosion considered
- *IsStressUniform*: Is the stress uniform
- k_1: Bearing factor
- k_2: Bearing factor
- k: Outside corner radius
- L: Length
- L: Angle length
- $L_{c\text{-}end}$: Clear distance
- L_e: Effective length
- L_e: Edge distance
- L_{eh}: Horizontal edge distance

L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
$L_{c\text{-}spa}$: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

Current Date: 2016-05-06 2:19 PM
Units system: English
File name:

Steel connections

Results

Connection name	:	**DA BG All bolted**
Connection ID	:	**SC-06-12**

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W18X40

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	45.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	11.50	8.02	14.90	✔	p. 10-8

$L_{min} = T/2 = 16.05[in]/2 = \mathbf{8.02}[in]$ p. 10-8

$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 17.9[in] - \max(0.927[in], 1.5[in]) - \max(0.927[in], 1.5[in]) = \mathbf{14.9}[in]$ p. 10-8

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ Tables J3.4, J3.5

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ Tables J3.4, J3.5

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$ Sec. J3.3

$IsCorrosionConsidered \rightarrow \mathbf{False}$

$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.313[in], 12\ [in]) = \mathbf{7.5}[in]$ Sec. J3.5

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8\ [in]$ p. 10-9

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Support side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ Tables J3.4, J3.5

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ Tables J3.4,

J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$ — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12 [in]) = \min(24*0.313[in], 12 [in]) = \mathbf{7.5}[in]$ — Sec. J3.5

Beam

Top cope length	[in]	4.00	--	35.80	✔

$c_{max} = 2*d = 2*17.9[in] = \mathbf{35.8}[in]$

Bottom cope length	[in]	4.00	--	35.80	✔

$c_{max} = 2*d = 2*17.9[in] = \mathbf{35.8}[in]$

Top cope depth	[in]	1.50	--	3.20	✔

$d_{ctmax} = \min(d/2, d_{top} - w) = \min(17.9[in]/2, 3.2[in] - 0[in]) = \mathbf{3.2}[in]$

Bottom cope depth	[in]	1.50	--	3.20	✔

$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(17.9[in]/2, 17.9[in] - 11.5[in] - 3.2[in] - 0[in]) = \mathbf{3.2}[in]$

Vertical edge distance	[in]	2.95	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.38	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	84.86	45.00	DL	0.53	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61[kip]) = \mathbf{84.86}[kip]$ — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	45.00	DL	0.39	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{116.23}[kip]$ — Eq. J3-6

Shear yielding	[Kip]	103.50	45.00	DL	0.43	Eq. J4-3

$A_g = L_p*t_p = 11.5[in]*0.313[in] = \mathbf{3.59}[in2]$ — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = \mathbf{103.5}[kip]$ — Eq. J4-3

Shear rupture	[Kip]	87.00	45.00	DL	0.52	Eq. J4-4

$L_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = \mathbf{0.875}[in]$ — Sec. D3-2

$L_e = L - n*L_h = 11.5[in] - 4*0.875[in] = \mathbf{8}[in]$ — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8[in]*0.313[in] = \mathbf{2.5}[in2]$ — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = \mathbf{87}[kip]$ — Eq. J4-4

Block shear	[Kip]	81.65	45.00	DL	0.55	Eq. J4-5

$dh_h = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = \mathbf{0.875}[in]$ — Sec. D3-2

$dh_v = d_h + 1/16 [in] = 0.813[in] + 1/16 [in] = \mathbf{0.875}[in]$ — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*3[in] - (1 - 0.5)*$

$0.875\text{[in]})*0.313\text{[in]} = \mathbf{0.215}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (4 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{3.2}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (4 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{2.25}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*2.25\text{[in2]} + 1*58000\text{[lb/in2]}*0.215\text{[in2]}, 0.6*36000\text{[lb/in2]}*3.2\text{[in2]} + 1*58000\text{[lb/in2]}*0.215\text{[in2]})) = \mathbf{81.65}\text{[kip]}$ Eq. J4-5

Angle (Support side)

Bolts shear	[Kip]	84.86	45.00	DL	0.53	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{10.61}\text{[kip]}$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61\text{[kip]}) = \mathbf{84.86}\text{[kip]}$ Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	45.00	DL	0.39	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25\text{[in]} - 0.813\text{[in]}/2) = \mathbf{0.844}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(4/(1*4))*(\min(1.2*0.844\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(4 - 1))*0.313\text{[in]}*58000\text{[lb/in2]}*1) = \mathbf{116.23}\text{[kip]}$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	103.50	45.00	DL	0.43	Eq. J4-3

$A_g = L_p*t_p = 11.5\text{[in]}*0.313\text{[in]} = \mathbf{3.59}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000\text{[lb/in2]}*3.59\text{[in2]}) = \mathbf{103.5}\text{[kip]}$ Eq. J4-3

Shear rupture	[Kip]	87.00	45.00	DL	0.52	Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 11.5\text{[in]} - 4*0.875\text{[in]} = \mathbf{8}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8\text{[in]}*0.313\text{[in]} = \mathbf{2.5}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000\text{[lb/in2]}*2.5\text{[in2]}) = \mathbf{87}\text{[kip]}$ Eq. J4-4

Block shear	[Kip]	81.65	45.00	DL	0.55	Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13\text{[in]} + (1 - 1)*5.5\text{[in]} - (1 - 0.5)*0.875\text{[in]})*0.313\text{[in]} = \mathbf{0.215}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25\text{[in]} + (4 - 1)*3\text{[in]})*0.313\text{[in]} = \mathbf{3.2}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25\text{[in]} + (4 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.313\text{[in]} = \mathbf{2.25}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000\text{[lb/in2]}*2.25\text{[in2]} + 1*58000\text{[lb/in2]}*0.215\text{[in2]}, 0.6*36000\text{[lb/in2]}*3.2\text{[in2]} + 1*58000\text{[lb/in2]}*0.215\text{[in2]})) = \mathbf{81.65}\text{[kip]}$ Eq. J4-5

Resulting tension capacity due prying action	[Kip]	14.33	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 45\text{[kip]}/(0.442\text{[in2]}*8) = \mathbf{12726.24}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*12726.24\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{69276.58}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*69276.58\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{15.31}\text{[kip]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 45\text{[kip]}/(0.442\text{[in2]}*8) = \mathbf{12726.24}\text{[lb/in2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000\text{[lb/in2]} - 90000\text{[lb/in2]}*12726.24\text{[lb/in2]}/(0.5*48000\text{[lb/in2]}), 0.0), 90000\text{[lb/in2]}) = \mathbf{69276.58}\text{[lb/in2]}$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*69276.58\text{[lb/in2]}*0.442\text{[in2]} = \mathbf{15.31}\text{[kip]}$ Eq. J3-2

$a' = \text{Min}(a + d/2, 1.25*b + d/2) = \text{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/3[in] = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*15.31[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))^{0.5} = \mathbf{1.17}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1+\rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.17[in]/0.313[in])^2 - 1) = \mathbf{6.99}$ p. 9-13

$Q = (t_p/t_c)^2*(1+\delta) = (0.313[in]/1.17[in])^2*(1 + 0.729) = \mathbf{0.123}$ p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*15.31[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} = \mathbf{1.22}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1+\rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.22[in]/0.313[in])^2 - 1) = \mathbf{7.94}$ p. 9-13

$Q = (t_p/t_c)^2*(1+\delta) = (0.313[in]/1.22[in])^2*(1 + 0.705) = \mathbf{0.111}$ p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.111 + (4 - 2)*0.123)/4 = \mathbf{0.117}$ p. 9-13

$T_{avail} = 8 * (B*Q) = 8 * (15.31[kip]*0.117) = \mathbf{14.33}[kip]$ p. 9-10

Beam

Bolt bearing under shear load [Kip] 73.71 45.00 DL 0.61 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 2.95[in] - 0.813[in]/2) = \mathbf{2.54}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*2.54[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.315[in]*65000[lb/in2]*1 = \mathbf{73.71}[kip]$ Eq. J3-6

Shear yielding [Kip] 93.87 45.00 DL 0.48 Eq. J4-3

$A_g = L_p*t_p = 14.9[in]*0.315[in] = \mathbf{4.69}[in2]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*4.69[in2] = \mathbf{93.87}[kip]$ Eq. J4-3

Shear rupture [Kip] 70.02 45.00 DL 0.64 Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 14.9[in] - 4*0.875[in] = \mathbf{11.4}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 11.4[in]*0.315[in] = \mathbf{3.59}[in2]$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000[lb/in2]*3.59[in2] = \mathbf{70.02}[kip]$ Eq. J4-4

Block shear [Kip] 74.43 45.00 DL 0.60 Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.38[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.315[in] = \mathbf{0.61}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (2.95[in] + (4 - 1)*3[in])*0.315[in] = \mathbf{3.76}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (2.95[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.315[in] = \mathbf{2.8}[in2]$ Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*65000[lb/in2]*2.8[in2] + 1*65000[lb/in2]*0.61[in2], 0.6*50000[lb/in2]*3.76[in2] + 1*65000[lb/in2]*0.61[in2]) = \mathbf{74.43}[kip]$ Eq. J4-5

Flexural yielding [Kip] 77.55 45.00 DL 0.58 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000[lb/in2]*11.66[in3]/4.5[in] = \mathbf{77.55}[kip]$ p. 9-6

Flexural rupture [Kip] 84.18 45.00 DL 0.53 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000[lb/in2]*11.66[in3]/4.5[in] = \mathbf{84.18}[kip]$ p. 9-6

Local web buckling [Kip] 77.55 45.00 DL 0.58 p. 9-8, p. 9-7

$h_o = d - d_c = 17.9[in] - 3[in] = \mathbf{14.9}[in]$ p. 9-7

IsBeamCopedAtBothFlanges $= (c_t <= 2*d)$ and $(d_{ct} <= 0.2*d)$ and $(c_b <= 2*d)$ and $(d_{cb} <= 0.2*d) = (4[in] <= 2*17.9[in])$ and $(1.5[in] <= 0.2*17.9[in])$ and $(4[in] <= 2*17.9[in])$ and $(1.5[in] <= 0.2*$

17.9[in]) = **True** p. 9-8

f_d = 3.5 - 7.5*(d_c/d) = 3.5 - 7.5*(1.5[in]/17.9[in]) = **2.87** p. 9-8

F_{cr} = 0.62*π*E*t_w^2/(c*h_o)*f_d = 0.62*π*2.90E+07[lb/in2]*0.315[in]^2/(4[in]*14.9[in])*2.87 = **2.70E+05**[lb/in2] p. 9-8

$(1/\Omega)R_n$ = $(1/\Omega)$*min(F_y, F_{cr})*S_{net}/e = 0.599*min(50000[lb/in2], 2.70E+05[lb/in2])* 11.66[in3]/4.5[in] = **77.55**[kip] p. 9-7

Support

Bolt bearing under shear load	[Kip]	201.24	45.00	DL	0.22	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4* 0.75[in])*(4 - 1))*0.43[in]*65000[lb/in2]*1) = **201.24**[kip] Eq. J3-6

Global critical strength ratio **0.64**

NOTATION

a: Plate depth
A_b: Nominal bolt area
A_g: Gross area
A_{gv}: Gross area subject to shear
A_{nt}: Net area subject to tension
A_{nv}: Net area subjected to shear
a': Distance for prying action
α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
B: Available tensile strength per bolt
B: Available strength of all bolts
b': Distance for prying action
b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
C: Bolt group coefficient
c: Coped length
C_2: Edge distance increment
c_b: Bottom cope length
c_t: Top cope length
c_{max}: Maximum coped length
d: Nominal bolt diameter
d_c: Coped depth
d_{cb}: Bottom cope depth
d_{cbmax}: Maximum bottom coped depth
d_{ct}: Top cope depth
d_{ctmax}: Maximum top coped depth
d_h: Nominal hole dimension
d_{top}: Beam top edge distance
d': Width of the hole along the length of the fitting
δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
d: Beam depth
dh_h: Horizontal hole dimension
dh_v: Vertical hole dimension
e: Load eccentricity
E: Elastic modulus
F: Required shear force for combined tension and shear
F_{cr}: Critical stress, flexural stress buckling
f_d: Plate buckling model adjustment factor for beam coped at both flanges
F_{nt}: Nominal tensile stress
F_{nv}: Nominal shear stress
F_u: Specified minimum tensile strength
f_v: Required shear stress
F_y: Specified minimum yield stress
F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
h_o: Reduced beam depth
HasEqualLengths: Has equal tributary length for interior and exterior bolts
IsBeamCopedAtBothFlanges: Is beam coped at both flanges
IsCorrosionConsidered: Is corrosion considered
IsStressUniform: Is the stress uniform
k_1: Bearing factor
k_2: Bearing factor
k: Outside corner radius
L: Length
L: Angle length
$L_{c\text{-}end}$: Clear distance

L_e: Effective length
L_e: Edge distance
L_{eh}: Horizontal edge distance
L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
$L_{c\text{-}spa}$: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

Current Date: 2016-05-06 2:27 PM
Units system: English
File name:

Steel connections

Results

Connection name : DA BG All bolted
Connection ID : SC-06-13

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W18X65

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	45.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle</u>						
Length	[in]	11.50	8.05	15.40	✔	p. 10-8
$L_{min} = T/2 = 16.1[in]/2 = \mathbf{8.05}[in]$						p. 10-8
$L_{max} = d$ - max(k, d_{ct}) - max(k, d_{cb}) = 18.4[in] - max(1.15[in], 1.5[in]) - max(1.15[in], 1.5[in]) = **15.4**[in]						p. 10-8
<u>Angle (Beam side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12[in]) = \min(24*0.313[in], 12[in]) = \mathbf{7.5}[in]$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8$ [in]						p. 10-9
<u>Angle (Support side)</u>						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.25	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0.125[in] = \mathbf{1.13}[in]$						Tables J3.4,

J3.5

Vertical center-to-center spacing (pitch) | [in] | 3.00 | 2.00 | 7.50 | ✓ | Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$ — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.313[in], 12\ [in]) = \mathbf{7.5}[in]$ — Sec. J3.5

Beam

Top cope length | [in] | 4.00 | -- | 36.80 | ✓

$c_{max} = 2*d = 2*18.4[in] = \mathbf{36.8}[in]$

Bottom cope length | [in] | 4.00 | -- | 36.80 | ✓

$c_{max} = 2*d = 2*18.4[in] = \mathbf{36.8}[in]$

Top cope depth | [in] | 1.50 | -- | 3.45 | ✓

$d_{ctmax} = \min(d/2, d_{top} - w) = \min(18.4[in]/2, 3.45[in] - 0[in]) = \mathbf{3.45}[in]$

Bottom cope depth | [in] | 1.50 | -- | 3.45 | ✓

$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(18.4[in]/2, 18.4[in] - 11.5[in] - 3.45[in] - 0[in]) = \mathbf{3.45}[in]$

Vertical edge distance | [in] | 3.20 | 1.00 | -- | ✓ | Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ — Tables J3.4, J3.5

Horizontal edge distance | [in] | 2.25 | 1.00 | -- | ✓ | Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Angle (Beam side)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	84.86	45.00	DL	0.53	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61[kip]) = \mathbf{84.86}[kip]$ — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	116.23	45.00	DL	0.39	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ — Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4* 0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{116.23}[kip]$ — Eq. J3-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Kip]	103.50	45.00	DL	0.43	Eq. J4-3

$A_g = L_p*t_p = 11.5[in]*0.313[in] = \mathbf{3.59}[in2]$ — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = \mathbf{103.5}[kip]$ — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear rupture	[Kip]	87.00	45.00	DL	0.52	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ — Sec. D3-2

$L_e = L - n*L_h = 11.5[in] - 4*0.875[in] = \mathbf{8}[in]$ — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8[in]*0.313[in] = \mathbf{2.5}[in2]$ — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = \mathbf{87}[kip]$ — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear	[Kip]	83.91	45.00	DL	0.54	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ — Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.25[in] + (1 - 1)*3[in] - (1 - 0.5)*$

0.875[in])*0.313[in] = **0.254**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (4 - 1)*3[in])*0.313[in] = **3.2**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.25**[in2] Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}))$ = 2 * (0.5*min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.254[in2], 0.6*36000[lb/in2]*3.2[in2] + 1*58000[lb/in2]*0.254[in2])) = **83.91**[kip] Eq. J4-5

Angle (Support side)

Bolts shear [Kip] 84.86 45.00 DL 0.53 Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n)$ = 2 * (4*10.61[kip]) = **84.86**[kip] Tables (7-1..14)

Bolt bearing under shear load [Kip] 116.23 45.00 DL 0.39 p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c)$ = 2 * (0.5*(4/(1*4))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = **116.23**[kip] p. 7-18, Sec. J3.10

Shear yielding [Kip] 103.50 45.00 DL 0.43 Eq. J4-3

$A_g = L_p*t_p$ = 11.5[in]*0.313[in] = **3.59**[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g)$ = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = **103.5**[kip] Eq. J4-3

Shear rupture [Kip] 87.00 45.00 DL 0.52 Eq. J4-4

$L_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$L_e = L - n*L_h$ = 11.5[in] - 4*0.875[in] = **8**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 8[in]*0.313[in] = **2.5**[in2] Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv})$ = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = **87**[kip] Eq. J4-4

Block shear [Kip] 82.21 45.00 DL 0.55 Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.25[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.225**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (4 - 1)*3[in])*0.313[in] = **3.2**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.25**[in2] Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}))$ = 2 * (0.5*min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.225[in2], 0.6*36000[lb/in2]*3.2[in2] + 1*58000[lb/in2]*0.225[in2])) = **82.21**[kip] Eq. J4-5

Resulting tension capacity due prying action [Kip] 15.14 0.00 DL 0.00 p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts})$ = 45[kip]/(0.442[in2]*8) = **12726.24**[lb/in2] Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*12726.24[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **69276.58**[lb/in2] Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*69276.58[lb/in2]*0.442[in2] = **15.31**[kip] Eq. J3-2

$f_v = F/(A_b*N_{bolts})$ = 45[kip]/(0.442[in2]*8) = **12726.24**[lb/in2] Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*12726.24[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **69276.58**[lb/in2] Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*69276.58[lb/in2]*0.442[in2] = **15.31**[kip] Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2)$ = Min(1.25[in] + 0.75[in]/2, 1.25*2.59[in] + 0.75[in]/2) = **1.63**[in] p. 9-12

$b' = b - d/2$ = 2.59[in] - 0.75[in]/2 = **2.22**[in] p. 9-12

$\rho = b'/a'$ = 2.22[in]/1.63[in] = **1.37** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*15.31\text{[kip]}*2.22\text{[in]})/(0.5*3\text{[in]}*58000\text{[lb/in2]}))^{0.5} = \mathbf{1.14}\text{[in]}$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.37)))*((1.14\text{[in]}/0.313\text{[in]})^2 - 1) = \mathbf{7.14}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313\text{[in]}/1.14\text{[in]})^2*(1 + 0.729) = \mathbf{0.13}$ p. 9-13

$a' = \text{Min}(a + d/2, 1.25*b + d/2) = \text{Min}(1.25\text{[in]} + 0.75\text{[in]}/2, 1.25*2.59\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.63}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.59\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.22}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.22\text{[in]}/1.63\text{[in]} = \mathbf{1.37}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/2.75\text{[in]} = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*15.31\text{[kip]}*2.22\text{[in]})/(0.5*2.75\text{[in]}*58000\text{[lb/in2]}))^{0.5} = \mathbf{1.19}\text{[in]}$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.37)))*((1.19\text{[in]}/0.313\text{[in]})^2 - 1) = \mathbf{8.12}$ p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313\text{[in]}/1.19\text{[in]})^2*(1 + 0.705) = \mathbf{0.117}$ p. 9-13

$HasEqualLengths \rightarrow$ **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.117 + (4 - 2)*0.13)/4 = \mathbf{0.124}$ p. 9-13

$T_{avail} = 8 * (B*Q) = 8 * (15.31\text{[kip]}*0.124) = \mathbf{15.14}\text{[kip]}$ p. 9-10

Beam

Bolt bearing under shear load [Kip] 105.30 45.00 DL 0.43 Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 3.2\text{[in]} - 0.813\text{[in]}/2) = \mathbf{2.79}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*2.79\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(4 - 1))*0.45\text{[in]}*65000\text{[lb/in2]}*1 = \mathbf{105.3}\text{[kip]}$ Eq. J3-6

Shear yielding [Kip] 138.60 45.00 DL 0.32 Eq. J4-3

$A_g = L_p*t_p = 15.4\text{[in]}*0.45\text{[in]} = \mathbf{6.93}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000\text{[lb/in2]}*6.93\text{[in2]} = \mathbf{138.6}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 104.42 45.00 DL 0.43 Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 15.4\text{[in]} - 4*0.875\text{[in]} = \mathbf{11.9}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 11.9\text{[in]}*0.45\text{[in]} = \mathbf{5.36}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000\text{[lb/in2]}*5.36\text{[in2]} = \mathbf{104.42}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 106.69 45.00 DL 0.42 Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.25\text{[in]} + (1 - 1)*3\text{[in]} - (1 - 0.5)*0.875\text{[in]})*0.45\text{[in]} = \mathbf{0.816}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (3.2\text{[in]} + (4 - 1)*3\text{[in]})*0.45\text{[in]} = \mathbf{5.49}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (3.2\text{[in]} + (4 - 1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.45\text{[in]} = \mathbf{4.11}\text{[in2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*65000\text{[lb/in2]}*4.11\text{[in2]} + 1*65000\text{[lb/in2]}*0.816\text{[in2]}, 0.6*50000\text{[lb/in2]}*5.49\text{[in2]} + 1*65000\text{[lb/in2]}*0.816\text{[in2]}) = \mathbf{106.69}\text{[kip]}$ Eq. J4-5

Flexural yielding [Kip] 118.34 45.00 DL 0.38 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000\text{[lb/in2]}*17.79\text{[in3]}/4.5\text{[in]} = \mathbf{118.34}\text{[kip]}$ p. 9-6

Flexural rupture [Kip] 128.46 45.00 DL 0.35 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000\text{[lb/in2]}*17.79\text{[in3]}/4.5\text{[in]} = \mathbf{128.46}\text{[kip]}$ p. 9-6

Local web buckling [Kip] 118.34 45.00 DL 0.38 p. 9-8, p. 9-7

$h_o = d - d_c = 18.4\text{[in]} - 3\text{[in]} = \mathbf{15.4}\text{[in]}$ p. 9-7

$IsBeamCopedAtBothFlanges = (c_t<=2*d) \text{ and } (d_{ct}<=0.2*d) \text{ and } (c_b<=2*d) \text{ and } (d_{cb}<=0.2*d) =$

$(4_{[in]} <= 2*18.4_{[in]})$ and $(1.5_{[in]} <= 0.2*18.4_{[in]})$ and $(4_{[in]} <= 2*18.4_{[in]})$ and $(1.5_{[in]} <= 0.2*18.4_{[in]})$ = **True** p. 9-8

$f_d = 3.5 - 7.5*(d_c/d) = 3.5 - 7.5*(1.5_{[in]}/18.4_{[in]}) = \mathbf{2.89}$ p. 9-8

$F_{cr} = 0.62*\pi*E*t_w^2/(c*h_o)*f_d = 0.62*\pi*2.90E+07_{[lb/in2]}*0.45_{[in]}^2/(4_{[in]}*15.4_{[in]})*2.89 = \mathbf{5.36E+05}_{[lb/in2]}$ p. 9-8

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e = 0.599*\min(50000_{[lb/in2]}, 5.36E+05_{[lb/in2]})*17.79_{[in3]}/4.5_{[in]} = \mathbf{118.34}_{[kip]}$ p. 9-7

Support

Bolt bearing under shear load	[Kip]	210.60	45.00	DL	0.21	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.20E+31_{[in]} - 0.813_{[in]}/2) = \mathbf{1.20E+31}_{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3_{[in]} - 0.813_{[in]}) = \mathbf{2.19}_{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31_{[in]}, 2.4*0.75_{[in]}) + \min(1.2*2.19_{[in]}, 2.4*0.75_{[in]})*(4 - 1))*0.45_{[in]}*65000_{[lb/in2]}*1) = \mathbf{210.6}_{[kip]}$ Eq. J3-6

Global critical strength ratio **0.55**

NOTATION

a: Plate depth
A_b: Nominal bolt area
A_g: Gross area
A_{gv}: Gross area subject to shear
A_{nt}: Net area subject to tension
A_{nv}: Net area subjected to shear
a': Distance for prying action
α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
B: Available tensile strength per bolt
B: Available strength of all bolts
b': Distance for prying action
b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
C: Bolt group coefficient
c: Coped length
C_2: Edge distance increment
c_b: Bottom cope length
c_t: Top cope length
c_{max}: Maximum coped length
d: Nominal bolt diameter
d_c: Coped depth
d_{cb}: Bottom cope depth
d_{cbmax}: Maximum bottom coped depth
d_{ct}: Top cope depth
d_{ctmax}: Maximum top coped depth
d_h: Nominal hole dimension
d_{top}: Beam top edge distance
d': Width of the hole along the length of the fitting
δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
d: Beam depth
dh_h: Horizontal hole dimension
dh_v: Vertical hole dimension
e: Load eccentricity
E: Elastic modulus
F: Required shear force for combined tension and shear
F_{cr}: Critical stress, flexural stress buckling
f_d: Plate buckling model adjustment factor for beam coped at both flanges
F_{nt}: Nominal tensile stress
F_{nv}: Nominal shear stress
F_u: Specified minimum tensile strength
f_v: Required shear stress
F_y: Specified minimum yield stress
F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
h_o: Reduced beam depth
HasEqualLengths: Has equal tributary length for interior and exterior bolts
IsBeamCopedAtBothFlanges: Is beam coped at both flanges
IsCorrosionConsidered: Is corrosion considered
IsStressUniform: Is the stress uniform
k_1: Bearing factor
k_2: Bearing factor
k: Outside corner radius
L: Length

L: Angle length
$L_{c\text{-}end}$: Clear distance
L_e: Effective length
L_e: Edge distance
L_{eh}: Horizontal edge distance
L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
$L_{c\text{-}spa}$: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

Current Date: 2016-05-06 2:29 PM
Units system: English
File name:

Steel connections

Results

Connection name	:	**DA BG All bolted**
Connection ID	:	**SC-06-14**

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W21X44

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	55.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	11.50	9.40	15.45	✔	p. 10-8
$L_{min} = T/2 = 18.8[in]/2 = \mathbf{9.4}[in]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 20.7[in] - \max(0.95[in], 1.25[in]) - \max(0.95[in], 4[in]) = \mathbf{15.45}[in]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$						Sec. J3.3
$IsCorrosionConsidered \rightarrow$ **False**						
$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.313[in], 12\ [in]) = \mathbf{7.5}[in]$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8\ [in]$						p. 10-9
Angle (Support side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[in] + 0.125[in] = \mathbf{1.13}[in]$						Tables J3.4,

J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$ — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.313[in], 12\ [in]) = \mathbf{7.5}[in]$ — Sec. J3.5

Beam

Top cope length	[in]	4.00	--	41.40

$c_{max} = 2*d = 2*20.7[in] = \mathbf{41.4}[in]$

Bottom cope length	[in]	4.00	--	41.40

$c_{max} = 2*d = 2*20.7[in] = \mathbf{41.4}[in]$

Top cope depth	[in]	1.25	--	2.50

$d_{ctmax} = \min(d/2, d_{top} - w) = \min(20.7[in]/2, 2.5[in] - 0[in]) = \mathbf{2.5}[in]$

Bottom cope depth	[in]	4.00	--	6.70

$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(20.7[in]/2, 20.7[in] - 11.5[in] - 2.5[in] - 0[in]) = \mathbf{6.7}[in]$

Vertical edge distance	[in]	2.50	1.00	--	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.38	1.00	--	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	84.86	55.00	DL	0.65	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61[kip]) = \mathbf{84.86}[kip]$ — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	55.00	DL	0.47	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4* 0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{116.23}[kip]$ — Eq. J3-6

Shear yielding	[Kip]	103.50	55.00	DL	0.53	Eq. J4-3

$A_g = L_p*t_p = 11.5[in]*0.313[in] = \mathbf{3.59}[in2]$ — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = \mathbf{103.5}[kip]$ — Eq. J4-3

Shear rupture	[Kip]	87.00	55.00	DL	0.63	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ — Sec. D3-2

$L_e = L - n*L_h = 11.5[in] - 4*0.875[in] = \mathbf{8}[in]$ — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8[in]*0.313[in] = \mathbf{2.5}[in2]$ — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = \mathbf{87}[kip]$ — Eq. J4-4

Block shear	[Kip]	81.65	55.00	DL	0.67	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ — Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*3[in] - (1 - 0.5)*$

$0.875[in])*0.313[in] = \mathbf{0.215}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (4 - 1)*3[in])*0.313[in] = \mathbf{3.2}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{2.25}[in2]$ Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.215[in2], 0.6*36000[lb/in2]*3.2[in2] + 1*58000[lb/in2]*0.215[in2])) = \mathbf{81.65}[kip]$ Eq. J4-5

Angle (Support side)

Bolts shear	[Kip]	84.86	55.00	DL	0.65	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61[kip]) = \mathbf{84.86}[kip]$ Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	55.00	DL	0.47	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(4/(1*4))*(\min(1.2*0.844[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{116.23}[kip]$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	103.50	55.00	DL	0.53	Eq. J4-3

$A_g = L_p*t_p = 11.5[in]*0.313[in] = \mathbf{3.59}[in2]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = \mathbf{103.5}[kip]$ Eq. J4-3

Shear rupture	[Kip]	87.00	55.00	DL	0.63	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 11.5[in] - 4*0.875[in] = \mathbf{8}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8[in]*0.313[in] = \mathbf{2.5}[in2]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = \mathbf{87}[kip]$ Eq. J4-4

Block shear	[Kip]	79.95	55.00	DL	0.69	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 1[in] + 1/16\ [in] = \mathbf{1.06}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = \mathbf{0.186}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (4 - 1)*3[in])*0.313[in] = \mathbf{3.2}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{2.25}[in2]$ Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*3.2[in2] + 1*58000[lb/in2]*0.186[in2])) = \mathbf{79.95}[kip]$ Eq. J4-5

Resulting tension capacity due prying action	[Kip]	14.33	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 55[kip]/(0.442[in2]*8) = \mathbf{15554.3}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*15554.3[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{58671.38}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*58671.38[lb/in2]*0.442[in2] = \mathbf{12.97}[kip]$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 55[kip]/(0.442[in2]*8) = \mathbf{15554.3}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*15554.3[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{58671.38}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*58671.38[lb/in2]*0.442[in2] = \mathbf{12.97}[kip]$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/3\text{[in]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*12.97\text{[kip]}*2.34\text{[in]})/(0.5*3\text{[in]}*58000\text{[lb/in2]}))^{0.5} = \mathbf{1.08}\text{[in]}$ p. 9-12

$\alpha' = (1/(\delta*(1+\rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1+1.56)))*((1.08\text{[in]}/0.313\text{[in]})^2 - 1) = \mathbf{5.84}$ p. 9-13

$Q = (t_p/t_c)^2*(1+\delta) = (0.313\text{[in]}/1.08\text{[in]})^2*(1+0.729) = \mathbf{0.145}$ p. 9-13

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13\text{[in]} + 0.75\text{[in]}/2, 1.25*2.72\text{[in]} + 0.75\text{[in]}/2) = \mathbf{1.5}\text{[in]}$ p. 9-12

$b' = b - d/2 = 2.72\text{[in]} - 0.75\text{[in]}/2 = \mathbf{2.34}\text{[in]}$ p. 9-12

$\rho = b'/a' = 2.34\text{[in]}/1.5\text{[in]} = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813\text{[in]}/2.75\text{[in]} = \mathbf{0.705}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*12.97\text{[kip]}*2.34\text{[in]})/(0.5*2.75\text{[in]}*58000\text{[lb/in2]}))^{0.5} = \mathbf{1.13}\text{[in]}$ p. 9-12

$\alpha' = (1/(\delta*(1+\rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1+1.56)))*((1.13\text{[in]}/0.313\text{[in]})^2 - 1) = \mathbf{6.64}$ p. 9-13

$Q = (t_p/t_c)^2*(1+\delta) = (0.313\text{[in]}/1.13\text{[in]})^2*(1+0.705) = \mathbf{0.131}$ p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n-2)*Q_{int})/n = (2*0.131 + (4-2)*0.145)/4 = \mathbf{0.138}$ p. 9-13

$T_{avail} = 8 * (B*Q) = 8 * (12.97\text{[kip]}*0.138) = \mathbf{14.33}\text{[kip]}$ p. 9-10

<u>Beam</u>

Bolt bearing under shear load [Kip] 81.90 55.00 DL 0.67 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 2.5\text{[in]} - 0.813\text{[in]}/2) = \mathbf{2.09}\text{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3\text{[in]} - 0.813\text{[in]}) = \mathbf{2.19}\text{[in]}$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n-1))*t_p*F_u*n_c = 0.5*(\min(1.2*2.09\text{[in]}, 2.4*0.75\text{[in]}) + \min(1.2*2.19\text{[in]}, 2.4*0.75\text{[in]})*(4-1))*0.35\text{[in]}*65000\text{[lb/in2]}*1 = \mathbf{81.9}\text{[kip]}$ Eq. J3-6

Shear yielding [Kip] 108.15 55.00 DL 0.51 Eq. J4-3

$A_g = L_p*t_p = 15.45\text{[in]}*0.35\text{[in]} = \mathbf{5.41}\text{[in2]}$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000\text{[lb/in2]}*5.41\text{[in2]} = \mathbf{108.15}\text{[kip]}$ Eq. J4-3

Shear rupture [Kip] 81.56 55.00 DL 0.67 Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$L_e = L - n*L_h = 15.45\text{[in]} - 4*0.875\text{[in]} = \mathbf{11.95}\text{[in]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 11.95\text{[in]}*0.35\text{[in]} = \mathbf{4.18}\text{[in2]}$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000\text{[lb/in2]}*4.18\text{[in2]} = \mathbf{81.56}\text{[kip]}$ Eq. J4-4

Block shear [Kip] 79.63 55.00 DL 0.69 Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 0.813\text{[in]} + 1/16\text{ [in]} = \mathbf{0.875}\text{[in]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.38\text{[in]} + (1-1)*3\text{[in]} - (1-0.5)*0.875\text{[in]})*0.35\text{[in]} = \mathbf{0.678}\text{[in2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n-1)*s)*t_p = (2.5\text{[in]} + (4-1)*3\text{[in]})*0.35\text{[in]} = \mathbf{4.03}\text{[in2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n-1)*(s - dh_v) - dh_v/2)*t_p = (2.5\text{[in]} + (4-1)*(3\text{[in]} - 0.875\text{[in]}) - 0.875\text{[in]}/2)*0.35\text{[in]} = \mathbf{2.95}\text{[in2]}$ Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*65000\text{[lb/in2]}*2.95\text{[in2]} + 1*65000\text{[lb/in2]}*0.678\text{[in2]}, 0.6*50000\text{[lb/in2]}*4.03\text{[in2]} + 1*65000\text{[lb/in2]}*0.678\text{[in2]}) = \mathbf{79.63}\text{[kip]}$ Eq. J4-5

Flexural yielding [Kip] 92.64 55.00 DL 0.59 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000\text{[lb/in2]}*13.92\text{[in3]}/4.5\text{[in]} = \mathbf{92.64}\text{[kip]}$ p. 9-6

Flexural rupture [Kip] 100.56 55.00 DL 0.55 p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000\text{[lb/in2]}*13.92\text{[in3]}/4.5\text{[in]} = \mathbf{100.56}\text{[kip]}$ p. 9-6

Local web buckling [Kip] 92.64 55.00 DL 0.59 p. 9-8, p. 9-7

$h_o = d - d_c = 20.7\text{[in]} - 5.25\text{[in]} = \mathbf{15.45}\text{[in]}$ p. 9-7

IsBeamCopedAtBothFlanges $= (c_t <= 2*d)$ and $(d_{ct} <= 0.2*d)$ and $(c_b <= 2*d)$ and $(d_{cb} <= 0.2*d) = (4\text{[in]} <= 2*20.7\text{[in]})$ and $(1.25\text{[in]} <= 0.2*20.7\text{[in]})$ and $(4\text{[in]} <= 2*20.7\text{[in]})$ and $(4\text{[in]} <= 0.2*$

20.7[in]) = **True** p. 9-8

f_d = 3.5 - 7.5*(d_c/d) = 3.5 - 7.5*(4[in]/20.7[in]) = **2.05** p. 9-8

F_{cr} = 0.62*π*E*t_w^2/(c*h_o)*f_d = 0.62*π*2.90E+07[lb/in2]*0.35[in]^2/(4[in]*15.45[in])*2.05 = **2.30E+05**[lb/in2] p. 9-8

$(1/\Omega)R_n$ = $(1/\Omega)$*min(F_y, F_{cr})*S_{net}/e = 0.599*min(50000[lb/in2], 2.30E+05[lb/in2])*13.92[in3]/4.5[in] = **92.64**[kip] p. 9-7

<u>Support</u>

Bolt bearing under shear load	[Kip]	194.22	55.00	DL	0.28	Eq. J3-6

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n$ = 2 * ($(1/\Omega)$*(min(k_1*$L_{c\text{-}end}$, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.415[in]*65000[lb/in2]*1) = **194.22**[kip] Eq. J3-6

Global critical strength ratio **0.69**

NOTATION

a:	Plate depth
A_b:	Nominal bolt area
A_g:	Gross area
A_{gv}:	Gross area subject to shear
A_{nt}:	Net area subject to tension
A_{nv}:	Net area subjected to shear
a':	Distance for prying action
α':	Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
B:	Available tensile strength per bolt
B:	Available strength of all bolts
b':	Distance for prying action
b:	Distance from bolt centerline to the face/centerline of tee stem/angle leg.
C:	Bolt group coefficient
c:	Coped length
C_2:	Edge distance increment
c_b:	Bottom cope length
c_t:	Top cope length
c_{max}:	Maximum coped length
d:	Nominal bolt diameter
d_c:	Coped depth
d_{cb}:	Bottom cope depth
d_{cbmax}:	Maximum bottom coped depth
d_{ct}:	Top cope depth
d_{ctmax}:	Maximum top coped depth
d_h:	Nominal hole dimension
d_{top}:	Beam top edge distance
d':	Width of the hole along the length of the fitting
δ:	Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
d:	Beam depth
dh_h:	Horizontal hole dimension
dh_v:	Vertical hole dimension
e:	Load eccentricity
E:	Elastic modulus
F:	Required shear force for combined tension and shear
F_{cr}:	Critical stress, flexural stress buckling
f_d:	Plate buckling model adjustment factor for beam coped at both flanges
F_{nt}:	Nominal tensile stress
F_{nv}:	Nominal shear stress
F_u:	Specified minimum tensile strength
f_v:	Required shear stress
F_y:	Specified minimum yield stress
F'_{nt}:	Nominal tensile stress modified to include the effects of shear stress
h_o:	Reduced beam depth
HasEqualLengths:	Has equal tributary length for interior and exterior bolts
IsBeamCopedAtBothFlanges:	Is beam coped at both flanges
IsCorrosionConsidered:	Is corrosion considered
IsStressUniform:	Is the stress uniform
k_1:	Bearing factor
k_2:	Bearing factor
k:	Outside corner radius
L:	Length
L:	Angle length
$L_{c\text{-}end}$:	Clear distance

L_e: Effective length
L_e: Edge distance
L_{eh}: Horizontal edge distance
L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
$L_{c\text{-}spa}$: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

Current Date: 2016-05-06 2:35 PM
Units system: English
File name:

Steel connections

Results

Connection name	:	**DA BG All bolted**
Connection ID	:	**W24X68**

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W24X68

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	35.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	11.50	10.76	19.81	✔	p. 10-8

$L_{min} = T/2 = 21.52[in]/2 = \mathbf{10.76}[in]$ — p. 10-8

$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 23.7[in] - \max(1.09[in], 2.8[in]) - \max(1.09[in], 0[in]) = \mathbf{19.81}[in]$ — p. 10-8

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ — Tables J3.4, J3.5

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ — Tables J3.4, J3.5

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75[in] = \mathbf{2}[in]$ — Sec. J3.3

$IsCorrosionConsidered \rightarrow$ **False**

$s_{max} = \min(24*t_p, 12\ [in]) = \min(24*0.313[in], 12\ [in]) = \mathbf{7.5}[in]$ — Sec. J3.5

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Thickness	[in]	0.31	--	0.63	✔	p. 10-9

$t_{pmax} = 5/8\ [in]$ — p. 10-9

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Support side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0[in] = \mathbf{1}[in]$ — Tables J3.4, J3.5

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1[in] + 0.125[in] = \mathbf{1.13}[in]$ — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $=$ **2**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) =$ **7.5**[in] — Sec. J3.5

<u>Beam</u>

Top cope length	[in]	8.00	--	47.40	✔

$c_{max} = 2*d = 2*23.7$[in] $=$ **47.4**[in]

Bottom cope length	[in]	0.00	--	47.40	✔

$c_{max} = 2*d = 2*23.7$[in] $=$ **47.4**[in]

Top cope depth	[in]	2.80	--	6.10	✔

$d_{ctmax} = \min(d/2, d_{top} - w) = \min(23.7$[in]$/2, 6.1$[in] $- 0$[in]$) =$ **6.1**[in]

Bottom cope depth	[in]	0.00	--	6.10	✔

$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(23.7$[in]$/2, 23.7$[in] $- 11.5$[in] $- 6.1$[in] $- 0$[in]$) =$ **6.1**[in]

Vertical edge distance	[in]	4.55	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.38	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $=$ **1**[in] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Angle (Beam side)</u>						
Bolts shear	[Kip]	84.86	35.00	DL	0.41	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $=$ **10.61**[kip] — Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61$[kip]$) =$ **84.86**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	35.00	DL	0.30	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) =$ **0.844**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) =$ **2.19**[in] — Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))* t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in], $2.4*0.75$[in]$) + \min(1.2*2.19$[in], $2.4* 0.75$[in]$)*(4 - 1))*0.313$[in]$*58000$[lb/in2]$*1) =$ **116.23**[kip] — Eq. J3-6

Shear yielding	[Kip]	103.50	35.00	DL	0.34	Eq. J4-3

$A_g = L_p*t_p = 11.5$[in]$*0.313$[in] $=$ **3.59**[in2] — Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*3.59$[in2]$) =$ **103.5**[kip] — Eq. J4-3

Shear rupture	[Kip]	87.00	35.00	DL	0.40	Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$L_e = L - n*L_h = 11.5$[in] $- 4*0.875$[in] $=$ **8**[in] — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8$[in]$*0.313$[in] $=$ **2.5**[in2] — Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*2.5$[in2]$) =$ **87**[kip] — Eq. J4-4

Block shear	[Kip]	81.65	35.00	DL	0.43	Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $=$ **0.875**[in] — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13$[in] $+ (1 - 1)*3$[in] $- (1 - 0.5)* 0.875$[in]$)*0.313$[in] $=$ **0.215**[in2] — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25$[in] $+ (4 - 1)*3$[in]$)*0.313$[in] $=$ **3.2**[in2] — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25$[in] $+ (4 - 1)*(3$[in] $- 0.875$[in]$) -$

$0.875[in]/2)*0.313[in] = \mathbf{2.25}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.215[in2], 0.6*36000[lb/in2]*3.2[in2] + 1*58000[lb/in2]*0.215[in2])) = \mathbf{81.65}[kip]$ Eq. J4-5

Angle (Support side)

Bolts shear	[Kip]	84.86	35.00	DL	0.41	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000[lb/in2]*0.442[in2] = \mathbf{10.61}[kip]$ Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (4*10.61[kip]) = \mathbf{84.86}[kip]$ Tables (7-1..14)

Bolt bearing under shear load	[Kip]	116.23	35.00	DL	0.30	p. 7-18, Sec. J3.10

$L_{c-end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25[in] - 0.813[in]/2) = \mathbf{0.844}[in]$ Sec. J4.10

$L_{c-spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 0.813[in]) = \mathbf{2.19}[in]$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.5*(4/(1*4))*(\min(1.2*0.844[in], 2.4*0.75[in]) + \min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.313[in]*58000[lb/in2]*1) = \mathbf{116.23}[kip]$ p. 7-18, Sec. J3.10

Shear yielding	[Kip]	103.50	35.00	DL	0.34	Eq. J4-3

$A_g = L_p*t_p = 11.5[in]*0.313[in] = \mathbf{3.59}[in2]$ Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000[lb/in2]*3.59[in2]) = \mathbf{103.5}[kip]$ Eq. J4-3

Shear rupture	[Kip]	87.00	35.00	DL	0.40	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$L_e = L - n*L_h = 11.5[in] - 4*0.875[in] = \mathbf{8}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 8[in]*0.313[in] = \mathbf{2.5}[in2]$ Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000[lb/in2]*2.5[in2]) = \mathbf{87}[kip]$ Eq. J4-4

Block shear	[Kip]	79.95	35.00	DL	0.44	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 1[in] + 1/16\ [in] = \mathbf{1.06}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] = \mathbf{0.875}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = \mathbf{0.186}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.25[in] + (4 - 1)*3[in])*0.313[in] = \mathbf{3.2}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.25[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = \mathbf{2.25}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.5*\min(0.6*58000[lb/in2]*2.25[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*3.2[in2] + 1*58000[lb/in2]*0.186[in2])) = \mathbf{79.95}[kip]$ Eq. J4-5

Resulting tension capacity due prying action	[Kip]	14.33	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 35[kip]/(0.442[in2]*8) = \mathbf{9898.19}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*9898.19[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{79881.79}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*79881.79[lb/in2]*0.442[in2] = \mathbf{17.65}[kip]$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 35[kip]/(0.442[in2]*8) = \mathbf{9898.19}[lb/in2]$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt}) = \min(\max(1.3*90000[lb/in2] - 90000[lb/in2]*9898.19[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = \mathbf{79881.79}[lb/in2]$ Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b = 0.5*79881.79[lb/in2]*0.442[in2] = \mathbf{17.65}[kip]$ Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = \mathbf{1.5}[in]$ p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 = \mathbf{2.34}[in]$ p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] = \mathbf{1.56}$ p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/3[in] = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*17.65[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))^{0.5} = \mathbf{1.26}[in]$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.26[in]/0.313[in])^2 - 1) =$ **8.14** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.26[in])^2*(1 + 0.729) =$ **0.107** p. 9-13

$a' = Min(a + d/2, 1.25*b + d/2) = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) =$ **1.5**[in] p. 9-12

$b' = b - d/2 = 2.72[in] - 0.75[in]/2 =$ **2.34**[in] p. 9-12

$\rho = b'/a' = 2.34[in]/1.5[in] =$ **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813[in]/2.75[in] =$ **0.705** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*17.65[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))^{0.5} =$ **1.31**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.31[in]/0.313[in])^2 - 1) =$ **9.25** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313[in]/1.31[in])^2*(1 + 0.705) =$ **0.0963** p. 9-13

$HasEqualLengths \rightarrow$ **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n = (2*0.0963 + (4 - 2)*0.107)/4 =$ **0.101** p. 9-13

$T_{avail} = 8 * (B*Q) = 8 * (17.65[kip]*0.101) =$ **14.33**[kip] p. 9-10

Beam

Check	Unit	Capacity	Demand	Load	Ratio	Reference
Bolt bearing under shear load	[Kip]	97.11	35.00	DL	0.36	Eq. J3-6

$L_{c-end} = Max(0.0, L_e - d_h/2) = Max(0.0, 4.55[in] - 0.813[in]/2) =$ **4.14**[in] Sec. J4.10

$L_{c-spa} = Max(0.0, s - d_h) = Max(0.0, 3[in] - 0.813[in]) =$ **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(min(k_1*L_{c-end}, k_2*d) + min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(min(1.2*4.14[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(4 - 1))*0.415[in]*65000[lb/in2]*1 =$ **97.11**[kip] Eq. J3-6

Check	Unit	Capacity	Demand	Load	Ratio	Reference
Shear yielding	[Kip]	173.47	35.00	DL	0.20	Eq. J4-3

$A_g = L_p*t_p = 20.9[in]*0.415[in] =$ **8.67**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*8.67[in2] =$ **173.47**[kip] Eq. J4-3

Check	Unit	Capacity	Demand	Load	Ratio	Reference
Shear rupture	[Kip]	140.81	35.00	DL	0.25	Eq. J4-4

$L_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] =$ **0.875**[in] Sec. D3-2

$L_e = L - n*L_h = 20.9[in] - 4*0.875[in] =$ **17.4**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 17.4[in]*0.415[in] =$ **7.22**[in2] Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000[lb/in2]*7.22[in2] =$ **140.81**[kip] Eq. J4-4

Check	Unit	Capacity	Demand	Load	Ratio	Reference
Block shear	[Kip]	110.48	35.00	DL	0.32	Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] =$ **0.875**[in] Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 0.813[in] + 1/16\ [in] =$ **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2.38[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.415[in] =$ **0.804**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (4.55[in] + (4 - 1)*3[in])*0.415[in] =$ **5.62**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (4.55[in] + (4 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.415[in] =$ **4.35**[in2] Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*min(0.6*65000[lb/in2]*4.35[in2] + 1*65000[lb/in2]*0.804[in2], 0.6*50000[lb/in2]*5.62[in2] + 1*65000[lb/in2]*0.804[in2]) =$ **110.48**[kip] Eq. J4-5

Check	Unit	Capacity	Demand	Load	Ratio	Reference
Flexural yielding	[Kip]	160.51	35.00	DL	0.22	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e = 0.599*50000[lb/in2]*45.57[in3]/8.5[in] =$ **160.51**[kip] p. 9-6

Check	Unit	Capacity	Demand	Load	Ratio	Reference
Flexural rupture	[Kip]	174.23	35.00	DL	0.20	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e = 0.5*65000[lb/in2]*45.57[in3]/8.5[in] =$ **174.23**[kip] p. 9-6

Check	Unit	Capacity	Demand	Load	Ratio	Reference
Local web buckling	[Kip]	160.51	35.00	DL	0.22	p. 9-7

$h_o = d - d_c = 23.7[in] - 2.8[in] =$ **20.9**[in] p. 9-7

$IsTopFlangeBeamCoped = (c<=2*d)$ and $(d_c<=d/2) = (8[in]<=2*23.7[in])$ and $(2.8[in]<=23.7[in]/2) =$ **True** p. 9-7

$c/d<=1 \rightarrow 8[in]/23.7[in]<=1 \rightarrow$ **True**

$f = 2*c/d = 2*8[in]/23.7[in] =$ **0.675** p. 9-7

$c/h_o<=1 \rightarrow 8[in]/20.9[in]<=1 \rightarrow$ **True**

$k = 2.2*(h_o/c)^{1.65} = 2.2*(20.9_{[in]}/8_{[in]})^{1.65} = \mathbf{10.73}$ p. 9-7

$F_{cr} = \pi^2*E/(12*(1 - \nu^2))*(t_w/h_o)^2*f*k = \pi^2*2.90E+07_{[lb/in2]}/(12*(1 - 0.3^2))*$
$(0.415_{[in]}/20.9_{[in]})^2*0.675*10.73 = \mathbf{74854.16}_{[lb/in2]}$ p. 9-7

$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e = 0.599*\min(50000_{[lb/in2]}, 74854.16_{[lb/in2]})*$
$45.57_{[in3]}/8.5_{[in]} = \mathbf{160.51}_{[kip]}$ p. 9-7

Support

Bolt bearing under shear load	[Kip]	442.26	35.00	DL	0.08	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.20E+31_{[in]} - 0.813_{[in]}/2) = \mathbf{1.20E+31}_{[in]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 3_{[in]} - 0.813_{[in]}) = \mathbf{2.19}_{[in]}$ Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*$
$t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*1.20E+31_{[in]}, 2.4*0.75_{[in]}) + \min(1.2*2.19_{[in]}, 2.4*$
$0.75_{[in]})*(4 - 1))*0.945_{[in]}*65000_{[lb/in2]}*1) = \mathbf{442.26}_{[kip]}$ Eq. J3-6

Global critical strength ratio **0.44**

NOTATION

a: Plate depth
A_b: Nominal bolt area
A_g: Gross area
A_{gv}: Gross area subject to shear
A_{nt}: Net area subject to tension
A_{nv}: Net area subjected to shear
a': Distance for prying action
α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
B: Available tensile strength per bolt
B: Available strength of all bolts
b': Distance for prying action
b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
C: Bolt group coefficient
c: Coped length
C_2: Edge distance increment
c_{max}: Maximum coped length
d: Nominal bolt diameter
d_c: Coped depth
d_{cb}: Bottom cope depth
d_{cbmax}: Maximum bottom coped depth
d_{ct}: Top cope depth
d_{ctmax}: Maximum top coped depth
d_h: Nominal hole dimension
d_{top}: Beam top edge distance
d': Width of the hole along the length of the fitting
δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
d: Beam depth
dh_h: Horizontal hole dimension
dh_v: Vertical hole dimension
e: Load eccentricity
E: Elastic modulus
f: Plate buckling model adjustment factor
F: Required shear force for combined tension and shear
F_{cr}: Critical stress, flexural stress buckling
F_{nt}: Nominal tensile stress
F_{nv}: Nominal shear stress
F_u: Specified minimum tensile strength
f_v: Required shear stress
F_y: Specified minimum yield stress
F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
h_o: Reduced beam depth
HasEqualLengths: Has equal tributary length for interior and exterior bolts
IsCorrosionConsidered: Is corrosion considered
IsStressUniform: Is the stress uniform
IsTopFlangeBeamCoped: Is the top beam flange coped
k: Plate buckling coefficient
k_1: Bearing factor
k_2: Bearing factor
k: Outside corner radius
L: Length
L: Angle length
$L_{c\text{-}end}$: Clear distance
L_e: Effective length
L_e: Edge distance

L_{eh}: Horizontal edge distance
L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
ν: Poisson's ratio
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
$L_{c\text{-}spa}$: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

Current Date: 2016-05-06 2:38 PM
Units system: English
File name:

Steel connections

Results

Connection name	:	**DA BG All bolted**
Connection ID	:	**SC-06-16**

Family: Beam - Girder (BG)
Type: Angle(s)
Description: W24X62

Design code: AISC 360-05 ASD

DEMANDS

Description	Ru [Kip]	Pu [Kip]	Load type
DL	70.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[in]	14.50	10.76	19.81	✔	p. 10-8
$L_{min} = T/2 = 21.52[\text{in}]/2 = \mathbf{10.76}[\text{in}]$						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 23.7[\text{in}] - \max(1.09[\text{in}], 2.8[\text{in}]) - \max(1.09[\text{in}], 0[\text{in}]) = \mathbf{19.81}[\text{in}]$						p. 10-8
Angle (Beam side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[\text{in}] + 0[\text{in}] = \mathbf{1}[\text{in}]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[\text{in}] + 0[\text{in}] = \mathbf{1}[\text{in}]$						Tables J3.4, J3.5
Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3 * d = 8/3 * 0.75[\text{in}] = \mathbf{2}[\text{in}]$						Sec. J3.3
$IsCorrosionConsidered \rightarrow \textbf{False}$						
$s_{max} = \min(24 * t_p, 12\ [\text{in}]) = \min(24 * 0.313[\text{in}], 12\ [\text{in}]) = \mathbf{7.5}[\text{in}]$						Sec. J3.5
Thickness	[in]	0.31	--	0.63	✔	p. 10-9
$t_{pmax} = 5/8\ [\text{in}]$						p. 10-9
Angle (Support side)						
Vertical edge distance	[in]	1.25	1.00	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[\text{in}] + 0[\text{in}] = \mathbf{1}[\text{in}]$						Tables J3.4, J3.5
Horizontal edge distance	[in]	1.13	1.13	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2 = 1[\text{in}] + 0.125[\text{in}] = \mathbf{1.13}[\text{in}]$						Tables J3.4,

J3.5

Vertical center-to-center spacing (pitch)	[in]	3.00	2.00	7.50	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*0.75$[in] $= \mathbf{2}$[in] Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]$) = \min(24*0.313$[in], 12 [in]$) = \mathbf{7.5}$[in] Sec. J3.5

Beam

Top cope length	[in]	8.00	--	47.40	✔

$c_{max} = 2*d = 2*23.7$[in] $= \mathbf{47.4}$[in]

Bottom cope length	[in]	0.00	--	47.40	✔

$c_{max} = 2*d = 2*23.7$[in] $= \mathbf{47.4}$[in]

Top cope depth	[in]	2.80	--	4.60	✔

$d_{ctmax} = \min(d/2, d_{top} - w) = \min(23.7$[in]$/2, 4.6$[in] $- 0$[in]$) = \mathbf{4.6}$[in]

Bottom cope depth	[in]	0.00	--	4.60	✔

$d_{cbmax} = \min(d/2, d - L - d_{top} - w) = \min(23.7$[in]$/2, 23.7$[in] $- 14.5$[in] $- 4.6$[in] $- 0$[in]$) =$ $\mathbf{4.6}$[in]

Vertical edge distance	[in]	3.05	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in] Tables J3.4, J3.5

Horizontal edge distance	[in]	2.38	1.00	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1$[in] $+ 0$[in] $= \mathbf{1}$[in] Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Bolts shear	[Kip]	106.08	70.00	DL	0.66	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b = 0.5*48000$[lb/in2]$*0.442$[in2] $= \mathbf{10.61}$[kip] Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n) = 2 * (5*10.61$[kip]$) = \mathbf{106.08}$[kip] Tables (7-1..14)

Bolt bearing under shear load	[Kip]	148.85	70.00	DL	0.47	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.25$[in] $- 0.813$[in]$/2) = \mathbf{0.844}$[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3$[in] $- 0.813$[in]$) = \mathbf{2.19}$[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*$ $t_p*F_u*n_c) = 2 * (0.5*(\min(1.2*0.844$[in], $2.4*0.75$[in]$) + \min(1.2*2.19$[in], $2.4*$ 0.75[in]$)*(5 - 1))*0.313$[in]$*58000$[lb/in2]$*1) = \mathbf{148.85}$[kip] Eq. J3-6

Shear yielding	[Kip]	130.50	70.00	DL	0.54	Eq. J4-3

$A_g = L_p*t_p = 14.5$[in]$*0.313$[in] $= \mathbf{4.53}$[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g) = 2 * (0.667*0.60*36000$[lb/in2]$*4.53$[in2]$) = \mathbf{130.5}$[kip] Eq. J4-3

Shear rupture	[Kip]	110.11	70.00	DL	0.64	Eq. J4-4

$L_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $= \mathbf{0.875}$[in] Sec. D3-2

$L_e = L - n*L_h = 14.5$[in] $- 5*0.875$[in] $= \mathbf{10.13}$[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 10.13$[in]$*0.313$[in] $= \mathbf{3.16}$[in2] Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv}) = 2 * (0.5*0.60*58000$[lb/in2]$*3.16$[in2]$) = \mathbf{110.11}$[kip] Eq. J4-4

Block shear	[Kip]	101.90	70.00	DL	0.69	Eq. J4-5

$dh_h = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $= \mathbf{0.875}$[in] Sec. D3-2

$dh_v = d_h + 1/16$ [in] $= 0.813$[in] $+ 1/16$ [in] $= \mathbf{0.875}$[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (1.13$[in] $+ (1 - 1)*3$[in] $- (1 - 0.5)*$

0.875[in])*0.313[in] = **0.215**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (5 - 1)*3[in])*0.313[in] = **4.14**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (5 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.91**[in2] Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}))$ = 2 * (0.5*min(0.6*58000[lb/in2]*2.91[in2] + 1*58000[lb/in2]*0.215[in2], 0.6*36000[lb/in2]*4.14[in2] + 1*58000[lb/in2]*0.215[in2])) = **101.9**[kip] Eq. J4-5

<u>Angle (Support side)</u>

Bolts shear	[Kip]	106.08	70.00	DL	0.66	Tables (7-1..14)

$(1/\Omega)R_n = (1/\Omega)*F_{nv}*A_b$ = 0.5*48000[lb/in2]*0.442[in2] = **10.61**[kip] Eq. J3-1

$(1/\Omega)R_n = 2 * (C*(1/\Omega)R_n)$ = 2 * (5*10.61[kip]) = **106.08**[kip] Tables (7-1..14)

Bolt bearing under shear load	[Kip]	148.85	70.00	DL	0.47	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.25[in] - 0.813[in]/2) = **0.844**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = 2 * ((1/\Omega)*(C/(n_c*n))*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c)$ = 2 * (0.5*(5/(1*5))*(min(1.2*0.844[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.313[in]*58000[lb/in2]*1) = **148.85**[kip] p. 7-18, Sec. J3.10

Shear yielding	[Kip]	130.50	70.00	DL	0.54	Eq. J4-3

$A_g = L_p*t_p$ = 14.5[in]*0.313[in] = **4.53**[in2] Sec. D3-1

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_y*A_g)$ = 2 * (0.667*0.60*36000[lb/in2]*4.53[in2]) = **130.5**[kip] Eq. J4-3

Shear rupture	[Kip]	110.11	70.00	DL	0.64	Eq. J4-4

$L_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$L_e = L - n*L_h$ = 14.5[in] - 5*0.875[in] = **10.13**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 10.13[in]*0.313[in] = **3.16**[in2] Sec. J4-2

$(1/\Omega)R_n = 2 * ((1/\Omega)*0.60*F_u*A_{nv})$ = 2 * (0.5*0.60*58000[lb/in2]*3.16[in2]) = **110.11**[kip] Eq. J4-4

Block shear	[Kip]	100.20	70.00	DL	0.70	Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 1[in] + 1/16 [in] = **1.06**[in] Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (1.13[in] + (1 - 1)*5.5[in] - (1 - 0.5)*1.06[in])*0.313[in] = **0.186**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.25[in] + (5 - 1)*3[in])*0.313[in] = **4.14**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.25[in] + (5 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.313[in] = **2.91**[in2] Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = 2 * ((1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}))$ = 2 * (0.5*min(0.6*58000[lb/in2]*2.91[in2] + 1*58000[lb/in2]*0.186[in2], 0.6*36000[lb/in2]*4.14[in2] + 1*58000[lb/in2]*0.186[in2])) = **100.2**[kip] Eq. J4-5

Resulting tension capacity due prying action	[Kip]	18.10	0.00	DL	0.00	p. 9-13, p. 9-10

$f_v = F/(A_b*N_{bolts})$ = 70[kip]/(0.442[in2]*10) = **15837.1**[lb/in2] Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*15837.1[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **57610.86**[lb/in2] Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*57610.86[lb/in2]*0.442[in2] = **12.73**[kip] Eq. J3-2

$f_v = F/(A_b*N_{bolts})$ = 70[kip]/(0.442[in2]*10) = **15837.1**[lb/in2] Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/((1/\Omega)*F_{nv}), 0.0), F_{nt})$ = min(max(1.3*90000[lb/in2] - 90000[lb/in2]*15837.1[lb/in2]/(0.5*48000[lb/in2]), 0.0), 90000[lb/in2]) = **57610.86**[lb/in2] Eq. J3-3

$(1/\Omega)R_n = (1/\Omega)*F'_{nt}*A_b$ = 0.5*57610.86[lb/in2]*0.442[in2] = **12.73**[kip] Eq. J3-2

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2)$ = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

$\rho = b'/a'$ = 2.34[in]/1.5[in] = **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813$[in]/3[in] = **0.729** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*12.73$[kip]*2.34[in])/(0.5*3[in]*58000[lb/in2]))$^{0.5}$ = **1.07**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 1.56)))*((1.07$[in]/0.313[in])^2 - 1) = **5.72** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313$[in]/1.07[in])^2*(1 + 0.729) = **0.148** p. 9-13

$a' = \text{Min}(a + d/2, 1.25*b + d/2)$ = Min(1.13[in] + 0.75[in]/2, 1.25*2.72[in] + 0.75[in]/2) = **1.5**[in] p. 9-12

$b' = b - d/2$ = 2.72[in] - 0.75[in]/2 = **2.34**[in] p. 9-12

$\rho = b'/a'$ = 2.34[in]/1.5[in] = **1.56** p. 9-12

$\delta = 1 - d'/p = 1 - 0.813$[in]/2.75[in] = **0.705** p. 9-11

$t_c = ((3.33*B*b')/((1/\Omega)*p*F_u))^{0.5} = ((3.33*12.73$[kip]*2.34[in])/(0.5*2.75[in]*58000[lb/in2]))$^{0.5}$ = **1.12**[in] p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.705*(1 + 1.56)))*((1.12$[in]/0.313[in])^2 - 1) = **6.51** p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (0.313$[in]/1.12[in])^2*(1 + 0.705) = **0.134** p. 9-13

HasEqualLengths → **False**

$Q = (2*Q_{ext} + (n - 2)*Q_{int})/n$ = (2*0.134 + (5 - 2)*0.148)/5 = **0.142** p. 9-13

$T_{avail} = 10 * (B*Q)$ = 10 * (12.73[kip]*0.142) = **18.1**[kip] p. 9-10

<u>Beam</u>

Bolt bearing under shear load	[Kip]	125.78	70.00	DL	0.56	Eq. J3-6

$L_{c-end} = \text{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 3.05[in] - 0.813[in]/2) = **2.64**[in] Sec. J4.10

$L_{c-spa} = \text{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(min(1.2*2.64[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*0.75[in])*(5 - 1))*0.43[in]*65000[lb/in2]*1 = **125.78**[kip] Eq. J3-6

Shear yielding	[Kip]	179.74	70.00	DL	0.39	Eq. J4-3

$A_g = L_p*t_p$ = 20.9[in]*0.43[in] = **8.99**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*8.99[in2] = **179.74**[kip] Eq. J4-3

Shear rupture	[Kip]	138.56	70.00	DL	0.51	Eq. J4-4

$L_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$L_e = L - n*L_h$ = 20.9[in] - 5*0.875[in] = **16.53**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 16.53[in]*0.43[in] = **7.11**[in2] Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv}$ = 0.5*0.60*65000[lb/in2]*7.11[in2] = **138.56**[kip] Eq. J4-4

Block shear	[Kip]	120.25	70.00	DL	0.58	Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 0.813[in] + 1/16 [in] = **0.875**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (2.38[in] + (1 - 1)*3[in] - (1 - 0.5)*0.875[in])*0.43[in] = **0.833**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (3.05[in] + (5 - 1)*3[in])*0.43[in] = **6.47**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (3.05[in] + (5 - 1)*(3[in] - 0.875[in]) - 0.875[in]/2)*0.43[in] = **4.78**[in2] Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$ = 0.5*min(0.6*65000[lb/in2]*4.78[in2] + 1*65000[lb/in2]*0.833[in2], 0.6*50000[lb/in2]*6.47[in2] + 1*65000[lb/in2]*0.833[in2]) = **120.25**[kip] Eq. J4-5

Flexural yielding	[Kip]	159.07	70.00	DL	0.44	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_y*S_{net}/e$ = 0.599*50000[lb/in2]*45.16[in3]/8.5[in] = **159.07**[kip] p. 9-6

Flexural rupture	[Kip]	172.67	70.00	DL	0.41	p. 9-6

$(1/\Omega)R_n = (1/\Omega)*F_u*Z_{net}/e$ = 0.5*65000[lb/in2]*45.16[in3]/8.5[in] = **172.67**[kip] p. 9-6

Local web buckling	[Kip]	159.07	70.00	DL	0.44	p. 9-7

$h_o = d - d_c$ = 23.7[in] - 2.8[in] = **20.9**[in] p. 9-7

IsTopFlangeBeamCoped = (c<=2*d) and (d_c<=d/2) = (8[in]<=2*23.7[in]) and (2.8[in]<=23.7[in]/2) = **True** p. 9-7

c/d<=1 → 8[in]/23.7[in]<=1 → **True**
$f = 2*c/d = 2*8$[in]$/23.7$[in] = **0.675** p. 9-7
c/h_o<=1 → 8[in]/20.9[in]<=1 → **True**
$k = 2.2*(h_o/c)^{1.65} = 2.2*(20.9$[in]$/8$[in]$)^{1.65}$ = **10.73** p. 9-7
$F_{cr} = \pi^2*E/(12*(1 - \nu^2))*(t_w/h_o)^2*f*k = \pi^2*2.90E+07$[lb/in2]$/(12*(1 - 0.3^2))*$
$(0.43$[in]$/20.9$[in]$)^2*0.675*10.73$ = **80363.1**[lb/in2] p. 9-7
$(1/\Omega)R_n = (1/\Omega)*\min(F_y, F_{cr})*S_{net}/e$ = 0.599*min(50000[lb/in2], 80363.1[lb/in2])*45.16[in3]/
8.5[in] = **159.07**[kip] p. 9-7

<u>Support</u>

Bolt bearing under shear load	[Kip]	517.73	70.00	DL	0.14	Eq. J3-6

$L_{c-end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.20E+31[in] - 0.813[in]/2) = **1.20E+31**[in] Sec. J4.10
$L_{c-spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 0.813[in]) = **2.19**[in] Sec. J4.10
$(1/\Omega)R_n = 2 * ((1/\Omega)*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*(n - 1))*$
$t_p*F_u*n_c)$ = 2 * (0.5*(min(1.2*1.20E+31[in], 2.4*0.75[in]) + min(1.2*2.19[in], 2.4*
0.75[in])*(5 - 1))*0.885[in]*65000[lb/in2]*1) = **517.73**[kip] Eq. J3-6

Global critical strength ratio **0.70**

NOTATION

a: Plate depth
A_b: Nominal bolt area
A_g: Gross area
A_{gv}: Gross area subject to shear
A_{nt}: Net area subject to tension
A_{nv}: Net area subjected to shear
a': Distance for prying action
α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
B: Available tensile strength per bolt
B: Available strength of all bolts
b': Distance for prying action
b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
C: Bolt group coefficient
c: Coped length
C_2: Edge distance increment
c_{max}: Maximum coped length
d: Nominal bolt diameter
d_c: Coped depth
d_{cb}: Bottom cope depth
d_{cbmax}: Maximum bottom coped depth
d_{ct}: Top cope depth
d_{ctmax}: Maximum top coped depth
d_h: Nominal hole dimension
d_{top}: Beam top edge distance
d': Width of the hole along the length of the fitting
δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
d: Beam depth
dh_h: Horizontal hole dimension
dh_v: Vertical hole dimension
e: Load eccentricity
E: Elastic modulus
f: Plate buckling model adjustment factor
F: Required shear force for combined tension and shear
F_{cr}: Critical stress, flexural stress buckling
F_{nt}: Nominal tensile stress
F_{nv}: Nominal shear stress
F_u: Specified minimum tensile strength
f_v: Required shear stress
F_y: Specified minimum yield stress
F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
h_o: Reduced beam depth
HasEqualLengths: Has equal tributary length for interior and exterior bolts
IsCorrosionConsidered: Is corrosion considered
IsStressUniform: Is the stress uniform
IsTopFlangeBeamCoped: Is the top beam flange coped
k: Plate buckling coefficient
k_1: Bearing factor
k_2: Bearing factor
k: Outside corner radius
L: Length

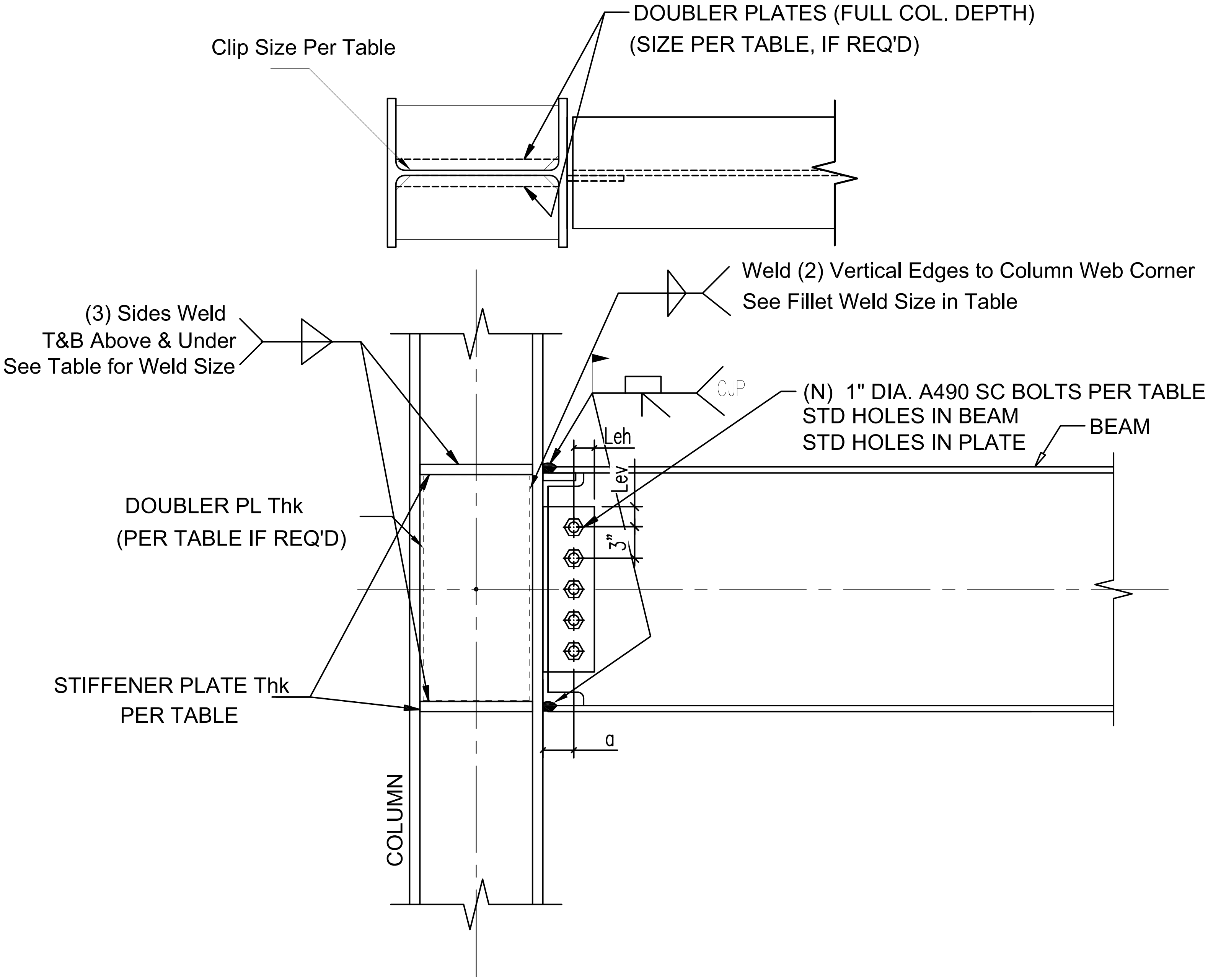
L: Angle length
$L_{c\text{-}end}$: Clear distance
L_e: Effective length
L_e: Edge distance
L_{eh}: Horizontal edge distance
L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
e_{dmin}: Minimum edge distance
n: Bolts rows number
N_{bolts}: Number of bolts
n_c: Number of bolt columns
ν: Poisson's ratio
$(1/\Omega)$: Design factors
$(1/\Omega)R_n$: Design or allowable strength
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q_{ext}: Prying action coefficient for exterior bolts
Q_{int}: Prying action coefficient for interior bolts
Q: Prying action coefficient
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
S_{net}: Net section modulus
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
$L_{c\text{-}spa}$: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t_p: Plate thickness
t_{pmax}: Maximum plate thickness
t_w: Web thickness
U_{bs}: Stress index
w: Weld size
Z_{net}: Net plastic section modulus

MC-01 BEAM TO COLUMN MOMENT CONNECTION

			Column					Beam Flange Connection Detail							Beam Web Connection Detail							
Connection ID	Level /Location	Beam Size	Size	Web/Flange	Shear Design Load (kip)	Moment Design Load (Kip-ft) *	Axial Design Load (kip)	Extens. Pl. (A572 Gr.50) Thk. (inch)	Weld Size (inch)	Stiff. Pl. (A572 Gr.50) Size (inch)	Clip Size (inch)	Weld Size to Web and Flange (inch)	Doubler Plate Thk.td (inch)	Weld Size to Web (inch)	Shear Tab (A572 Gr.50)Thk. (inch)	Weld Size to Support (inch)	Bolt Row.xCol	Bolt Grade & Size	Bolt Spacing （inch） "Spa."	Distance between Weld to Bolts (inch) "a"	Bolt Edge Vertical Distance "Lev" (inch)	Bolt Edge Horizontal Distance "Leh" (inch)
MC-01-1	L3/B3-5	W24X76	W12X87	Flange	100	440	-	-	-	1/2 x4 1/2	3/4"	3/8	3/8 (2 sides)	1/4	1/2	5/16	7x1	1" A490 SC	3	3	1 3/4	2
MC-01-2	L3/B3-6	W24X62	W10x49	Flange	91	327	-	-	-	1/2x4 1/2	3/4"	3/8	3/8 (2 sides)	1/4	1/2	5/16	7x1	1" A490 SC	3	3	1 3/4	2
MC-01-3	L3/A6-7.1	W24X55	W10X39	Flange	42	285	-	-	-	5/8x3 3/4	3/4"	CJP	3/8 (2 sides)	1/4	1/2	5/16	6x1	1" A490 SC	3	3	1 3/4	2

* Elastic moment strength values =Fy*Sx/Ω from AISC manual
Make sure stiffener extends beyond the toe of the column flange to eliminate the effects of triaxial stresses.
SC-Bolt connection to have Class-A faying surface.
See VB design table for Brace connection design
Use Standard Bolt Hole at Shear Tab

MC-01 Beam to Column Moment Connection



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Steel connections

Results

Connection name : DW BCF

Connection ID : MC-01-1M

Family: Beam - Column flange (BCF)

Type: Directly welded flanges

Description: B:W24X76

Design code: AISC 360-05 ASD

DEMANDS

	Beam			Right beam		Left beam		Column	Panel	
Description	**Ru**	**Pu**	**Mu**	**PufTop**	**PufBot**	**PufTop**	**PufBot**	**Pu**	**Vu**	**Load type**
	[Kip]	[Kip]	[Kip*ft]	[Kip]	[Kip]	[Kip]	[Kip]	[Kip]	[Kip]	
DL	0.00	0.00	439.00	-226.87	226.87	0.00	0.00	0.00	226.87	Design

GEOMETRIC CONSIDERATIONS

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
Transverse stiffeners						
Length	[in]	10.88	5.44	--	✔	Sec. J10.8
$l_{smin} = (d_c - 2*t_{cf})/2 = (12.5\text{[in]} - 2*0.81\text{[in]})/2 = \mathbf{5.44}\text{[in]}$						Sec. J10.8
Width	[in]	4.50	2.74	--	✔	Sec. J10.8
$b_{smin} = b/3 - t_w/2 = 8.99\text{[in]}/3 - 0.515\text{[in]}/2 = \mathbf{2.74}\text{[in]}$						Sec. J10.8
Thickness	[in]	0.50	0.34	--	✔	Sec. J10.8
$HasOppositeConnection \rightarrow$ **False**						
$t_{smin} = \text{Max}(t_p*0.5, b_s/15) = \text{Max}(0.68\text{[in]}*0.5, 4.5\text{[in]}/15) = \mathbf{0.34}\text{[in]}$						Sec. J10.8

Weld size [1/16in] 6 5 -- ✔ DG 13 Eq. 4.3-6

$w_{min} = (0.943*F_{ys}*t_p)/F_{EXX} = (0.943*50000$[lb/in2]$*0.5$[in]$)/70000$[lb/in2] = **0.337**[in] — DG 13 Eq. 4.3-6

<u>Doublers</u>

Recommended thickness for beveling and welding [in] 0.38 0.35 -- ✔ Sec. G2.1, DG 13 Eq. 4.4-4

$h = d_c - 2*k = 12.5$[in] $- 2*1.41$[in] = **9.68**[in] — Sec. G2.1

$t_{min} = h/(1.1*(5*E/F_y)^{1/2}) = 9.68$[in]$/(1.1*(5*2.90E+07$[lb/in2]$/50000$[lb/in2]$)^{1/2})$ = **0.163**[in] — Sec. G2.1

$t_{min} = k - t_f - r_e = 1.41$[in] $- 0.81$[in] $- 0.25$[in] = **0.35**[in] — DG 13 Eq. 4.4-4

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

<u>Support</u>

Panel web shear	[Kip]	284.06	226.87	DL	0.80	Sec. J10-6, Eq. J10-9

$P_c = (1/\Omega)*F_y*A = 0.6*50000$[lb/in2]$*25.6$[in2] = **768**[kip] — Sec. J10-6

$IsPanelZoneDeformationConsidered = IsPanelZoneDeformationConsidered$ = **False** — Sec. J10-6

$P_r<=0.4*P_c \rightarrow 0$[kip]$<=0.4*768$[kip] $\rightarrow$ **True**

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*d_c*t_w = 0.599*0.60*50000$[lb/in2]$*12.5$[in]$*0.515$[in] = **115.64**[kip] — Eq. J10-9

$(1/\Omega)R_{ndp} = 2 * ((1/\Omega)*0.6*F_y*d_c*t_p) = 2 * (0.599*0.6*50000$[lb/in2]$*12.5$[in]$*0.375$[in]$)$ = **168.41**[kip] — DG13 Eq. 4.4-1

$(1/\Omega)R_n = (1/\Omega)R_n + (1/\Omega)R_{ndp} = 115.64$[kip] $+ 168.41$[kip] = **284.06**[kip] — Sec. J10

<u>Support - right side</u>

Bottom local flange bending	[Kip]	235.05	226.87	DL	0.97	Eq. J10-1

$IsMemberEnd \rightarrow$ **False**

$(1/\Omega)R_n = (1/\Omega)*6.25*t_f^2*F_{yf} = 0.599*6.25*0.81$[in]^{2*50000}[lb/in2] = **122.77**[kip] — Eq. J10-1

$A_{st} = t_p*(b_s - clip) = 0.5$[in]$*(4.5$[in] $- 0.75$[in]$)$ = **1.88**[in2] — DG13 Sec. 4.3

$(1/\Omega)R_{nts} = 2 * ((1/\Omega)*F_y*A_{st}) = 2 * (0.599*50000$[lb/in2]$*1.88$[in2]$)$ = **112.28**[kip] — DG13 Eq. 4.3-1

$(1/\Omega)R_n = (1/\Omega)R_n + (1/\Omega)R_{nts} = 122.77$[kip] $+ 112.28$[kip] = **235.05**[kip] — Sec. J10

Local web yielding	[Kip]	438.22	226.87	DL	0.52	Eq. J10-2

$IsBeamReaction \rightarrow$ **False**

$N = N$ = **0.68**[in] — Sec. J10-2

$IsMemberEnd \rightarrow$ **False**

$(1/\Omega)R_n = (1/\Omega)*(5*k + N)*F_{yw}*t_w = 0.667*(5*1.41$[in] $+ 0.68$[in]$)*50000$[lb/in2]$*0.515$[in] = **132.7**[kip] — Eq. J10-2

$IsMemberEnd \rightarrow$ **False**

$(1/\Omega)R_{ndp} = 2 * ((1/\Omega)*(5*k + N)*F_y*t_p) = 2 * (0.667*(5*1.41$[in] $+ 0.68$[in]$)*50000$[lb/in2]$*0.375$[in]$)$ = **193.25**[kip] — Eq. J10-2

$(1/\Omega)R_n = (1/\Omega)R_n + (1/\Omega)R_{ndp} = 132.7$[kip] $+ 193.25$[kip] = **325.95**[kip] — Sec. J10

$A_{st} = t_p*(b_s - clip) = 0.5$[in]$*(4.5$[in] $- 0.75$[in]$)$ = **1.88**[in2] — DG13 Sec. 4.3

$(1/\Omega)R_{nts} = 2 * ((1/\Omega)*F_y*A_{st}) = 2 * (0.599*50000\text{[lb/in2]}*1.88\text{[in2]}) = \mathbf{112.28}\text{[kip]}$ DG13 Eq. 4.3-1

$(1/\Omega)R_n = (1/\Omega)R_n + (1/\Omega)R_{nts} = 325.95\text{[kip]} + 112.28\text{[kip]} = \mathbf{438.22}\text{[kip]}$ Sec. J10

Transverse stiffeners - top

Yielding strength due to axial load	[Kip]	112.28	0.00	DL	0.00	Eq. D2-1

$A_g = 2 * ((b_s - clip)*t_p) = 2 * ((4.5\text{[in]} - 0.75\text{[in]})*0.5\text{[in]}) = \mathbf{3.75}\text{[in2]}$ Sec. D3.1

$(1/\Omega)R_n = (1/\Omega)*F_y*A_g = 0.599*50000\text{[lb/in2]}*3.75\text{[in2]} = \mathbf{112.28}\text{[kip]}$ Eq. D2-1

Compression	[Kip]	94.20	53.40	DL	0.57	Sec. J4.4

$r = t_p/(12)^{1/2} = 0.5\text{[in]}/(12)^{1/2} = \mathbf{0.144}\text{[in]}$ Sec. E2

$A_g = L_p*t_p = 3.75\text{[in]}*0.5\text{[in]} = \mathbf{1.88}\text{[in2]}$ Sec. D3-1

$K*L/r>25 \rightarrow 0.65*10.88\text{[in]}/0.144\text{[in]}>25 \rightarrow \mathbf{True}$

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.90E+07\text{[lb/in2]}/(0.65*10.88\text{[in]}/0.144\text{[in]})^2 = \mathbf{1.19E+05}\text{[lb/in2]}$ Eq. E3-4

$F_e>=0.44*Q*F_y \rightarrow 1.19E+05\text{[lb/in2]}>=0.44*1*50000\text{[lb/in2]} \rightarrow \mathbf{True}$

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*50000\text{[lb/in2]}/1.19E+05\text{[lb/in2]})}*50000\text{[lb/in2]} =$
$\mathbf{41950.71}\text{[lb/in2]}$ Eq. E7-2

$(1/\Omega)P_n = 2 * ((1/\Omega)*F_{cr}*A_g) = 2 * (0.599*41950.71\text{[lb/in2]}*1.88\text{[in2]}) = \mathbf{94.2}\text{[kip]}$ Sec. J4.4

Flange weld capacity	[Kip]	112.76	53.40	DL	0.47	Eq. J2-4

$L = b_{st} - clip - w = 4.5\text{[in]} - 0.75\text{[in]} - 0.375\text{[in]} = \mathbf{3.38}\text{[in]}$ Comm. J10.8

$LoadAngleFactor = 1 + 0.5*(\sin(\theta))^{1.5} = 1 + 0.5*(\sin(1.57))^{1.5} = \mathbf{1.5}$ p. 8-9

$F_w = 0.6*F_{EXX}*LoadAngleFactor = 0.6*70000\text{[lb/in2]}*1.5 = \mathbf{63000}\text{[lb/in2]}$ Sec. J2.5

$A_w = (2)^{1/2}/2*D/16\ \text{[in]}*L = (2)^{1/2}/2*6/16\ \text{[in]}*3.38\text{[in]} = \mathbf{0.895}\text{[in2]}$ Sec. J2.4

$(1/\Omega)R_n = 4 * ((1/\Omega)*F_w*A_w) = 4 * (0.5*63000\text{[lb/in2]}*0.895\text{[in2]}) = \mathbf{112.76}\text{[kip]}$ Eq. J2-4

Web weld capacity	[Kip]	217.28	53.40	DL	0.25	Eq. J2-4

$L = l - clip - w = 10.88\text{[in]} - 0.75\text{[in]} - 0.375\text{[in]} = \mathbf{9.76}\text{[in]}$ Comm. J10.8

$F_w = 0.6*F_{EXX} = 0.6*70000\text{[lb/in2]} = \mathbf{42000}\text{[lb/in2]}$ Sec. J2.4

$A_w = (2)^{1/2}/2*D/16\ \text{[in]}*L = (2)^{1/2}/2*6/16\ \text{[in]}*9.76\text{[in]} = \mathbf{2.59}\text{[in2]}$ Sec. J2.4

$(1/\Omega)R_n = 4 * ((1/\Omega)*F_w*A_w) = 4 * (0.5*42000\text{[lb/in2]}*2.59\text{[in2]}) = \mathbf{217.28}\text{[kip]}$ Eq. J2-4

Transverse stiffeners - bottom

Yielding strength due to axial load	[Kip]	112.28	104.10	DL	0.93	Eq. D2-1

$A_g = 2 * ((b_s - clip)*t_p) = 2 * ((4.5\text{[in]} - 0.75\text{[in]})*0.5\text{[in]}) = \mathbf{3.75}\text{[in2]}$ Sec. D3.1

$(1/\Omega)R_n = (1/\Omega)*F_y*A_g = 0.599*50000\text{[lb/in2]}*3.75\text{[in2]} = \mathbf{112.28}\text{[kip]}$ Eq. D2-1

Compression	[Kip]	94.20	0.00	DL	0.00	Sec. J4.4

$r = t_p/(12)^{1/2} = 0.5\text{[in]}/(12)^{1/2} = \mathbf{0.144}\text{[in]}$ Sec. E2

$A_g = L_p*t_p = 3.75\text{[in]}*0.5\text{[in]} = \mathbf{1.88}\text{[in2]}$ Sec. D3-1

$K*L/r>25 \rightarrow 0.65*10.88\text{[in]}/0.144\text{[in]}>25 \rightarrow \mathbf{True}$

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.90E+07\text{[lb/in2]}/(0.65*10.88\text{[in]}/0.144\text{[in]})^2 = \mathbf{1.19E+05}\text{[lb/in2]}$ Eq. E3-4

$F_e>=0.44*Q*F_y \rightarrow 1.19E+05\text{[lb/in2]}>=0.44*1*50000\text{[lb/in2]} \rightarrow \mathbf{True}$

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*50000\text{[lb/in2]}/1.19E+05\text{[lb/in2]})}*50000\text{[lb/in2]} =$
$\mathbf{41950.71}\text{[lb/in2]}$ Eq. E7-2

$(1/\Omega)P_n = 2 * ((1/\Omega)*F_{cr}*A_g) = 2 * (0.599*41950.71\text{[lb/in2]}*1.88\text{[in2]}) = \mathbf{94.2}\text{[kip]}$ Sec. J4.4

Flange weld capacity	[Kip]	112.76	104.10	DL	0.92	Eq. J2-4

$L = b_{st} - clip - w = 4.5$[in] $- 0.75$[in] $- 0.375$[in] $=$ **3.38**[in] — Comm. J10.8

$LoadAngleFactor = 1 + 0.5*(\sin(\theta))^{1.5} = 1 + 0.5*(\sin(1.57))^{1.5} =$ **1.5** — p. 8-9

$F_w = 0.6*F_{EXX}*LoadAngleFactor = 0.6*70000$[lb/in2]$*1.5 =$ **63000**[lb/in2] — Sec. J2.5

$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}/2*6/16$ [in]$*3.38$[in] $=$ **0.895**[in2] — Sec. J2.4

$(1/\Omega)R_n = 4 * ((1/\Omega)*F_w*A_w) = 4 * (0.5*63000$[lb/in2]$*0.895$[in2]$) =$ **112.76**[kip] — Eq. J2-4

Web weld capacity	[Kip]	217.28	104.10	DL	0.48	Eq. J2-4

$L = l - clip - w = 10.88$[in] $- 0.75$[in] $- 0.375$[in] $=$ **9.76**[in] — Comm. J10.8

$F_w = 0.6*F_{EXX} = 0.6*70000$[lb/in2] $=$ **42000**[lb/in2] — Sec. J2.4

$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}/2*6/16$ [in]$*9.76$[in] $=$ **2.59**[in2] — Sec. J2.4

$(1/\Omega)R_n = 4 * ((1/\Omega)*F_w*A_w) = 4 * (0.5*42000$[lb/in2]$*2.59$[in2]$) =$ **217.28**[kip] — Eq. J2-4

Global critical strength ratio **0.97**

NOTATION

A: Column cross-sectional area

A_g: Gross area

A_{st}: Transverse stiffener cross-sectional area

A_w: Effective area of the weld

b: Plate, connector or member width

b_s: Transverse stiffener width

b_{st}: Contact length between transverse stiffener and support flange

b_{smin}: Minimum transverse stiffener width

N: Bearing length

clip: Transverse stiffener corner clip dimension

d: Beam depth

d_c: Column depth

D: Number of sixteenths of an inch in the weld size

E: Elastic modulus

F_{cr}: Critical stress, flexural stress buckling

F_e: Elastic critical buckling stress

F_{EXX}: Electrode classification number

F_w: Nominal strength of the weld metal per unit area

F_y: Specified minimum yield stress

F_{yf}: Specified minimum yield stress of flange

F_{ys}: Specified minimum yield stress of stiffener material

F_{yw}: Specified minimum yield stress of web

h: Clear distance between flanges

HasOppositeConnection: Has opposite connection

IsBeamReaction: Is beam reaction

IsMemberEnd: Is member end

IsPanelZoneDeformationConsidered: Is panel zone deformation considered on frame stability

K: Effective length factor

k: Distance from outer face of flange to the web toe of fillet

l: Length

l_{smin}: Stiffener minimum length

L: Length

L_p: Plate length

L: Length of weld

LoadAngleFactor: Load angle factor

N: Bearing length

P_c: Available axial compressive strength

P_r: Required axial stress

$(1/\Omega)$: Design factors

$(1/\Omega)P_n$: Design or allowable strength

$(1/\Omega)R_n$: Design or allowable strength

$(1/\Omega)R_{nts}$: Transverse stiffener design or allowable strength

$(1/\Omega)R_{ndp}$: Doubler plate design or allowable strength

Q: Prying action coefficient

r: Radius of gyration

r_e: Permissible encroachment

t_p: Thickness of the connected material

t_{cf}: Thickness of the column flange

t_f: Thickness of the loaded flange

t_{min}: Minimum thickness

t_p: Plate thickness

t_{smin}: Minimum transverse stiffener thickness

t_w: Web thickness

θ: Load angle

w_{min}: Minimum weld size required

w: Weld size

Current Date: 2016-05-06 2:27 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\MC-01 Beam to Column Moment Connection\MC.cnx\

Steel connections

Results

Connection name : SP BCF

Connection ID : MC-01-1V

Family: Beam - Column flange (BCF)

Type: Single plate

Description: B:W24X76

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru**	**Pu**	**Pu**	**Mu22**	**Mu33**	**Load type**
	[Kip]	[Kip]	[Kip]	[Kip*ft]	[Kip*ft]	
DL	100.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Shear plate						
Length	[in]	21.50	10.77	21.54	✓	p. 10-104
$L_{min} = T/2 = 21.54_{[in]}/2 = \mathbf{10.77}_{[in]}$						p. 10-104
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 23.9_{[in]} - \max(1.18_{[in]}, 0_{[in]}) - \max(1.18_{[in]}, 0_{[in]}) = \mathbf{21.54}_{[in]}$						p. 10-49
Thickness	[in]	0.50	--	0.56	✓	p. 10-102
$t_{pmax} = d/2 + 1/16_{[in]} = 1_{[in]}/2 + 1/16_{[in]} = \mathbf{0.563}_{[in]}$						p. 10-102
Vertical edge distance	[in]	1.75	1.75	--	✓	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75$[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.00	2.00	--	✔	p. 10-102

$L_{emin} = 2*d = 2*1$[in] = **2**[in] — p. 10-102

Vertical center-to-center spacing (pitch)	[in]	3.00	2.67	10.56	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*1$[in] = **2.67**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.44[in], 12 [in]) = **10.56**[in] — Sec. J3.5

Beam

Vertical edge distance	[in]	2.95	1.75	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75$[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Horizontal edge distance	[in]	2.50	2.00	--	✔	p. 10-102

$L_{emin} = 2*d = 2*1$[in] = **2**[in] — p. 10-102

Support

Weld size	[1/16in]	5	5	--	✔	p. 10-101

$w_{min} = (5/8)*t_p = (5/8)*0.5$[in] = **0.026** — p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear plate						
Bolts shear	[Kip]	118.12	100.00	DL	0.85	Tables (7-1..14)

(n>=10) and (n<=12) and (*IsStandardHole*) → (7>=10) and (7<=12) and (True) → **False**

BoltFactor = 1 — p. 10-102

$k_s = \max(1 - T_u/((1/\Omega)*D_u*T_b*N_b), 0.0)$ = max(1 - 0[kip]/(0.667*1.13*64[kip]*1), 0.0) = **1** — Eq. J3-5

$(1/\Omega)R_n = (1/\Omega)*\mu*D_u*h_{sc}*T_b*N_s*k_s$ = 0.667*0.35*1.13*1*64[kip]*1*1 = **16.87**[kip] — Eq. J3-4

$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor$ = 7*16.87[kip]*1 = **118.12**[kip] — Tables (7-1..14)

Bolt bearing under shear load	[Kip]	250.45	100.00	DL	0.40	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.75[in] - 1.06[in]/2) = **1.22**[in] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(min(1.2*1.22[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(7 - 1))*0.5[in]*65000[lb/in2]*1 = **250.45**[kip] — Eq. J3-6

Shear yielding	[Kip]	215.00	100.00	DL	0.47	Eq. J4-3

$A_g = L_p*t_p = 21.5$[in]$*0.5$[in] = **10.75**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000$[lb/in2]$*10.75$[in2] = **215**[kip] Eq. J4-3

Shear rupture	[Kip]	132.84	100.00	DL	0.75	Eq. J4-4

$L_h = d_h + 1/16$ [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$L_e = L - n*L_h = 21.5$[in] - 7*1.13[in] = **13.63**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 13.63$[in]*0.5[in] = **6.81**[in2] Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000$[lb/in2]*6.81[in2] = **132.84**[kip] Eq. J4-4

Block shear	[Kip]	144.63	100.00	DL	0.69	Eq. J4-5

$dh_h = d_h + 1/16$ [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$dh_v = d_h + 1/16$ [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (2[in] + (1 - 1)*3[in] - (1 - 0.5)*1.13[in])*0.5[in] = **0.719**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.75[in] + (7 - 1)*3[in])*0.5[in] = **9.88**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.75[in] + (7 - 1)*(3[in] - 1.13[in]) - 1.13[in]/2)*0.5[in] = **6.22**[in2] Sec. J4-3

IsStressUniform → **True**

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$ = 0.5*min(0.6*65000[lb/in2]*6.22[in2] + 1*65000[lb/in2]*0.719[in2], 0.6*50000[lb/in2]*9.88[in2] + 1*65000[lb/in2]*0.719[in2]) = **144.63**[kip] Eq. J4-5

Plate (support side)

Weld capacity	[Kip]	199.54	100.00	DL	0.50	Tables 8-4 .. 8-11

$(1/\Omega)R_n = (1/\Omega)*C*C_1*D*L = 0.5*3.71$[kip/in]*1*5*21.5[in] = **199.54**[kip] Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load	[Kip]	233.81	100.00	DL	0.43	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 2.95[in] - 1.06[in]/2) = **2.42**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(min(1.2*2.42[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(7 - 1))*0.44[in]*65000[lb/in2]*1 = **233.81**[kip] Eq. J3-6

Shear yielding	[Kip]	210.32	100.00	DL	0.48	Eq. J4-3

$A_g = L_p*t_p = 23.9$[in]*0.44[in] = **10.52**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000$[lb/in2]*10.52[in2] = **210.32**[kip] Eq. J4-3

Support

Welds rupture	[Kip/ft]	379.08	55.81	DL	0.15	p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000$[lb/in2]*0.81[in] = **31.59**[kip/in] p. 9-5

$D_{min} = P/((1/\Omega)*C*C_1*L)$ = 100[kip]/(0.5*3.71[kip/in]*1*21.5[in]) = **2.51** tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] = 0.6*70000[lb/in2]*$(2)^{1/2}$/2*2.51/16 [in] = **4.65**[kip/in] p. 9-5

Global critical strength ratio **0.85**

NOTATION

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}:Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

D_u: Bolt pretension ratio

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

F_{EXX}: Electrode classification number

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

h_{sc}: Hole factor

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

k_s: Slip resistance factor

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

L: Length of weld

e_{dmin}: Minimum edge distance

μ: Mean slip coefficient

n: Bolts rows number

N_b: Number of bolts carrying the applied tension

n_c: Number of bolt columns

N_s: Number of slip planes

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_b: Minimum fastener pretension

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

T_u: Tension force

U_{bs}: Stress index

w_{min}: Minimum weld size required

Current Date: 2016-05-06 2:46 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\MC-01 Beam to Column Moment Connection\MC.cnx\

Steel connections

Results

Connection name : DW BCF

Connection ID : MC-01-2M

Family: Beam - Column flange (BCF)

Type: Directly welded flanges

Description: B:W24x62

Design code: AISC 360-05 ASD

DEMANDS

	Beam			Right beam		Left beam		Column	Panel	
Description	**Ru**	**Pu**	**Mu**	**PufTop**	**PufBot**	**PufTop**	**PufBot**	**Pu**	**Vu**	**Load type**
	[Kip]	[Kip]	[Kip*ft]	[Kip]	[Kip]	[Kip]	[Kip]	[Kip]	[Kip]	
DL	0.00	0.00	326.90	-169.74	169.74	0.00	0.00	0.00	169.74	Design

GEOMETRIC CONSIDERATIONS

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
Transverse stiffeners						
Length	[in]	8.88	4.44	--	✔	Sec. J10.8
$l_{smin} = (d_c - 2*t_{cf})/2 = (10[in] - 2*0.56[in])/2 = \mathbf{4.44}[in]$						Sec. J10.8
Width	[in]	4.50	2.18	--	✔	Sec. J10.8
$b_{smin} = b/3 - t_w/2 = 7.04[in]/3 - 0.34[in]/2 = \mathbf{2.18}[in]$						Sec. J10.8
Thickness	[in]	0.50	0.30	--	✔	Sec. J10.8
$HasOppositeConnection \rightarrow$ **False**						
$t_{smin} = Max(t_p*0.5, b_s/15) = Max(0.59[in]*0.5, 4.5[in]/15) = \mathbf{0.3}[in]$						Sec. J10.8

Weld size	[1/16in]	6	5	--	✓	DG 13 Eq. 4.3-6

$w_{min} = (0.943*F_{ys}*t_p)/F_{EXX} = (0.943*50000[lb/in2]*0.5[in])/70000[lb/in2] = \mathbf{0.337}[in]$ DG 13 Eq. 4.3-6

Doublers

Recommended thickness for beveling and welding	[in]	0.38	0.31	--	✓	Sec. G2.1, DG 13 Eq. 4.4-4

$h = d_c - 2*k = 10[in] - 2*1.06[in] = \mathbf{7.88}[in]$ Sec. G2.1

$t_{min} = h/(1.1*(5*E/F_y)^{1/2}) = 7.88[in]/(1.1*(5*2.90E+07[lb/in2]/50000[lb/in2])^{1/2}) = \mathbf{0.133}[in]$ Sec. G2.1

$t_{min} = k - t_f - r_e = 1.06[in] - 0.56[in] - 0.188[in] = \mathbf{0.313}[in]$ DG 13 Eq. 4.4-4

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Support

Panel web shear	[Kip]	195.81	169.74	DL	0.87	Sec. J10-6, Eq. J10-9

$P_c = (1/\Omega)*F_y*A = 0.6*50000[lb/in2]*14.4[in2] = \mathbf{432}[kip]$ Sec. J10-6

$IsPanelZoneDeformationConsidered = IsPanelZoneDeformationConsidered = \mathbf{False}$ Sec. J10-6

$P_r <= 0.4*P_c \rightarrow 0[kip] <= 0.4*432[kip] \rightarrow \mathbf{True}$

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*d_c*t_w = 0.599*0.60*50000[lb/in2]*10[in]*0.34[in] = \mathbf{61.08}[kip]$ Eq. J10-9

$(1/\Omega)R_{ndp} = 2 * ((1/\Omega)*0.6*F_y*d_c*t_p) = 2 * (0.599*0.6*50000[lb/in2]*10[in]*0.375[in]) = \mathbf{134.73}[kip]$ DG13 Eq. 4.4-1

$(1/\Omega)R_n = (1/\Omega)R_n + (1/\Omega)R_{ndp} = 61.08[kip] + 134.73[kip] = \mathbf{195.81}[kip]$ Sec. J10

Support - right side

Bottom local flange bending	[Kip]	170.96	169.74	DL	0.99	Eq. J10-1

$IsMemberEnd \rightarrow \mathbf{False}$

$(1/\Omega)R_n = (1/\Omega)*6.25*t_f^2*F_{yf} = 0.599*6.25*0.56[in]^2*50000[lb/in2] = \mathbf{58.68}[kip]$ Eq. J10-1

$A_{st} = t_p*(b_s - clip) = 0.5[in]*(4.5[in] - 0.75[in]) = \mathbf{1.88}[in2]$ DG13 Sec. 4.3

$(1/\Omega)R_{nts} = 2 * ((1/\Omega)*F_y*A_{st}) = 2 * (0.599*50000[lb/in2]*1.88[in2]) = \mathbf{112.28}[kip]$ DG13 Eq. 4.3-1

$(1/\Omega)R_n = (1/\Omega)R_n + (1/\Omega)R_{nts} = 58.68[kip] + 112.28[kip] = \mathbf{170.96}[kip]$ Sec. J10

Local web yielding	[Kip]	326.28	169.74	DL	0.52	Eq. J10-2

$IsBeamReaction \rightarrow \mathbf{False}$

$N = N = \mathbf{0.59}[in]$ Sec. J10-2

$IsMemberEnd \rightarrow \mathbf{False}$

$(1/\Omega)R_n = (1/\Omega)*(5*k + N)*F_{yw}*t_w = 0.667*(5*1.06[in] + 0.59[in])*50000[lb/in2]*0.34[in] = \mathbf{66.75}[kip]$ Eq. J10-2

$IsMemberEnd \rightarrow \mathbf{False}$

$(1/\Omega)R_{ndp} = 2 * ((1/\Omega)*(5*k + N)*F_y*t_p) = 2 * (0.667*(5*1.06[in] + 0.59[in])*50000[lb/in2]*0.375[in]) = \mathbf{147.25}[kip]$ Eq. J10-2

$(1/\Omega)R_n = (1/\Omega)R_n + (1/\Omega)R_{ndp} = 66.75[kip] + 147.25[kip] = \mathbf{214}[kip]$ Sec. J10

$A_{st} = t_p*(b_s - clip) = 0.5[in]*(4.5[in] - 0.75[in]) = \mathbf{1.88}[in2]$ DG13 Sec. 4.3

$(1/\Omega)R_{nts} = 2 * ((1/\Omega)*F_y*A_{st}) = 2 * (0.599*50000[lb/in2]*1.88[in2]) = \mathbf{112.28}[kip]$ DG13 Eq. 4.3-1

$(1/\Omega)R_n = (1/\Omega)R_n + (1/\Omega)R_{nts} = 214\text{[kip]} + 112.28\text{[kip]} = \mathbf{326.28}\text{[kip]}$ Sec. J10

<u>Transverse stiffeners - top</u>

Yielding strength due to axial load	[Kip]	112.28	0.00	DL	0.00	Eq. D2-1

$A_g = 2 * ((b_s - clip)*t_p) = 2 * ((4.5\text{[in]} - 0.75\text{[in]})*0.5\text{[in]}) = \mathbf{3.75}\text{[in2]}$ Sec. D3.1

$(1/\Omega)R_n = (1/\Omega)*F_y*A_g = 0.599*50000\text{[lb/in2]}*3.75\text{[in2]} = \mathbf{112.28}\text{[kip]}$ Eq. D2-1

Compression	[Kip]	99.89	92.30	DL	0.92	Sec. J4.4

$r = t_p/(12)^{1/2} = 0.5\text{[in]}/(12)^{1/2} = \mathbf{0.144}\text{[in]}$ Sec. E2

$A_g = L_p*t_p = 3.75\text{[in]}*0.5\text{[in]} = \mathbf{1.88}\text{[in2]}$ Sec. D3-1

$K*L/r>25 \rightarrow 0.65*8.88\text{[in]}/0.144\text{[in]}>25 \rightarrow \mathbf{True}$

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.90E+07\text{[lb/in2]}/(0.65*8.88\text{[in]}/0.144\text{[in]})^2 = \mathbf{1.79E+05}\text{[lb/in2]}$ Eq. E3-4

$F_e>=0.44*Q*F_y \rightarrow 1.79E+05\text{[lb/in2]}>=0.44*1*50000\text{[lb/in2]} \rightarrow \mathbf{True}$

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*50000\text{[lb/in2]}/1.79E+05\text{[lb/in2]})}*50000\text{[lb/in2]} =$

$\mathbf{44482.52}\text{[lb/in2]}$ Eq. E7-2

$(1/\Omega)P_n = 2 * ((1/\Omega)*F_{cr}*A_g) = 2 * (0.599*44482.52\text{[lb/in2]}*1.88\text{[in2]}) = \mathbf{99.89}\text{[kip]}$ Sec. J4.4

Flange weld capacity	[Kip]	112.76	92.30	DL	0.82	Eq. J2-4

$L = b_{st} - clip - w = 4.5\text{[in]} - 0.75\text{[in]} - 0.375\text{[in]} = \mathbf{3.38}\text{[in]}$ Comm. J10.8

$LoadAngleFactor = 1 + 0.5*(\sin(\theta))^{1.5} = 1 + 0.5*(\sin(1.57))^{1.5} = \mathbf{1.5}$ p. 8-9

$F_w = 0.6*F_{EXX}*LoadAngleFactor = 0.6*70000\text{[lb/in2]}*1.5 = \mathbf{63000}\text{[lb/in2]}$ Sec. J2.5

$A_w = (2)^{1/2}/2*D/16\ \text{[in]}*L = (2)^{1/2}/2*6/16\ \text{[in]}*3.38\text{[in]} = \mathbf{0.895}\text{[in2]}$ Sec. J2.4

$(1/\Omega)R_n = 4 * ((1/\Omega)*F_w*A_w) = 4 * (0.5*63000\text{[lb/in2]}*0.895\text{[in2]}) = \mathbf{112.76}\text{[kip]}$ Eq. J2-4

Web weld capacity	[Kip]	172.73	92.30	DL	0.53	Eq. J2-4

$L = l - clip - w = 8.88\text{[in]} - 0.75\text{[in]} - 0.375\text{[in]} = \mathbf{7.76}\text{[in]}$ Comm. J10.8

$F_w = 0.6*F_{EXX} = 0.6*70000\text{[lb/in2]} = \mathbf{42000}\text{[lb/in2]}$ Sec. J2.4

$A_w = (2)^{1/2}/2*D/16\ \text{[in]}*L = (2)^{1/2}/2*6/16\ \text{[in]}*7.76\text{[in]} = \mathbf{2.06}\text{[in2]}$ Sec. J2.4

$(1/\Omega)R_n = 4 * ((1/\Omega)*F_w*A_w) = 4 * (0.5*42000\text{[lb/in2]}*2.06\text{[in2]}) = \mathbf{172.73}\text{[kip]}$ Eq. J2-4

<u>Transverse stiffeners - bottom</u>

Yielding strength due to axial load	[Kip]	112.28	111.06	DL	0.99	Eq. D2-1

$A_g = 2 * ((b_s - clip)*t_p) = 2 * ((4.5\text{[in]} - 0.75\text{[in]})*0.5\text{[in]}) = \mathbf{3.75}\text{[in2]}$ Sec. D3.1

$(1/\Omega)R_n = (1/\Omega)*F_y*A_g = 0.599*50000\text{[lb/in2]}*3.75\text{[in2]} = \mathbf{112.28}\text{[kip]}$ Eq. D2-1

Compression	[Kip]	99.89	0.00	DL	0.00	Sec. J4.4

$r = t_p/(12)^{1/2} = 0.5\text{[in]}/(12)^{1/2} = \mathbf{0.144}\text{[in]}$ Sec. E2

$A_g = L_p*t_p = 3.75\text{[in]}*0.5\text{[in]} = \mathbf{1.88}\text{[in2]}$ Sec. D3-1

$K*L/r>25 \rightarrow 0.65*8.88\text{[in]}/0.144\text{[in]}>25 \rightarrow \mathbf{True}$

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.90E+07\text{[lb/in2]}/(0.65*8.88\text{[in]}/0.144\text{[in]})^2 = \mathbf{1.79E+05}\text{[lb/in2]}$ Eq. E3-4

$F_e>=0.44*Q*F_y \rightarrow 1.79E+05\text{[lb/in2]}>=0.44*1*50000\text{[lb/in2]} \rightarrow \mathbf{True}$

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*50000\text{[lb/in2]}/1.79E+05\text{[lb/in2]})}*50000\text{[lb/in2]} =$

$\mathbf{44482.52}\text{[lb/in2]}$ Eq. E7-2

$(1/\Omega)P_n = 2 * ((1/\Omega)*F_{cr}*A_g) = 2 * (0.599*44482.52\text{[lb/in2]}*1.88\text{[in2]}) = \mathbf{99.89}\text{[kip]}$ Sec. J4.4

Flange weld capacity	[Kip]	112.76	111.06	DL	0.98	Eq. J2-4

$L = b_{st}$ - $clip$ - w = 4.5[in] - 0.75[in] - 0.375[in] = **3.38**[in] Comm. J10.8

$LoadAngleFactor = 1 + 0.5*(\sin(\theta))^{1.5} = 1 + 0.5*(\sin(1.57))^{1.5} = \mathbf{1.5}$ p. 8-9

$F_w = 0.6*F_{EXX}*LoadAngleFactor$ = 0.6*70000[lb/in2]*1.5 = **63000**[lb/in2] Sec. J2.5

$A_w = (2)^{1/2}/2*D/16$ [in]*$L = (2)^{1/2}/2*6/16$ [in]*3.38[in] = **0.895**[in2] Sec. J2.4

$(1/\Omega)R_n = 4 * ((1/\Omega)*F_w*A_w)$ = 4 * (0.5*63000[lb/in2]*0.895[in2]) = **112.76**[kip] Eq. J2-4

Web weld capacity	[Kip]	172.73	111.06	DL	0.64	Eq. J2-4

$L = l$ - $clip$ - w = 8.88[in] - 0.75[in] - 0.375[in] = **7.76**[in] Comm. J10.8

$F_w = 0.6*F_{EXX}$ = 0.6*70000[lb/in2] = **42000**[lb/in2] Sec. J2.4

$A_w = (2)^{1/2}/2*D/16$ [in]*$L = (2)^{1/2}/2*6/16$ [in]*7.76[in] = **2.06**[in2] Sec. J2.4

$(1/\Omega)R_n = 4 * ((1/\Omega)*F_w*A_w)$ = 4 * (0.5*42000[lb/in2]*2.06[in2]) = **172.73**[kip] Eq. J2-4

Global critical strength ratio **0.99**

NOTATION

A: Column cross-sectional area

A_g: Gross area

A_{st}: Transverse stiffener cross-sectional area

A_w: Effective area of the weld

b: Plate, connector or member width

b_s: Transverse stiffener width

b_{st}: Contact length between transverse stiffener and support flange

b_{smin}: Minimum transverse stiffener width

N: Bearing length

$clip$: Transverse stiffener corner clip dimension

d: Beam depth

d_c: Column depth

D: Number of sixteenths of an inch in the weld size

E: Elastic modulus

F_{cr}: Critical stress, flexural stress buckling

F_e: Elastic critical buckling stress

F_{EXX}: Electrode classification number

F_w: Nominal strength of the weld metal per unit area

F_y: Specified minimum yield stress

F_{yf}: Specified minimum yield stress of flange

F_{ys}: Specified minimum yield stress of stiffener material

F_{yw}: Specified minimum yield stress of web

h: Clear distance between flanges

HasOppositeConnection: Has opposite connection

IsBeamReaction: Is beam reaction

IsMemberEnd: Is member end

IsPanelZoneDeformationConsidered: Is panel zone deformation considered on frame stability

K: Effective length factor

k: Distance from outer face of flange to the web toe of fillet

l: Length

l_{smin}: Stiffener minimum length

L: Length

L_p: Plate length

L: Length of weld

LoadAngleFactor: Load angle factor

N: Bearing length

P_c: Available axial compressive strength

P_r: Required axial stress

$(1/\Omega)$: Design factors

$(1/\Omega)P_n$: Design or allowable strength

$(1/\Omega)R_n$: Design or allowable strength

$(1/\Omega)R_{nts}$: Transverse stiffener design or allowable strength

$(1/\Omega)R_{ndp}$: Doubler plate design or allowable strength

Q: Prying action coefficient

r: Radius of gyration

r_e: Permissible encroachment

t_p: Thickness of the connected material

t_{cf}: Thickness of the column flange

t_f: Thickness of the loaded flange

t_{min}: Minimum thickness

t_p: Plate thickness

t_{smin}: Minimum transverse stiffener thickness

t_w: Web thickness

θ: Load angle

w_{min}: Minimum weld size required

w: Weld size

Current Date: 2016-05-06 2:33 PM

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File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\MC-01 Beam to Column Moment Connection\MC.cnx\

Steel connections

Results

Connection name : SP BCF

Connection ID : MC-01-2V

Family: Beam - Column flange (BCF)

Type: Single plate

Description: B:W24x62

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru**	**Pu**	**Pu**	**Mu22**	**Mu33**	**Load type**
	[Kip]	[Kip]	[Kip]	[Kip*ft]	[Kip*ft]	
DL	91.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Shear plate						
Length	[in]	21.50	10.76	21.52	✔	p. 10-104
$L_{min} = T/2 = 21.52\text{[in]}/2 = \mathbf{10.76}\text{[in]}$						p. 10-104
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 23.7\text{[in]} - \max(1.09\text{[in]}, 0\text{[in]}) - \max(1.09\text{[in]}, 0\text{[in]}) = \mathbf{21.52}\text{[in]}$						p. 10-49
Thickness	[in]	0.50	--	0.56	✔	p. 10-102
$t_{pmax} = d/2 + 1/16\text{ [in]} = 1\text{[in]}/2 + 1/16\text{ [in]} = \mathbf{0.563}\text{[in]}$						p. 10-102
Vertical edge distance	[in]	1.75	1.75	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 1.75[in] + 0[in] = **1.75**[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	2.00	2.00	--	✔	p. 10-102
$L_{emin} = 2*d$ = 2*1[in] = **2**[in]						p. 10-102
Vertical center-to-center spacing (pitch)	[in]	3.00	2.67	10.32	✔	Sec. J3.3, Sec. J3.5
$s_{min} = 8/3*d$ = 8/3*1[in] = **2.67**[in]						Sec. J3.3
IsCorrosionConsidered → **False**						
s_{max} = min(24*t_p, 12 [in]) = min(24*0.43[in], 12 [in]) = **10.32**[in]						Sec. J3.5
Beam						
Vertical edge distance	[in]	2.85	1.75	--	✔	Tables J3.4, J3.5
$L_{emin} = e_{dmin} + C_2$ = 1.75[in] + 0[in] = **1.75**[in]						Tables J3.4, J3.5
Horizontal edge distance	[in]	2.50	2.00	--	✔	p. 10-102
$L_{emin} = 2*d$ = 2*1[in] = **2**[in]						p. 10-102
Support						
Weld size	[1/16in]	5	5	--	✔	p. 10-101
$w_{min} = (5/8)*t_p$ = (5/8)*0.5[in] = **0.026**						p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear plate						
Bolts shear	[Kip]	118.12	91.00	DL	0.77	Tables (7-1..14)
(n>=10) and (n<=12) and (*IsStandardHole*) → (7>=10) and (7<=12) and (True) → **False**						
BoltFactor = 1						p. 10-102
$k_s = \max(1 - T_u/((1/\Omega)*D_u*T_b*N_b), 0.0)$ = max(1 - 0[kip]/(0.667*1.13*64[kip]*1), 0.0) = **1**						Eq. J3-5
$(1/\Omega)R_n = (1/\Omega)*\mu*D_u*h_{sc}*T_b*N_s*k_s$ = 0.667*0.35*1.13*1*64[kip]*1*1 = **16.87**[kip]						Eq. J3-4
$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor$ = 7*16.87[kip]*1 = **118.12**[kip]						Tables (7-1..14)
Bolt bearing under shear load	[Kip]	250.45	91.00	DL	0.36	Eq. J3-6
$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.75[in] - 1.06[in]/2) = **1.22**[in]						Sec. J4.10
$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in]						Sec. J4.10
$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(min(1.2*1.22[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(7 - 1))*0.5[in]*65000[lb/in2]*1 = **250.45**[kip]						Eq. J3-6
Shear yielding	[Kip]	215.00	91.00	DL	0.42	Eq. J4-3

$A_g = L_p*t_p$ = 21.5[in]*0.5[in] = **10.75**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*10.75[in2] = **215**[kip] Eq. J4-3

Shear rupture	[Kip]	132.84	91.00	DL	0.69	Eq. J4-4

$L_h = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$L_e = L - n*L_h$ = 21.5[in] - 7*1.13[in] = **13.63**[in] DG4 Eq. 3-13

$A_{nv} = L_e*t_p$ = 13.63[in]*0.5[in] = **6.81**[in2] Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv}$ = 0.5*0.60*65000[lb/in2]*6.81[in2] = **132.84**[kip] Eq. J4-4

Block shear	[Kip]	144.63	91.00	DL	0.63	Eq. J4-5

$dh_h = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$dh_v = d_h$ + 1/16 [in] = 1.06[in] + 1/16 [in] = **1.13**[in] Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p$ = (2[in] + (1 - 1)*3[in] - (1 - 0.5)*1.13[in])*0.5[in] = **0.719**[in2] Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p$ = (1.75[in] + (7 - 1)*3[in])*0.5[in] = **9.88**[in2] Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p$ = (1.75[in] + (7 - 1)*(3[in] - 1.13[in]) - 1.13[in]/2)*0.5[in] = **6.22**[in2] Sec. J4-3

IsStressUniform → **True**

U_{bs} = 1 Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$ = 0.5*min(0.6*65000[lb/in2]*6.22[in2] + 1*65000[lb/in2]*0.719[in2], 0.6*50000[lb/in2]*9.88[in2] + 1*65000[lb/in2]*0.719[in2]) = **144.63**[kip] Eq. J4-5

Plate (support side)

Weld capacity	[Kip]	199.54	91.00	DL	0.46	Tables 8-4 .. 8-11

$(1/\Omega)R_n = (1/\Omega)*C*C_1*D*L$ = 0.5*3.71[kip/in]*1*5*21.5[in] = **199.54**[kip] Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load	[Kip]	228.49	91.00	DL	0.40	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 2.85[in] - 1.06[in]/2) = **2.32**[in] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(min(1.2*2.32[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(7 - 1))*0.43[in]*65000[lb/in2]*1 = **228.49**[kip] Eq. J3-6

Shear yielding	[Kip]	203.82	91.00	DL	0.45	Eq. J4-3

$A_g = L_p*t_p$ = 23.7[in]*0.43[in] = **10.19**[in2] Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g$ = 0.667*0.60*50000[lb/in2]*10.19[in2] = **203.82**[kip] Eq. J4-3

Support

Welds rupture	[Kip/ft]	262.08	50.79	DL	0.19	p. 9-5

$R_n = 0.6*F_u*t_p$ = 0.6*65000[lb/in2]*0.56[in] = **21.84**[kip/in] p. 9-5

$D_{min} = P/((1/\Omega)*C*C_1*L)$ = 91[kip]/(0.5*3.71[kip/in]*1*21.5[in]) = **2.28** tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in] = 0.6*70000[lb/in2]*$(2)^{1/2}$/2*2.28/16 [in] = **4.23**[kip/in] p. 9-5

Global critical strength ratio **0.77**

NOTATION

A_g: Gross area

A_{gv}:Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}:Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

D_u: Bolt pretension ratio

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

F_{EXX}: Electrode classification number

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

h_{sc}: Hole factor

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

k_s: Slip resistance factor

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

L: Length of weld

e_{dmin}: Minimum edge distance

μ: Mean slip coefficient

n: Bolts rows number

N_b: Number of bolts carrying the applied tension

n_c: Number of bolt columns

N_s: Number of slip planes

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_b: Minimum fastener pretension

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

T_u: Tension force

U_{bs}: Stress index

w_{min}: Minimum weld size required

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File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\MC-01 Beam to Column Moment Connection\MC.cnx\

Steel connections

Results

Connection name : DW BCF

Connection ID : MC-01-3M

Family: Beam - Column flange (BCF)

Type: Directly welded flanges

Description: B:W24x55

Design code: AISC 360-05 ASD

DEMANDS

	Beam			Right beam		Left beam		Column	Panel	
Description	**Ru**	**Pu**	**Mu**	**PufTop**	**PufBot**	**PufTop**	**PufBot**	**Pu**	**Vu**	**Load type**
	[Kip]	[Kip]	[Kip*ft]	[Kip]	[Kip]	[Kip]	[Kip]	[Kip]	[Kip]	
DL	0.00	0.00	285.00	-148.08	148.08	0.00	0.00	0.00	148.08	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Transverse stiffeners						
Length	[in]	8.86	4.43	--	✔	Sec. J10.8
$l_{smin} = (d_c - 2*t_{cf})/2 = (9.92[in] - 2*0.53[in])/2 = \mathbf{4.43}[in]$						Sec. J10.8
Width	[in]	3.75	2.18	--	✔	Sec. J10.8
$b_{smin} = b/3 - t_w/2 = 7.01[in]/3 - 0.315[in]/2 = \mathbf{2.18}[in]$						Sec. J10.8
Thickness	[in]	0.63	0.25	--	✔	Sec. J10.8
$HasOppositeConnection \rightarrow$ **False**						
$t_{smin} = Max(t_p*0.5, b_s/15) = Max(0.505[in]*0.5, 3.75[in]/15) = \mathbf{0.253}[in]$						Sec. J10.8

Doublers

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Recommended thickness for beveling and welding	[in]	0.38	0.31	--	✔	Sec. G2.1, DG 13 Eq. 4.4-4

$h = d_c - 2*k = 9.92$[in] $- 2*1.03$[in] $=$ **7.86**[in] — Sec. G2.1

$t_{min} = h/(1.1*(5*E/F_y)^{1/2}) = 7.86$[in]$/(1.1*(5*2.90E{+}07$[lb/in2]$/50000$[lb/in2]$)^{1/2}) =$ **0.133**[in] — Sec. G2.1

$t_{min} = k - t_f - r_e = 1.03$[in] $- 0.53$[in] $- 0.188$[in] $=$ **0.313**[in] — DG 13 Eq. 4.4-4

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Support						
Panel web shear	[Kip]	189.79	148.08	DL	0.78	Sec. J10-6, Eq. J10-9

$P_c = (1/\Omega)*F_y*A = 0.6*50000$[lb/in2]$*11.5$[in2] $=$ **345**[kip] — Sec. J10-6

IsPanelZoneDeformationConsidered = *IsPanelZoneDeformationConsidered* = **False** — Sec. J10-6

$P_r <= 0.4*P_c \rightarrow 0$[kip]$<=0.4*345$[kip] $\rightarrow$ **True**

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*d_c*t_w = 0.599*0.60*50000$[lb/in2]$*9.92$[in]$*0.315$[in] $=$ **56.13**[kip] — Eq. J10-9

$(1/\Omega)R_{ndp} = 2 * ((1/\Omega)*0.6*F_y*d_c*t_p) = 2 * (0.599*0.6*50000$[lb/in2]$*9.92$[in]$*0.375$[in]$) =$ **133.65**[kip] — DG13 Eq. 4.4-1

$(1/\Omega)R_n = (1/\Omega)R_n + (1/\Omega)R_{ndp} = 56.13$[kip] $+ 133.65$[kip] $=$ **189.79**[kip] — Sec. J10

Support - right side

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bottom local flange bending	[Kip]	164.84	148.08	DL	0.90	Eq. J10-1

IsMemberEnd $\rightarrow$ **False**

$(1/\Omega)R_n = (1/\Omega)*6.25*t_f^2*F_{yf} = 0.599*6.25*0.53$[in]^{2*50000}[lb/in2] $=$ **52.56**[kip] — Eq. J10-1

$A_{st} = t_p*(b_s - clip) = 0.625$[in]$*(3.75$[in] $- 0.75$[in]$) =$ **1.88**[in2] — DG13 Sec. 4.3

$(1/\Omega)R_{nts} = 2 * ((1/\Omega)*F_y*A_{st}) = 2 * (0.599*50000$[lb/in2]$*1.88$[in2]$) =$ **112.28**[kip] — DG13 Eq. 4.3-1

$(1/\Omega)R_n = (1/\Omega)R_n + (1/\Omega)R_{nts} = 52.56$[kip] $+ 112.28$[kip] $=$ **164.84**[kip] — Sec. J10

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Local web yielding	[Kip]	313.03	148.08	DL	0.47	Eq. J10-2

IsBeamReaction $\rightarrow$ **False**

$N = N =$ **0.505**[in] — Sec. J10-2

IsMemberEnd $\rightarrow$ **False**

$(1/\Omega)R_n = (1/\Omega)*(5*k + N)*F_{yw}*t_w = 0.667*(5*1.03$[in] $+ 0.505$[in]$)*50000$[lb/in2]$*0.315$[in] $=$ **59.38**[kip] — Eq. J10-2

IsMemberEnd $\rightarrow$ **False**

$(1/\Omega)R_{ndp} = 2 * ((1/\Omega)*(5*k + N)*F_y*t_p) = 2 * (0.667*(5*1.03$[in] $+ 0.505$[in]$)*50000$[lb/in2]$*0.375$[in]$) =$ **141.38**[kip] — Eq. J10-2

$(1/\Omega)R_n = (1/\Omega)R_n + (1/\Omega)R_{ndp} = 59.38$[kip] $+ 141.38$[kip] $=$ **200.75**[kip] — Sec. J10

$A_{st} = t_p*(b_s - clip) = 0.625$[in]$*(3.75$[in] $- 0.75$[in]$) =$ **1.88**[in2] — DG13 Sec. 4.3

$(1/\Omega)R_{nts} = 2 * ((1/\Omega)*F_y*A_{st}) = 2 * (0.599*50000$[lb/in2]$*1.88$[in2]$) =$ **112.28**[kip] — DG13 Eq. 4.3-1

$(1/\Omega)R_n = (1/\Omega)R_n + (1/\Omega)R_{nts} = 200.75$[kip] $+ 112.28$[kip] $=$ **313.03**[kip] — Sec. J10

Transverse stiffeners - top

Yielding strength due to axial load	[Kip]	112.28	0.00	DL	0.00	Eq. D2-1

$A_g = 2 * ((b_s - clip)*t_p) = 2 * ((3.75$[in] $- 0.75$[in]$)*0.625$[in]$) = \mathbf{3.75}$[in2] Sec. D3.1

$(1/\Omega)R_n = (1/\Omega)*F_y*A_g = 0.599*50000$[lb/in2]$*3.75$[in2] $= \mathbf{112.28}$[kip] Eq. D2-1

Compression	[Kip]	104.22	81.75	DL	0.78	Sec. J4.4

$r = t_p/(12)^{1/2} = 0.625$[in]$/(12)^{1/2} = \mathbf{0.18}$[in] Sec. E2

$A_g = L_p*t_p = 3$[in]$*0.625$[in] $= \mathbf{1.88}$[in2] Sec. D3-1

$K*L/r>25 \rightarrow 0.65*8.86$[in]$/0.18$[in]$>25 \rightarrow$ **True**

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.90E+07$[lb/in2]$/(0.65*8.86$[in]$/0.18$[in]$)^2 = \mathbf{2.81E+05}$[lb/in2] Eq. E3-4

$F_e>=0.44*Q*F_y \rightarrow 2.81E+05$[lb/in2]$>=0.44*1*50000$[lb/in2] $\rightarrow$ **True**

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*50000[lb/in2]/2.81E+05[lb/in2])}*50000$[lb/in2] $=$

$\mathbf{46410.54}$[lb/in2] Eq. E7-2

$(1/\Omega)P_n = 2 * ((1/\Omega)*F_{cr}*A_g) = 2 * (0.599*46410.54$[lb/in2]$*1.88$[in2]$) = \mathbf{104.22}$[kip] Sec. J4.4

Transverse stiffeners - bottom

Yielding strength due to axial load	[Kip]	112.28	95.52	DL	0.85	Eq. D2-1

$A_g = 2 * ((b_s - clip)*t_p) = 2 * ((3.75$[in] $- 0.75$[in]$)*0.625$[in]$) = \mathbf{3.75}$[in2] Sec. D3.1

$(1/\Omega)R_n = (1/\Omega)*F_y*A_g = 0.599*50000$[lb/in2]$*3.75$[in2] $= \mathbf{112.28}$[kip] Eq. D2-1

Compression	[Kip]	104.22	0.00	DL	0.00	Sec. J4.4

$r = t_p/(12)^{1/2} = 0.625$[in]$/(12)^{1/2} = \mathbf{0.18}$[in] Sec. E2

$A_g = L_p*t_p = 3$[in]$*0.625$[in] $= \mathbf{1.88}$[in2] Sec. D3-1

$K*L/r>25 \rightarrow 0.65*8.86$[in]$/0.18$[in]$>25 \rightarrow$ **True**

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.90E+07$[lb/in2]$/(0.65*8.86$[in]$/0.18$[in]$)^2 = \mathbf{2.81E+05}$[lb/in2] Eq. E3-4

$F_e>=0.44*Q*F_y \rightarrow 2.81E+05$[lb/in2]$>=0.44*1*50000$[lb/in2] $\rightarrow$ **True**

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*50000[lb/in2]/2.81E+05[lb/in2])}*50000$[lb/in2] $=$

$\mathbf{46410.54}$[lb/in2] Eq. E7-2

$(1/\Omega)P_n = 2 * ((1/\Omega)*F_{cr}*A_g) = 2 * (0.599*46410.54$[lb/in2]$*1.88$[in2]$) = \mathbf{104.22}$[kip] Sec. J4.4

Global critical strength ratio **0.90**

NOTATION

A: Column cross-sectional area

A_g: Gross area

A_{st}: Transverse stiffener cross-sectional area

b: Plate, connector or member width

b_s: Transverse stiffener width

b_{smin}: Minimum transverse stiffener width

N: Bearing length

clip: Transverse stiffener corner clip dimension

d: Beam depth

d_c: Column depth

E: Elastic modulus

F_{cr}: Critical stress, flexural stress buckling

F_e: Elastic critical buckling stress

F_y: Specified minimum yield stress

F_{yf}: Specified minimum yield stress of flange

F_{yw}: Specified minimum yield stress of web

h: Clear distance between flanges

HasOppositeConnection: Has opposite connection

IsBeamReaction: Is beam reaction

IsMemberEnd: Is member end

IsPanelZoneDeformationConsidered: Is panel zone deformation considered on frame stability

K: Effective length factor

k: Distance from outer face of flange to the web toe of fillet

l_{smin}: Stiffener minimum length

L: Length

L_p: Plate length

N: Bearing length

P_c: Available axial compressive strength

P_r: Required axial stress

$(1/\Omega)$: Design factors

$(1/\Omega)P_n$: Design or allowable strength

$(1/\Omega)R_n$: Design or allowable strength

$(1/\Omega)R_{nts}$: Transverse stiffener design or allowable strength

$(1/\Omega)R_{ndp}$: Doubler plate design or allowable strength

Q: Prying action coefficient

r: Radius of gyration

r_e: Permissible encroachment

t_p: Thickness of the connected material

t_{cf}: Thickness of the column flange

t_f: Thickness of the loaded flange

t_{min}: Minimum thickness

t_p: Plate thickness

t_{smin}: Minimum transverse stiffener thickness

t_w: Web thickness

Current Date: 2016-05-06 2:36 PM

Units system: English

File name: \\192.168.2.102\Design\Webster Connection Design Folder\Reports and Calculations\MC-01 Beam to Column Moment Connection\MC.cnx\

Steel connections

Results

Connection name : SP BCF

Connection ID : MC-01-3V

Family: Beam - Column flange (BCF)

Type: Single plate

Description: B:W24x55

Design code: AISC 360-05 ASD

DEMANDS

	Beam		Column			
Description	**Ru** [Kip]	**Pu** [Kip]	**Pu** [Kip]	**Mu22** [Kip*ft]	**Mu33** [Kip*ft]	**Load type**
DL	42.00	0.00	0.00	0.00	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Shear plate						
Length	[in]	18.50	10.79	21.58	✓	p. 10-104
$L_{min} = T/2 = 21.58$[in]$/2 =$ **10.79**[in]						p. 10-104
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 23.6$[in] $- \max(1.01$[in]$, 0$[in]$) - \max(1.01$[in]$, 0$[in]$) =$ **21.58**[in]						p. 10-49
Thickness	[in]	0.50	--	0.56	✓	p. 10-102
$t_{pmax} = d/2 + 1/16$ [in] $= 1$[in]$/2 + 1/16$ [in] $=$ **0.563**[in]						p. 10-102
Vertical edge distance	[in]	1.75	1.75	--	✓	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75$[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Horizontal edge distance	[in]	2.00	2.00	--	✔	p. 10-102

$L_{emin} = 2*d = 2*1$[in] = **2**[in] — p. 10-102

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Vertical center-to-center spacing (pitch)	[in]	3.00	2.67	9.48	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3*d = 8/3*1$[in] = **2.67**[in] — Sec. J3.3

IsCorrosionConsidered → **False**

$s_{max} = \min(24*t_p, 12$ [in]) = min(24*0.395[in], 12 [in]) = **9.48**[in] — Sec. J3.5

Beam

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Vertical edge distance	[in]	4.30	1.75	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 1.75$[in] + 0[in] = **1.75**[in] — Tables J3.4, J3.5

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Horizontal edge distance	[in]	2.50	2.00	--	✔	p. 10-102

$L_{emin} = 2*d = 2*1$[in] = **2**[in] — p. 10-102

Support

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Weld size	[1/16in]	5	5	--	✔	p. 10-101

$w_{min} = (5/8)*t_p = (5/8)*0.5$[in] = **0.026** — p. 10-101

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Shear plate

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolts shear	[Kip]	101.25	42.00	DL	0.41	Tables (7-1..14)

(n>=10) and (n<=12) and (*IsStandardHole*) → (6>=10) and (6<=12) and (True) → **False**

BoltFactor = 1 — p. 10-102

$k_s = \max(1 - T_u/((1/\Omega)*D_u*T_b*N_b), 0.0)$ = max(1 - 0[kip]/(0.667*1.13*64[kip]*1), 0.0) = **1** — Eq. J3-5

$(1/\Omega)R_n = (1/\Omega)*\mu*D_u*h_{sc}*T_b*N_s*k_s$ = 0.667*0.35*1.13*1*64[kip]*1*1 = **16.87**[kip] — Eq. J3-4

$(1/\Omega)R_n = C*(1/\Omega)R_n*BoltFactor$ = 6*16.87[kip]*1 = **101.25**[kip] — Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Kip]	212.67	42.00	DL	0.20	Eq. J3-6

$L_{c-end} = \mathrm{Max}(0.0, L_e - d_h/2)$ = Max(0.0, 1.75[in] - 1.06[in]/2) = **1.22**[in] — Sec. J4.10

$L_{c-spa} = \mathrm{Max}(0.0, s - d_h)$ = Max(0.0, 3[in] - 1.06[in]) = **1.94**[in] — Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c-end}, k_2*d) + \min(k_1*L_{c-spa}, k_2*d)*(n - 1))*t_p*F_u*n_c$ = 0.5*(min(1.2*1.22[in], 2.4*1[in]) + min(1.2*1.94[in], 2.4*1[in])*(6 - 1))*0.5[in]*65000[lb/in2]*1 = **212.67**[kip] — Eq. J3-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Kip]	185.00	42.00	DL	0.23	Eq. J4-3

$A_g = L_p*t_p = 18.5[in]*0.5[in] = \mathbf{9.25}[in2]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*9.25[in2] = \mathbf{185}[kip]$ Eq. J4-3

Shear rupture [Kip] 114.56 42.00 DL 0.37 Eq. J4-4

$L_h = d_h + 1/16\ [in] = 1.06[in] + 1/16\ [in] = \mathbf{1.13}[in]$ Sec. D3-2

$L_e = L - n*L_h = 18.5[in] - 6*1.13[in] = \mathbf{11.75}[in]$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 11.75[in]*0.5[in] = \mathbf{5.88}[in2]$ Sec. J4-2

$(1/\Omega)R_n = (1/\Omega)*0.60*F_u*A_{nv} = 0.5*0.60*65000[lb/in2]*5.88[in2] = \mathbf{114.56}[kip]$ Eq. J4-4

Block shear [Kip] 126.34 42.00 DL 0.33 Eq. J4-5

$dh_h = d_h + 1/16\ [in] = 1.06[in] + 1/16\ [in] = \mathbf{1.13}[in]$ Sec. D3-2

$dh_v = d_h + 1/16\ [in] = 1.06[in] + 1/16\ [in] = \mathbf{1.13}[in]$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (2[in] + (1 - 1)*3[in] - (1 - 0.5)*1.13[in])*0.5[in] = \mathbf{0.719}[in2]$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (1.75[in] + (6 - 1)*3[in])*0.5[in] = \mathbf{8.38}[in2]$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (1.75[in] + (6 - 1)*(3[in] - 1.13[in]) - 1.13[in]/2)*0.5[in] = \mathbf{5.28}[in2]$ Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ Sec. J4-3

$(1/\Omega)R_n = (1/\Omega)*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.5*\min(0.6*65000[lb/in2]*5.28[in2] + 1*65000[lb/in2]*0.719[in2], 0.6*50000[lb/in2]*8.38[in2] + 1*65000[lb/in2]*0.719[in2]) = \mathbf{126.34}[kip]$ Eq. J4-5

Plate (support side)

Weld capacity [Kip] 171.69 42.00 DL 0.24 Tables 8-4 .. 8-11

$(1/\Omega)R_n = (1/\Omega)*C*C_1*D*L = 0.5*3.71[kip/in]*1*5*18.5[in] = \mathbf{171.69}[kip]$ Tables 8-4 .. 8-11

Beam

Bolt bearing under shear load [Kip] 180.05 42.00 DL 0.23 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 4.3[in] - 1.06[in]/2) = \mathbf{3.77}[in]$ Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 3[in] - 1.06[in]) = \mathbf{1.94}[in]$ Sec. J4.10

$(1/\Omega)R_n = (1/\Omega)*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c = 0.5*(\min(1.2*3.77[in], 2.4*1[in]) + \min(1.2*1.94[in], 2.4*1[in])*(6 - 1))*0.395[in]*65000[lb/in2]*1 = \mathbf{180.05}[kip]$ Eq. J3-6

Shear yielding [Kip] 186.44 42.00 DL 0.23 Eq. J4-3

$A_g = L_p*t_p = 23.6[in]*0.395[in] = \mathbf{9.32}[in2]$ Sec. D3-1

$(1/\Omega)R_n = (1/\Omega)*0.60*F_y*A_g = 0.667*0.60*50000[lb/in2]*9.32[in2] = \mathbf{186.44}[kip]$ Eq. J4-3

Support

Welds rupture [Kip/ft] 248.04 27.24 DL 0.11 p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*65000[lb/in2]*0.53[in] = \mathbf{20.67}[kip/in]$ p. 9-5

$D_{min} = P/((1/\Omega)*C*C_1*L) = 42[kip]/(0.5*3.71[kip/in]*1*18.5[in]) = \mathbf{1.22}$ tables 8-4..11

$HasWeldsOnBothSides \rightarrow \mathbf{False}$

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16\ [in] = 0.6*70000[lb/in2]*(2)^{1/2}/2*1.22/16\ [in] = \mathbf{2.27}[kip/in]$ p. 9-5

Global critical strength ratio **0.41**

NOTATION

A_g: Gross area

A_{gv}: Gross area subject to shear

A_{nt}: Net area subject to tension

A_{nv}: Net area subjected to shear

$(1/\Omega)R_n$: Available shear strength per bolt

BoltFactor: Bolt capacity factor

C: Bolt group coefficient

C_1: Electrode strength coefficient

C_2: Edge distance increment

C: Weld group coefficient

d: Nominal bolt diameter

d_{cb}: Bottom cope depth

d_{ct}: Top cope depth

d_h: Nominal hole dimension

D_u: Bolt pretension ratio

dh_h: Horizontal hole dimension

dh_v: Vertical hole dimension

D: Number of sixteenths of an inch in the weld size

D_{min}: Number of sixteenths of an inch in the minimum weld size

F_{EXX}: Electrode classification number

F_u: Specified minimum tensile strength

F_y: Specified minimum yield stress

h_{sc}: Hole factor

HasWeldsOnBothSides: Has welds on both sides

IsCorrosionConsidered: Is corrosion considered

IsStandardHole: Is standard hole (STD)

IsStressUniform: Is the stress uniform

k_1: Bearing factor

k_2: Bearing factor

k: Outside corner radius

k_s: Slip resistance factor

L: Length

$L_{c\text{-}end}$: Clear distance

L_e: Effective length

L_e: Edge distance

L_{eh}: Horizontal edge distance

L_{emin}: Minimum horizontal edge distance

L_{emin}: Minimum edge distance

L_{ev}: Vertical edge distance

L_h: Hole dimension for tension and shear net area

L_{max}: Maximum length

L_{min}: Minimum length

L_p: Plate length

L: Length of weld

e_{dmin}: Minimum edge distance

μ: Mean slip coefficient

n: Bolts rows number

N_b: Number of bolts carrying the applied tension

n_c: Number of bolt columns

N_s: Number of slip planes

P: Required axial force

$(1/\Omega)$: Design factors

$(1/\Omega)R_n$: Design or allowable strength

R_n: Nominal strength

R_u: Required strength

s_{max}: Maximum spacing

s_{min}: Minimum spacing

spa: Transversal spacing between bolts or welds

s: Longitudinal bolt spacing

$L_{c\text{-}spa}$: Distance between adjacent holes edges

t_p: Thickness of the connected material

T: Clear distance between web fillets

T_b: Minimum fastener pretension

t_p: Plate thickness

t_{pmax}: Maximum plate thickness

T_u: Tension force

U_{bs}: Stress index

w_{min}: Minimum weld size required

CANNONDESIGN

SUBMITTAL IDENTIFICATION SHEET

To be completed by Contractor/CM

WEBSTER UNIVERSITY ISB
PROJECT NAME

8274 BIG BEND BLVD
ADDRESS

NUMBER

WEBSTER UNIVERSITY
OWNER

CANNON DESIGN
ARCHITECT / ENGINEER

Joe Voypick
SUBMITTED BY

051200-012	
CONTRACTOR / CM SUBMITTAL NO.	CANNON DESIGN SUBMITTAL NO.
	051200
DRAWING / DETAIL REFERENCE	SPECIFICATION SECTION / PARAGRAPH
Atlas Iron Works	
MANUFACTURER / SUPPLIER	ITEM / PRODUCT ID
REQUIRED DATE	PRIORITY ○ CRITICAL

ITEM BEING SUBMITTED (check only one)

- ◉ Shop Drawings
- ○ Samples (______ copies)
- ○ LEED Submittal
- ○ Certification / Qualifications
- ○ Record Documents
- ○ Product Data
- ○ Coordination Drawing
- ○ Calculations
- ○ Schedules
- ○ O&M Manuals
- ○ Other ______

ITEM BEING SUBMITTED FOR (check only one)

◉ Action ○ Information Only ○ Record

REMARKS OR DEVIATIONS

IT IS THE RESPONSIBILITY OF THE FABRICATOR TO COORDINATE DESIGN CALCULATIONS WITH STEEL SHOP DRAWINGS

CONTRACTOR / CM CERTIFICATION
(SUBMITTALS NOT CERTIFIED WILL BE RETURNED WITHOUT REVIEW)

PARIC
EXPERIENCE. EXCELLENCE.

PARIC CORPORATION
SUBMITTAL STAMP

THIS SHOP DRAWING HAS BEEN REVIEWED BY PARIC CORPORATION

Subcontractor remains responsible for dimensions, quantities, coordination with other trades and compliance with contract documents.

By:
Devin D. Gates

Joe Voypick	5/25/16
REVIEWED BY	DATE

To be completed by Reviewer

05 1200-012
CANNON DESIGN SUBMITTAL NUMBER

5/26/16
RECEIVED DATE

- ○ A. No Exceptions Taken
  No further review of submittal is required.
- ○ B. Make Corrections Noted
  Incorporate corrections in work; resubmission is not required.
- ○ C. Revise and Resubmit
  Revise as noted, and resubmit for review.
- ○ D. Rejected
  Submittal is not in compliance with Contract Documents; provide new submittal.
- ● E. For Record / Information Only
  Submittal was reviewed for Record / Information purposes only.
- ○ F. Not Required for Review
  Submittal is not required by Contract Documents and has not been reviewed.

Review is for conformance with the design concept of this project and for general compliance with contract documents. Contractor is responsible for quantities, dimensions and compliance with contract documents and for information that pertains to fabrication processes, construction techniques and coordination of this work with all trades which will be affected thereby. This review is null and void if submittal deviates from contract documents and does not indicate or note deviations.

A/E COMMENTS ○ See attached sheet(s) for additional comments

SHOP DRAWING / SUBMITTAL REVIEW

- ☐ NO EXCEPTION TAKEN
- ☐ EXCEPTIONS NOTED, RESUBMITTAL NOT REQUIRED
- ☐ REJECTED
- ☒ REVIEWED FOR INFORMATION ONLY
- ☐ REVISE AND RESUBMIT AS NOTED

Checking is only for general conformance with the design concept of the project and general compliance with the information given in the Contract Documents. Any action shown is subject to the requirements of the plans and specifications. Contractor is responsible for: Dimensions which shall be confirmed and correlated at the job site, fabrication processes and techniques of the construction, coordination of his work with that of all other trades and the satisfactory performance of his work.

DAVID MASON & ASSOCIATES, INC.

REVIEW BY: JYW DATE: 06/09/2016

REVIEWED BY	DATE

77 Westport Plaza
Suite 250
St. Louis, MO 63146

TRANSMITTAL

No. 15051-0060

Paric Corporation

PROJECT: Webster University Interdisciplinary Science Building

DATE: 05/23/2016

TO: Cannon Design
1100 Clark Ave
St Louis MO 63102

RE: Structural Steel Connection Design Calcs

ATTN: Kelvin Patel

JOB: 15051

WE ARE SENDING:	SUBMITTED FOR:	ACTION TAKEN:
☑ Shop Drawings	☑ Approval	☑ Approved as Submitted
☐ Letter	☐ Your Use	☐ Approved as Noted
☐ Prints	☐ As Requested	☐ Returned After Loan
☐ Change Order	☐ Review and Comment	☐ Resubmit
☐ Plans		☐ Submit
☐ Samples	**SENT VIA:**	☐ Returned
☐ Specifications	☐ Attached	☐ Returned for Corrections
☐ Other:	☐ Separate Cover Via:	☐ Due Date:

Item	*Package*	*Code*	*Rev.*	*Copies*	*Date*	*Description*	*Status*
Submittal		051200-012		1	05/23/2016	Structural Steel Connection Design Calcs	Submitted

NOTES:

CC: Paric Corporation, Kathy Bathe

Project Coordinator: Paric Corporation, Kathy Bathe

Signed: ______________________

Devin Gates