Bentley Systems

Current Date: 10/25/2018 10:14 AM
Units system: SI
File name: D:\User\RAM Connection v12 - HSS knife plate connection.rcnx\

Steel connections

Results

Connection name : CBB_DW
Connection ID : 1

Family: Column - Beams - Braces (CBB)
Type: Gusset
Design code: AISC 360-16 LRFD

DEMANDS

	Right beam			Left beam			Column		Pu				
Description	**Pu** [KN]	**Vu** [KN]	**Mu33** [KN*m]	**Pu** [KN]	**Vu** [KN]	**Mu33** [KN*m]	**Pu** [KN]	**Vu** [KN]	**Brace1** [KN]	**Brace2** [KN]	**Brace3** [KN]	**Brace4** [KN]	**Load type**
L1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.72	0.00	0.00	0.00	Design
L2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Design

Interface between Gusset - Top right brace
Connection: Directly bolted

DEMANDS

Pu [KN]	**Description**	**Load type**
66.72	L1	Design
0.00	L2	Design

DESIGN CHECK

Verification	**Unit**	**Capacity**	**Demand**	**Ctrl EQ**	**Ratio**	**References**
<u>Tab side</u>						
Bolts shear	[KN]	168.89	66.72	L1	**0.40**	Tables (7-1..14)

$k_{sc} = max(1 - T_u/(\phi*D_u*T_b*N_b), 0.0)$

= max(1 - 0[kN]/(1*1.13*124.55[kN]*4), 0.0)

= **1** — Eq. J3-5

$\phi R_n = \phi*\mu*D_u*h_f*T_b*n_s*k_{sc}$

= 1*0.3*1.13*1*124.55[kN]*1*1

= **42.22**[kN] — Eq. J3-4

$\phi R_n = C*\phi R_n$

= 4*42.22[kN]

= **168.89**[kN] — Tables (7-1..14)

Bolt bearing under shear load	[KN]	506.21	66.72	L1	**0.13**	Eq. J3-6

$L_{c-end} = Max(0.0, L_e - d_h/2)$

= Max(0.0, 38.1[mm] - 20.64[mm]/2)

= **27.78**[mm] — Sec. J3.10

L_{c-spa} = Max(0.0, s - d_h)
= Max(0.0, 76.2[mm] - 20.64[mm])
= **55.56**[mm] Sec. J3.10

$\phi R_n = \phi$*(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
= 0.75*(min(1.2*27.78[mm], 2.4*19.05[mm]) + min(1.2*55.56[mm], 2.4*19.05[mm])*(2 - 1))*9.53[mm]*448.16[N/mm2]*
2
= **506.21**[kN] Eq. J3-6

Bolt bearing on gusset	[KN]	903.39	66.72	L1	**0.07**	Eq. J3-6

L_{c-end} = Max(0.0, L_e - d_h/2)
= Max(0.0, 38.1[mm] - 20.64[mm]/2)
= **27.78**[mm] Sec. J3.10

L_{c-spa} = Max(0.0, s - d_h)
= Max(0.0, 76.2[mm] - 20.64[mm])
= **55.56**[mm] Sec. J3.10

$\phi R_n = \phi$*(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
= 0.75*(min(1.2*27.78[mm], 2.4*19.05[mm]) + min(1.2*55.56[mm], 2.4*19.05[mm])*(2 - 1))*19.05[mm]*399.89[N/mm2]*
2
= **903.39**[kN] Eq. J3-6

Block shear rupture at brace web	[KN]	414.73	66.72	L1	**0.16**	Eq. J4-5

L_h = d_h + 1/16 [in]
= 20.64[mm] + 1/16 [in]
= **22.22**[mm] Sec. D3-2

L_h = d_h + 1/16 [in]
= 20.64[mm] + 1/16 [in]
= **22.22**[mm] Sec. D3-2

A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p
= (38.1[mm] + (2 - 1)*76.2[mm] - (2 - 0.5)*22.22[mm])*9.53[mm]
= **771.17**[mm2] Sec. J4-3

A_{gv} = (L + (n_c - 1)*g)*t_p
= (38.1[mm] + (2 - 1)*76.2[mm])*9.53[mm]
= **1088.71**[mm2] Sec. J4-3

A_{nv} = (L + (n_c - 1)*g - dh_h*(n_c - 0.5))*t_p
= (38.1[mm] + (2 - 1)*76.2[mm] - 22.22[mm]*(2 - 0.5))*9.53[mm]
= **771.17**[mm2] Sec. J4-3

$\phi R_n = \phi$*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})
= 0.75*min(0.6*448.16[N/mm2]*771.17[mm2] + 1*448.16[N/mm2]*771.17[mm2], 0.6*344.74[N/mm2]*1088.71[mm2] + 1*
448.16[N/mm2]*771.17[mm2])
= **414.73**[kN] Eq. J4-5

Block shear on gusset	[KN]	794.80	66.72	L1	**0.08**	Eq. J4-5

L_h = d_h + 1/16 [in]
= 20.64[mm] + 1/16 [in]
= **22.22**[mm] Sec. D3-2

$L_h = d_h + 1/16$ [in]
= 20.64[mm] + 1/16 [in]
= **22.22**[mm] Sec. D3-2

$A_{nt} = t_p*((n - 1)*(g - L_h))$
= 19.05[mm]*((2 - 1)*(76.2[mm] - 22.22[mm]))
= **1028.22**[mm2] Sec. J4.3

$A_{gv} = 2*t_p*(L_{eh} + (n_c - 1)*s)$
= 2*19.05[mm]*(38.1[mm] + (2 - 1)*76.2[mm])
= **4354.83**[mm2] Sec. J4.3

$A_{nv} = 2*t_p*(L_{eh} + (n_c - 1)*(s - L_h) - L_h/2)$
= 2*19.05[mm]*(38.1[mm] + (2 - 1)*(76.2[mm] - 22.22[mm]) - 22.22[mm]/2)
= **3084.67**[mm2] Sec. J4.3

$\phi R_n = \phi*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})$
= 0.75*min(0.6*399.89[N/mm2]*3084.67[mm2] + 1*399.89[N/mm2]*1028.22[mm2], 0.6*248.21[N/mm2]*4354.83[mm2] + 1*399.89[N/mm2]*1028.22[mm2])
= **794.8**[kN] Eq. J4-5

Weld capacity	[KN]	743.09	66.72	L1	**0.09**	Eq. J2-4

$F_w = 0.6*F_{EXX}$
= 0.6*482.63[N/mm2]
= **289.58**[N/mm2] Sec. J2.4

$A_w = (2)^{1/2}/2*D/16$ [in]$*L$
= $(2)^{1/2}/2*6/16$ [in]*508[mm]
= **3421.48**[mm2] Sec. J2.4

$\phi R_n = \phi*F_w*A_w$
= 0.75*289.58[N/mm2]*3421.48[mm2]
= **743.09**[kN] Eq. J2-4

Tee stem tensile yielding	[KN]	562.98	66.72	L1	**0.12**	Eq. J4-1

$A_g = L_p*t_p$
= 190.5[mm]*9.53[mm]
= **1814.51**[mm2] Sec. D3-1

$\phi R_n = \phi*F_y*A_g$
= 0.9*344.74[N/mm2]*1814.51[mm2]
= **562.98**[kN] Eq. J4-1

Tee stem tensile rupture	[KN]	467.58	66.72	L1	**0.14**	Eq. J4-2

$A_g = L_p*t_p$
= 190.5[mm]*9.53[mm]
= **1814.51**[mm2] Sec. D3-1

IsBoltedConnection → **True**

$L_h = d_h + 1/16$ [in]
= 20.64[mm] + 1/16 [in]
= **22.22**[mm] Sec. D3-2

$A_n = (l - n*L_h)*t_p$
= (190.5[mm] - 2*22.22[mm])*9.53[mm]
= **1391.13**[mm2] Sec. D3-2

$A_e = min(0.85*A_g, A_n)$
= min(0.85*1814.51[mm2], 1391.13[mm2])
= **1391.13**[mm2] Sec. J4-1

$\phi R_n = \phi*F_u*A_e$
= 0.75*448.16[N/mm2]*1391.13[mm2]
= **467.58**[kN] Eq. J4-2

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Brace						
HSS wall shear yielding	[KN]	893.55	66.72	L1	0.07	Eq. J4-3

$A_g = L_p*t_p$
= 127[mm]*11.81[mm]
= **1500**[mm2] Sec. D3-1

$\phi R_n = 4 * (\phi*0.60*F_y*A_g)$
= 4 * (1*0.60*248.21[N/mm2]*1500[mm2])
= **893.55**[kN] Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
HSS wall shear rupture	[KN]	1079.71	66.72	L1	0.06	Eq. J4-4

$A_{nv} = L_e*t_p$
= 127[mm]*11.81[mm]
= **1500**[mm2] Sec. J4-2

$\phi R_n = 4 * (\phi*0.60*F_u*A_{nv})$
= 4 * (0.75*0.60*399.89[N/mm2]*1500[mm2])
= **1079.71**[kN] Eq. J4-4

Ratio **0.40**

Checks for gusset and brace

Ratio **0.10**

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Brace						
Yielding strength due to axial load	[KN]	1403.74	66.72	L1	0.05	Eq. J4-1

$\phi R_n = \phi*F_y*A_g$
= 0.9*248.21[N/mm2]*6283.86[mm2]
= **1403.74**[kN] Eq. J4-1

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Tension rupture	[KN]	949.96	66.72	L1	0.07	Eq. J4-2

$A_n = A_g - 2*(t_p + 1/8 [in])*t$
= 6283.86[mm2] - 2*(19.05[mm] + 1/8 [in])*11.81[mm]
= **5758.86**[mm2] Sec. D3.2

U = 1 - x/l
= 1 - 57.15[mm]/127[mm]
= **0.55** Table D3.1

$A_e = A_n*U$

= 5758.86[mm2]*0.55

= **3167.37**[mm2] Eq. D3-1

$\phi R_n = \phi*F_u*A_e$

= 0.75*399.89[N/mm2]*3167.37[mm2]

= **949.96**[kN] Eq. J4-2

Gusset

Tension yielding on the Whitmore section	[KN]	698.71	66.72	L1	**0.10**	Eq. J4-1

$A_g = L_w*t_p$

= 164.19[mm]*19.05[mm]

= **3127.78**[mm2]

$\phi R_n = \phi*F_y*A_g$

= 0.9*248.21[N/mm2]*3127.78[mm2]

= **698.71**[kN] Eq. J4-1

WARNINGS

- Connector length less than allowable Table D3.1

Calculation of the brace interface forces

Load condition :L1

H = P*cosθ

= 66.72[kN]*0.707

= **47.18**[kN]

V = P*sinθ

= 66.72[kN]*0.707

= **47.18**[kN]

Load condition :L2

H = P*cosθ

= 0[kN]*0.707

= **0**[kN]

V = P*sinθ

= 0[kN]*0.707

= **0**[kN]

Upper right gusset interface - column
Directly welded

DEMANDS

	Beam			Column			
Description	**Ru** [KN]	**Pu** [KN]	**Mu** [KN*m]	**Pu** [KN]	**Mu22** [KN*m]	**Mu33** [KN*m]	**Load type**
L1	47.18	47.18	0.00	0.00	0.00	0.00	Design
L2	0.00	0.00	0.00	0.00	0.00	0.00	Design

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Gusset</u>						
Beam yielding (normal stress)	[KN]	2628.03	47.18	L1	0.02	Eq. B-1, Appendix B, DG29, Eq. J4-1

$N_{eq} = V_{ub} + ((4*M_{ub})/L_p)$
= 47.18[kN] + ((4*0[kN*m])/617.55[mm])
= **47.18**[kN] — Eq. B-1, Appendix B, DG29

$A_g = L_p*t_p$
= 617.55[mm]*19.05[mm]
= **11764.37**[mm2] — Sec. D3-1

$\phi R_n = \phi*F_y*A_g$
= 0.9*248.21[N/mm2]*11764.37[mm2]
= **2628.03**[kN] — Eq. J4-1

$N_{eq} = V_{ub} + ((4*M_{ub})/L_p)$
= 47.18[kN] + ((4*0[kN*m])/617.55[mm])
= **47.18**[kN] — Eq. B-1, Appendix B, DG29

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[KN]	1752.02	47.18	L1	0.03	Eq. J4-3

$A_g = L_p*t_p$
= 617.55[mm]*19.05[mm]
= **11764.37**[mm2] — Sec. D3-1

$\phi R_n = \phi*0.60*F_y*A_g$
= 1*0.60*248.21[N/mm2]*11764.37[mm2]
= **1752.02**[kN] — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Gusset edge tension stress	[KN/mm2]	0.22	0.00	L1	0.02	J4-1

$\phi F_n = \phi*F_y$
= 0.9*248.21[N/mm2]
= **223.39**[N/mm2] — J4-1

$f_{ua} = H_c/(t_p*l)$
= 47.18[kN]/(19.05[mm]*617.55[mm])
= **4.01**[N/mm2] — [9]

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Gusset edge shear stress	[KN/mm2]	0.15	0.00	L1	0.03	J4-1

$\phi F_n = \phi*0.6*F_y$
= 1*0.6*248.21[N/mm2]
= **148.93**[N/mm2] — J4-1

$f_{uv} = V_c/(t_p*l)$
= 47.18[kN]/(19.05[mm]*617.55[mm])
= **4.01**[N/mm2] — [9]

Weld capacity	[KN]	1953.17	83.40	L1	**0.04**	Tables 8-4 .. 8-11

$\phi R_n = 2 * (\phi * C * C_1 * D * L)$
$= 2 * (0.75*0.422[kN/mm]*1*5*617.55[mm])$
$= \mathbf{1953.17}[kN]$ — Tables 8-4 .. 8-11

$f_{ua} = V_c/l$
$= 47.18[kN]/617.55[mm]$
$= \mathbf{0.0764}[kN/mm]$ — [9]

$f_{uv} = H_c/l$
$= 47.18[kN]/617.55[mm]$
$= \mathbf{0.0764}[kN/mm]$ — [9]

$f_{ub} = M_c/(l^2/6)$
$= 0[kN*m]/(617.55[mm]^2/6)$
$= \mathbf{0}[kN/mm]$ — [9]

$f_{uPeak} = ((f_{ua} + f_{ub})^2 + f_{uv}^2)^{1/2}$
$= ((0.0764[kN/mm] + 0[kN/mm])^2 + 0.0764[kN/mm]^2)^{1/2}$
$= \mathbf{0.108}[kN/mm]$ — [9]

$f_{uAve} = 0.5*(((f_{ua} - f_{ub})^2 + f_{uv}^2)^{1/2} + ((f_{ua} + f_{ub})^2 + f_{uv}^2)^{1/2})$
$= 0.5*(((0.0764[kN/mm] - 0[kN/mm])^2 + 0.0764[kN/mm]^2)^{1/2} + ((0.0764[kN/mm] + 0[kN/mm])^2 + 0.0764[kN/mm]^2)^{1/2})$
$= \mathbf{0.108}[kN/mm]$ — [9]

$f_{uWeld} = l*\max(f_{uPeak}, 1.25*f_{uAve})$
$= 617.55[mm]*\max(0.108[kN/mm], 1.25*0.108[kN/mm])$
$= \mathbf{83.4}[kN]$ — [9]

<u>Column</u>

Web crippling	[KN]	4407.56	47.18	L1	**0.01**	Eq. J10-4, Eq. B-1, Appendix B, DG29

IsBeamReaction $\rightarrow$ **False**

$l_b = N$
$= \mathbf{617.55}[mm]$ — Sec. J10-2

$\phi R_n = \phi*0.80*t_w^2*(1 + 3*(N/d)*(t_w/t_f)^{1.5})*(E*F_{yw}*t_f/t_w)^{1/2}*Q_f$
$= 0.75*0.80*19.68[mm]^2*(1 + 3*(617.55[mm]/784.86[mm])*(19.68[mm]/33.53[mm])^{1.5})*(2.00E+05[N/mm2]*248.21[N/mm2]*33.53[mm]/19.68[mm])^{1/2}*1$
$= \mathbf{4407.56}[kN]$ — Eq. J10-4

$N_{eq} = V_{ub} + ((4*M_{ub})/L_p)$
$= 47.18[kN] + ((4*0[kN*m])/617.55[mm])$
$= \mathbf{47.18}[kN]$ — Eq. B-1, Appendix B, DG29

Local web yielding	[KN]	4320.47	47.18	L1	**0.01**	Eq. J10-2, Eq. B-1, Appendix B, DG29

IsBeamReaction → **False**

l_b = N
= **617.55**[mm] Sec. J10-2

IsMemberEnd → **False**

$\phi R_n = \phi*(5*k + l_b)*F_{yw}*t_w$
= 1*(5*53.34[mm] + 617.55[mm])*248.21[N/mm2]*19.68[mm]
= **4320.47**[kN] Eq. J10-2

$N_{eq} = V_{ub} + ((4*M_{ub})/L_p)$
= 47.18[kN] + ((4*0[kN*m])/617.55[mm])
= **47.18**[kN] Eq. B-1, Appendix B, DG29

Ratio	**0.04**
Global critical strength ratio	**0.40**

NOTATION

A_e: Effective net area
A_g: Gross area
A_{gv}: Gross area subject to shear
A_n: Net area
A_{nt}: Net area subject to tension
A_{nv}: Net area subjected to shear
A_w: Effective area of the weld
N: Bearing length
C: Bolt group coefficient
C_1: Electrode strength coefficient
C: Weld group coefficient
$\cos\theta$: Cosine of the brace with the horizontal angle
d: Nominal bolt diameter
d_h: Nominal hole dimension
D_u: Bolt pretension ratio
d: Beam depth
dh_h: Horizontal hole dimension
D: Number of sixteenths of an inch in the weld size
E: Elastic modulus
F_{EXX}: Electrode classification number
F_u: Specified minimum tensile strength
f_{ua}: Axial stress on welds along gusset-beam or gusset-column interface
f_{ua}: Axial stress on welds along gusset-beam or gusset-column interface
f_{uAve}: Average weld stress on welds along gusset-beam or gusset-column interface
f_{ub}: Bending stress on welds along gusset-beam or gusset-column interface
f_{uPeak}: Peak weld stress on welds along gusset-beam or gusset-column interface
f_{uv}: Shear stress on welds along gusset-beam or gusset-column interface
f_{uv}: Shear stress on welds along gusset-beam or gusset-column interface
f_{uWeld}: Design weld force on welds along gusset-beam or gusset-column interface
F_w: Nominal strength of the weld metal per unit area
F_y: Specified minimum yield stress
F_{yw}: Specified minimum yield stress of web
g: Transversal gage between bolts
H_{Beam}: Beam horizontal force
$H_{BeamToColumn}$: Beam to column interrface total horizontal force
H_{Bot}: Bottom horizontal component of the gusset forces

H_c: Required axial force on the column to gusset connection
H: Brace axial force horizontal component
h_f: Factor for fillers
H_{Top}: Top horizontal component of the gusset forces
IsBeamReaction: Is beam reaction
IsBoltedConnection: Is bolted connection
IsMemberEnd: Is member end
k_1: Bearing factor
k_2: Bearing factor
k: Distance from outer face of flange to the web toe of fillet
k_{sc}: Slip resistance factor
l: Length
L: Length
l_b: Bearing length
$L_{c\text{-}end}$: Clear distance
L_e: Effective length
L_e: Edge distance
L_{eh}: Horizontal edge distance
L_h: Hole dimension for tension and shear net area
L_p: Plate length
L: Length of weld
L_w: Width of Whitmore section
M_c: Required moment on the column to gusset connection
M_{ub}: Moment applied to the interface
μ: Mean slip coefficient
n: Bolts rows number
N: Bearing length
N_b: Number of bolts carrying the applied tension
n_c: Number of bolt columns
N_{eq}: Equivalent normal force
n_s: Number of slip planes
P: Required axial force
ϕ: Design factors
ϕF_n: Design or allowable tension/shear yielding stress
ϕR_n: Design or allowable strength
Q_f: Chord stress interaction parameter
$\sin\theta$: Sine of the brace with the horizontal 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_b: Minimum fastener pretension
t: Design wall thickness of HSS member
t_f: Thickness of the loaded flange
t_p: Plate thickness
T_u: Tension force
t_w: Web thickness
U: Shear lag factor
U_{bs}: Stress index
V_{Beam}: Beam vertical force
$V_{BeamToColumn}$: Beam to column interrface total vertical force
V_{Bot}: Bottom vertical component of the gusset forces
V_c: Required shear force on the column to gusset connection
V: Brace axial force vertical component
V_{Top}: Top vertical component of the gusset forces
V_{ub}: Shear applied to the interface
x: Connection eccentricity

REFERENCES

[9] AISC 2005, Design Examples Version 13.0, pp. IIC-26 - IIC-27