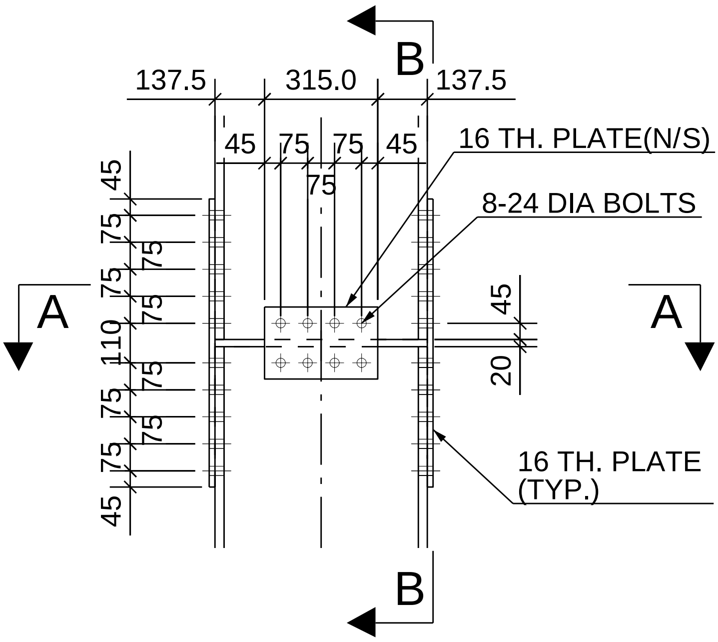
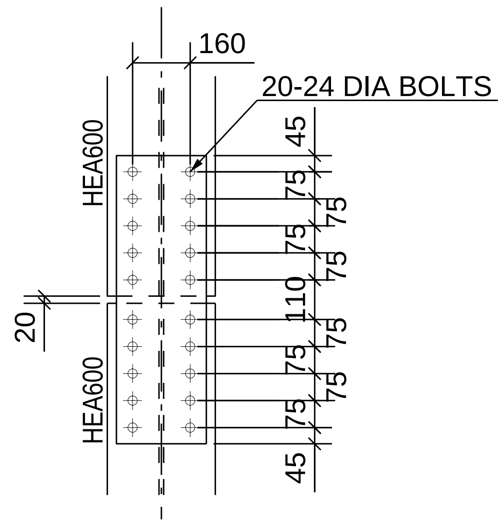
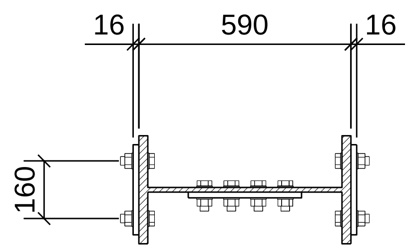
Detail J19B

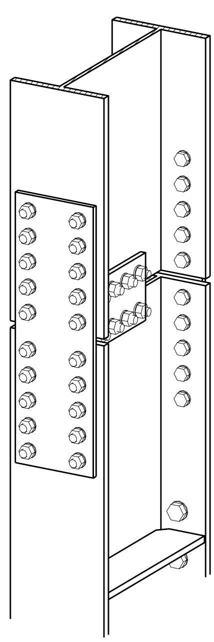




Section B - B



Section A - A



Isometric View

1:20

Tekla Structures

Column Splice with Butt Plate

Top Column: HE600A - A572M-345
Bottom Column: HE650A - A572M-345

Axial Force (Compression), C = 915,1x10^3 N
Axial Force (Tension), T = 274,0x10^2 N
Moment (Strong Axis), Ms = 296,9kN-m
Shear Force (Strong Axis), Vs = 197,6x10^3 N
Minimum Compr. Axial Force, Cmin = 0 N
Shear Force for Design, Vs = 197,6x10^3 N

All Attachments Are A572M-345

********** All Welds Are E48XX **********

Splice Plates and Stabilizers:

Butt Plate:

Thickness = 50 >_ 50 mm (OK)
Width = 300 >_ max(bf_upper; bf_lower) = 300 mm (OK)
Length = 715 >_ max(d_upper; d_lower) + 3 = 715 mm (OK)

Upper Column Bearing, FbrTop:

FbrTop = 0,75*1,8 * Min(Fy_uc; Fy_pl) * A_uc
= 0,75*1,8 * Min(345; 345) * 226,0x10^2
= 105,3x10^5 N

Lower Column Bearing, FbrBot:

FbrBot = 0,75*1,8 * Min(Fy_lc; Fy_pl) * A_lc
= 0,75*1,8 * Min(345; 345) * 242,0x10^2
= 112,7x10^5 N

Flange Forces:

Combined Moment & Tension

Upper Col. Flange Force, Ff_tu = T / 2 + Ms / d_uc
= 274,0x10^2 / 2 + 296,9x10^6 / 590 = 516,9x10^3 N
Lower Col. Flange Force, Ff_tl = T / 2 + Ms / d_lc
= 274,0x10^2 / 2 + 296,9x10^6 / 640 = 477,6x10^3 N
Plate Shear:

V = Min(Ffu;Ffl) = 477,6x10^3 N

ØRn = tpl * 0,9 *0,6 * Fy * Wpl
= 50 * 0,9 *0,6 * 345 * 300
= 279,4x10^4 >_ 477,6x10^3 N (OK)

Plate Bending:

Moment = V * |d_uc - d_lc| / 2 = 477,6x10^3 * 50 / 2= 119,4x10^5 N-mm

Mom. Capacity = 0,9* Fy * t^2 * Wpl / 4
= 0,9* 345 * 50^2 * 300 / 4
= 582,2x10^5 >_ 119,4x10^5 N-mm (OK)

Compression Side:

Upper Col. Flange Force, Ff_cu = Max[(Ms / d_uc - T / 2); 0]
= Max[(296,9x10^6 / 590 - 274,0x10^2 / 2); 0] = 489,5x10^3 N
Lower Col. Flange Force, Ff_cl = Max[(Ms / d_lc - T / 2); 0]
= Max[(296,9x10^6 / 640 - 274,0x10^2 / 2); 0] = 450,2x10^3 N

Upper Col. Flange End Bearing:

```
ØRn = 0,75*1,8 * Min(Fy_uc; Fy_pl) * (tf_uc * bf_uc)
= 0,75*1,8 * Min(345; 345) * (25 * 300)
= 349,3x10^4 >_ 489,5x10^3 N (OK)

Lower Col. Flange End Bearing:

ØRn = 0,75*1,8 * Min(Fy_lc; Fy_pl) * (tf_lc * bf_lc)
= 0,75*1,8 * Min(345; 345) * (26 * 300)
= 363,3x10^4 >_ 450,2x10^3 N (OK)

Combined Moment & Compression

Upper Col. Flange Comp. Force, Ff_cu = C / A_uc * (tf_uc * bf_uc) +  Ms / d_uc
= 915,1x10^3 / 226,0x10^2 * (25 * 300) + 296,9x10^6 / 590
= 806,9x10^3 N

Lower Col. Flange Comp. Force, Ff_cl = C / A_lc * (tf_lc * bf_lc) + Ms / d_lc
= 915,1x10^3 / 242,0x10^2 * (26 * 300) + 296,9x10^6 / 640
= 758,9x10^3 N
Plate Shear:

V = Min(Ffu;Ffl) = 758,9x10^3 N

ØRn = tpl * 0,9 *0,6 * Fy * Wpl
= 50 * 0,9 *0,6 * 345 * 300
= 279,4x10^4 >_ 758,9x10^3 N (OK)

Plate Bending:

Moment = V * |d_uc - d_lc| / 2 = 758,9x10^3 * 50 / 2= 189,7x10^5 N-mm

Mom. Capacity = 0,9* Fy * t^2 * Wpl / 4
= 0,9* 345 * 50^2 * 300 / 4
= 582,2x10^5 >_ 189,7x10^5 N-mm (OK)

Upper Col. Flange End Bearing:

ØRn = 0,75*1,8 * Min(Fy_uc; Fy_pl) * (tf_uc * bf_uc)
= 0,75*1,8 * Min(345; 345) * (25 * 300)
= 349,3x10^4 >_ 806,9x10^3 N (OK)

Lower Col. Flange End Bearing:

ØRn = 0,75*1,8 * Min(Fy_lc; Fy_pl) * (tf_lc * bf_lc)
= 0,75*1,8 * Min(345; 345) * (26 * 300)
= 363,3x10^4 >_ 758,9x10^3 N (OK)

Upper Col. Flange Ten. Force, Ff_tu = -C / A_uc * (tf_uc * bf_uc) + Ms / d_uc >_ 0
= -915,1x10^3 / 226,0x10^2 * (25 * 300) + 296,9x10^6 / 590
= 221,8x10^3 N

Lower Col. Flange Ten. Force, Ff_tl = -C / A_lc * (tf_lc * bf_lc) + Ms / d_lc >_ 0
= -915,1x10^3 / 242,0x10^2 * (26 * 300) + 296,9x10^6 / 640
= 188,6x10^3 N

Maximum Weld Forces (as applicable):

For PJP Groove Welds,

Fw_cu = Ff_cu/bf = 2690  N/mm (Up. Col.-Compression)
Fw_tu = Ff_tu/bf = 1723  N/mm (Up. Col.-Tension)
Fw_cl = Ff_cl/bf = 2530  N/mm (Lower Col.-Compression)
Fw_tl = Ff_tl/bf = 1592  N/mm (Lower Col.-Tension)

For CJP Groove and Fillet Welds,

Fw_u = 2690  N/mm (Upper Column)
Fw_l = 2530  N/mm (Lower Column)
```

Welds:

Upper Column/Butt Plate Fillet Weld: 19 mm

Minimum Weld Size = 8 <_ 19 mm   (OK)

Weld Capacity = 0,75 *0,4242* w * Fexx = 0,75 *0,4242 * 19 * 480
= 2902 >_ 2690 N/mm (OK)
Lower Column/Butt Plate Fillet Weld: 17 mm

Minimum Weld Size = 8 <_ 17 mm   (OK)

Weld Capacity = 0,75 *0,4242* w * Fexx = 0,75 *0,4242 * 17 * 480
= 2596 >_ 2530 N/mm (OK)

Upper Column Tension and Moment Check

Tension:

On Gross Area:

ØRn = 0,9 *Fy*A = 0,9 * 345 * 226,0x10^2
= 701,7x10^4 >_ 274,0x10^2 N (OK)

On Effective Net Area:

ØRn = 0,75* Fu * U *An = 0,75* 450 * 1 * 150,0x10^2
= 506,3x10^4 >_ 274,0x10^2 N (OK)

Moment:

Design Strength of Gross Section:

ØRn = 0,9 *Min(Fy*Z; 1,5*Fy*S)/10^6 = 0,9 *Min(345 * 535,0x10^4; 1,5* 345 * 478,7x10^4)/10^6
= 1661 >_ 296,9 kN-m (OK)

Lower Column Tension and Moment Check

Tension:

On Gross Area:

ØRn = 0,9 *Fy*A = 0,9 * 345 * 242,0x10^2
= 751,4x10^4 >_ 274,0x10^2 N (OK)

On Effective Net Area:

ØRn = 0,75* Fu * U *An = 0,75* 450 * 1 * 156,0x10^2
= 526,5x10^4 >_ 274,0x10^2 N (OK)

Moment:

ØRn = 0,9 *Min(Fy*Z; 1,5*Fy*S)/10^6 = 0,9 *Min(345 * 613,6x10^4; 1,5* 345 * 547,4x10^4)/10^6
= 1905 >_ 296,9 kN-m (OK)

Moment of Inertia:
(Provided for stiffness evaluation if required.)

Top Column = 141,2x10^7 mm^4
Bottom Column = 175,2x10^7 mm^4
Splice = 105,7x10^7 mm^4

Column Splice Connection
Left Side Column: HE600A - A572M-345
Right Side Column: HE600A - A572M-345
Moment: 296,9 kN-m
Shear: 197,6x10^3 N
Axial Force: 915,1x10^3 N

********** All Welds Are E48XX **********

Right Side Column
Moment Connection Using Flange Plate:

Flange Force, Ff:

Right Side:
RFf = P/2 + M/d
= 915,1x10^3/2) + 296,9x10^6/ 590
= 960,8x10^3 N

Left Side:
LFf = P/2 + M/d
= 915,1x10^3/2) + 296,9x10^6/ 590
= 960,8x10^3 N

Ff = Max(RFf;LFf) = 960,8x10^3 N

Top Flange Connection:

Top Plate: 810 mm   X 250 mm   X 15 mm
Plate Material: A572M-345

Bolts on Flange: 10 Bolts - 24Ø A325M- -STD in 2 Lines
Bolt Holes on Plate: 27 mm   Lateral X 27 mm   Longitudinal
Bolt Holes on Flange: 27 mm   Lateral X 27 mm   Longitudinal

Check Column:

Column Flange Effective Area:

Afg = tf*bf = 25*300 = 7500 mm^2
Afn = tf*(bf-Nt*(dh+ 2)) = 25 *(300 -(2 * (27 + 2))) = 6050 mm^2
Fy/Fu <_ 0,8 ---- Yt=1
Fu*Afn = 450 * 6050 = 272,3x10^4 N
Yt*Fy*Afg = 1*345 * 7500 = 258,8x10^4 N
Mn = Fy*Zx = 345*535,0x10^4 = 184,6x10^7 N-mm
ØMn = 0,9 *Mn = 1661 >_ 296,9 kN-m (OK)
(The effect of the Column axial force is not
included in the Column Bending Strength check.
The user must check this condition outside the program.)

Bolts

Spacing, s = 75 >_ Minimum Spacing = 65 mm   (OK)

Edge Distance on Plate:

Parallel to Column Axis, el:
= 42 >_ 42 mm   (OK)

Transverse to Column, et:
= 45 >_ 42 mm   (OK)

Edge Distance on Column Flange:

Parallel to Column Axis, el:
= 50 >_ 42 mm   (OK)

Transverse to Column, et:
= 70 >_ 30 mm   (OK)

Bolt Shear:

Design Strength = n*Fv = 10 * 112,0x10^3
= 112,0x10^4 >_ 960,8x10^3 N (OK)

Bolt Bearing:

Bolt Bearing on Plate:

Bearing Strength/Bolt/Thickness Using Bolt Edge Distance = Fbe
Edge Dist. = 42 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 28,5 * 450 = 115,4x10^2 N/mm
Bearing Strength/Bolt/Thickness Using Bolt Spacing = Fbs
Bolt Spacing = 75 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 48 * 450 = 194,4x10^2 N/mm

Design Strength = Nt *(Fbe + Fbs * (Nl - 1))*t
= 2 * (115,4x10^2 + 194,4x10^2 * (5 - 1)) * 15
= 267,9x10^4 >_ 960,8x10^3 N (OK)

Bolt Bearing on Flange:

Bearing Strength/Bolt/Thickness Using Bolt Edge Distance = Fbe
Edge Dist. = 50 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 36,5 * 450 = 147,8x10^2 N/mm
Bearing Strength/Bolt/Thickness Using Bolt Spacing = Fbs
Bolt Spacing = 75 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 48 * 450 = 194,4x10^2 N/mm

Design Strength = Nt *(Fbe + Fbs * (Nl - 1))*t
= 2 * (147,8x10^2 + 194,4x10^2 * (5 - 1)) * 25
= 462,7x10^4 >_ 960,8x10^3 N (OK)

Plate Tension Design Strength:

Tension Yielding:

ØRn = 0,9 *Fy*b*t
= 0,9 *345 * 250 * 15
= 116,4x10^4 >_ 960,8x10^3 N (OK)

Tension Rupture:

ØRn = 0,75 *Fu*(b-Max(0,15*b;Nt*(dh+ 2)))*t
= 0,75 * 450 * (250 - Max(0,15*250 ; 2 *(27 + 2)))* 15
= 972,0x10^3 >_ 960,8x10^3 N (OK)

Block shear rupture of the Plate:

Agt = Min(g,2*e)*t = 90 * 15
= 1350 mm^2

Ant = Agt - (dh+ 2)*t
= 1350 - (29) * 15
= 915 mm^2

Agv = 2 * ((nl - 1) * s + Le) * t
= 2 * ((5 - 1) * 75 + 42) * 15
= 102,6x10^2 mm^2

Anv = Agv - 2 * (nl - 0,5) * (dh + 2) * t
=102,6x10^2 - 2*(5 - 0,5)*(29)*15

= 6345 mm^2
ØRn = 0,75 * Min((0,6 * Fu * Anv + Ubs * Fu * Ant); (0,6 * Fy * Agv + Ubs * Fu * Ant))
= 0,75* Min((0,6 * 450 * 6345 + 1 * 450 * 915); (0,6 * 345 * 102,6x10^2 + 1 * 450 * 915))
= 159,4x10^4 >_ 960,8x10^3 N (OK)

Top Plate Compressive Strength:

Unbraced Length, L = gap + efR + efL = 26 + 50 + 50 = 126 mm
Effective Length Factor, K = 0,65

KL/r = k*L/(t/3,464) = 0,65 * 126/(15/3,464) = 18,914

kL/r <_ 25
Fcr = Fy = 345 N/mm^2

ØcPn = 0,9*Fcr*Ag = 0,9*345*250*15 = 116,4x10^4 >_ 960,8x10^3 N (OK)

Block shear rupture of the Column Top Flange:

Agt = (bf-g)*t = (300 - 160)* 25
= 3500 mm^2

Ant = Agt - (nt-1)*(dh+ 2)*t
= 3500 - (2 - 1)*(29) * 25
= 2775 mm^2

Agv = 2 * ((nl - 1) * s + ef) * t
= 2 * ((5 - 1) * 75 + 42) * 25
= 175,0x10^2 mm^2

Anv = Agv - 2 * (nl - 0,5) * (dh + 2) * t
=175,0x10^2 - 2*(5 - 0,5)*(29)*25
= 109,8x10^2 mm^2
ØRn = 0,75 * Min((0,6 * Fu * Anv + Ubs * Fu * Ant); (0,6 * Fy * Agv + Ubs * Fu * Ant))
= 0,75* Min((0,6 * 450 * 109,8x10^2 + 1 * 450 * 2775); (0,6 * 345 * 175,0x10^2 + 1 * 450 * 2775))
= 315,9x10^4 >_ 960,8x10^3 N (OK)

Bottom Flange Connection:

Bottom Plate: 810 mm   X 250 mm   X 15 mm

Bolts on Flange: 10 Bolts - 24Ø A325M- -STD in 2 Lines
Bolt Holes on Plate: 27 mm   Lateral X 27 mm   Longitudinal
Bolt Holes on Flange: 27 mm   Lateral X 27 mm   Longitudinal

Bolts

Spacing, s = 75 >_ Minimum Spacing = 65 mm   (OK)

Edge Distance on Plate:

Parallel to Column Axis, el:
= 42 >_ 42 mm   (OK)

Transverse to Column, et:
= 42 >_ 42 mm   (OK)

Edge Distance on Column Flange:

Parallel to Column Axis, el:
= 50 >_ 42 mm   (OK)

Transverse to Column, et:
= 70 >_ 30 mm   (OK)

Bolt Shear:

```
Capacity = n*Fv = 10 *  112,0x10^3
=  112,0x10^4 >_ 960,8x10^3 N (OK)

Bolt Bearing:

Bolt Bearing on Plate:

Bearing Strength/Bolt/Thickness Using Bolt Edge Distance = Fbe
Edge Dist. = 42 mm  , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu  <_ 0,75 * 2,4 * d * Fu = 194,4x10^2  N/mm
= 0,75 * 1,2 * 28,5 * 450 = 115,4x10^2  N/mm
Bearing Strength/Bolt/Thickness Using Bolt Spacing = Fbs
Bolt Spacing = 75 mm  , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu  <_ 0,75 * 2,4 * d * Fu = 194,4x10^2  N/mm
= 0,75 * 1,2 * 48 * 450 = 194,4x10^2  N/mm

Capcity = Nt *(Fbe + Fbs * (Nl - 1))*t
= 2 * (115,4x10^2 + 194,4x10^2 * (5 - 1)) * 15
= 267,9x10^4 >_ 960,8x10^3 N (OK)

Bolt Bearing on Flange:

Bearing Strength/Bolt/Thickness Using Bolt Edge Distance = Fbe
Edge Dist. = 50 mm  , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu  <_ 0,75 * 2,4 * d * Fu = 194,4x10^2  N/mm
= 0,75 * 1,2 * 36,5 * 450 = 147,8x10^2  N/mm
Bearing Strength/Bolt/Thickness Using Bolt Spacing = Fbs
Bolt Spacing = 75 mm  , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu  <_ 0,75 * 2,4 * d * Fu = 194,4x10^2  N/mm
= 0,75 * 1,2 * 48 * 450 = 194,4x10^2  N/mm

Capacity = Nt *(Fbe + Fbs * (Nl - 1))*t
= 2 * (147,8x10^2 + 194,4x10^2 * (5 - 1)) * 25
= 462,7x10^4 >_ 960,8x10^3 N (OK)

Plate Tension Design Strength:

Tension Yielding:

ØRn = 0,9  *Fy*b*t
= 0,9  *345 * 250 * 15
= 116,4x10^4 >_ 960,8x10^3 N (OK)


Tension Rupture:

ØRn = 0,75 *Fu*(b-Max(0,15*b;Nt*(dh+ 2)))*t
= 0,75  * 450 * (250 - Max(0,15*250 ; 2 *(27 +  2)))* 15
= 972,0x10^3 >_ 960,8x10^3 N (OK)

Block shear rupture of the Plate:

Agt = Min(g,2*e)*t = 90 * 15
= 1350 mm^2

Ant = Agt - (dh+ 2)*t
= 1350 - (29) * 15
= 915 mm^2

Agv = 2 * ((nl - 1) * s + Le) * t
= 2 * ((5 - 1) * 75 + 42) * 15
= 102,6x10^2 mm^2

Anv = Agv - 2 * (nl - 0,5) * (dh +  2) * t
=102,6x10^2 - 2*(5 - 0,5)*(29)*15
= 6345 mm^2
ØRn = 0,75 * Min((0,6 * Fu * Anv + Ubs * Fu * Ant); (0,6 * Fy * Agv + Ubs * Fu * Ant))
= 0,75* Min((0,6 * 450 * 6345 + 1 * 450 * 915); (0,6 * 345 * 102,6x10^2 + 1 * 450 * 915))
= 159,4x10^4 >_ 960,8x10^3 N (OK)
```

Block shear rupture of the Column Bottom Flange:

Agt = (bf-g)*t = (300 - 160)* 25
= 3500 mm^2

Ant = Agt - (nt-1)*(dh+ 2)*t
= 3500 - (2 - 1)*(29) * 25
= 2775 mm^2

Agv = 2 * ((nl - 1) * s + ef) * t
= 2 * ((5 - 1) * 75 + 42) * 25
= 175,0x10^2 mm^2

Anv = Agv - 2 * (nl - 0,5) * (dh + 2) * t
=175,0x10^2 - 2*(5 - 0,5)*(29)*25
= 109,8x10^2 mm^2
ØRn = 0,75 * Min((0,6 * Fu * Anv + Ubs * Fu * Ant); (0,6 * Fy * Agv + Ubs * Fu * Ant))
= 0,75* Min((0,6 * 450 * 109,8x10^2 + 1 * 450 * 2775); (0,6 * 345 * 175,0x10^2 + 1 * 450 * 2775))
= 315,9x10^4 >_ 960,8x10^3 N (OK)

Bottom Plate Compressive Strength:

Unbraced Length, L = gap + efR + efL = 26 + 50 + 50 = 126 mm
Effective Length Factor, K = 0,65

KL/r = k*L/(t/3,464) = 0,65 * 126/(15/3,464) = 18,914

kL/r <_ 25
Fcr = Fy = 345 N/mm^2

ØcPn = 0,9*Fcr*Ag = 0,9*345*250*15 = 116,4x10^4 >_ 960,8x10^3 N (OK)

Left Side Column
Moment Connection Using Flange Plate:

Flange Force, Ff:

Right Side:
RFf = P/2 + M/d
= 915,1x10^3/2) + 296,9x10^6/ 590
= 960,8x10^3 N

Left Side:
LFf = P/2 + M/d
= 915,1x10^3/2) + 296,9x10^6/ 590
= 960,8x10^3 N

Ff = Max(RFf;LFf) = 960,8x10^3 N

Top Flange Connection:

Top Plate: 810 mm   X 250 mm   X 15 mm
Plate Material: A572M-345

Bolts on Flange: 10 Bolts - 24Ø A325M- -STD in 2 Lines
Bolt Holes on Plate: 27 mm   Lateral X 27 mm   Longitudinal
Bolt Holes on Flange: 27 mm   Lateral X 27 mm   Longitudinal

Check Column:

Column Flange Effective Area:

Afg = tf*bf = 25*300 = 7500 mm^2
Afn = tf*(bf-Nt*(dh+ 2)) = 25 *(300 -(2 * (27 + 2))) = 6050 mm^2
Fy/Fu <_ 0,8 ---- Yt=1
Fu*Afn = 450 * 6050 = 272,3x10^4 N

Yt*Fy*Afg = 1*345 * 7500 = 258,8x10^4 N
Mn = Fy*Zx = 345*535,0x10^4 = 184,6x10^7 N-mm
ØMn = 0,9 *Mn = 1661 >_ 296,9 kN-m (OK)
(The effect of the Column axial force is not
included in the Column Bending Strength check.
The user must check this condition outside the program.)

Bolts

Spacing, s = 75 >_ Minimum Spacing = 65 mm   (OK)

Edge Distance on Plate:

Parallel to Column Axis, el:
= 42 >_ 42 mm   (OK)

Transverse to Column, et:
= 45 >_ 42 mm   (OK)

Edge Distance on Column Flange:

Parallel to Column Axis, el:
= 50 >_ 42 mm   (OK)

Transverse to Column, et:
= 70 >_ 30 mm   (OK)

Bolt Shear:

Design Strength = n*Fv = 10 * 112,0x10^3
= 112,0x10^4 >_ 960,8x10^3 N (OK)

Bolt Bearing:

Bolt Bearing on Plate:

Bearing Strength/Bolt/Thickness Using Bolt Edge Distance = Fbe
Edge Dist. = 42 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 28,5 * 450 = 115,4x10^2 N/mm
Bearing Strength/Bolt/Thickness Using Bolt Spacing = Fbs
Bolt Spacing = 75 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 48 * 450 = 194,4x10^2 N/mm

Design Strength = Nt *(Fbe + Fbs * (Nl - 1))*t
= 2 * (115,4x10^2 + 194,4x10^2 * (5 - 1)) * 15
= 267,9x10^4 >_ 960,8x10^3 N (OK)

Bolt Bearing on Flange:

Bearing Strength/Bolt/Thickness Using Bolt Edge Distance = Fbe
Edge Dist. = 50 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 36,5 * 450 = 147,8x10^2 N/mm
Bearing Strength/Bolt/Thickness Using Bolt Spacing = Fbs
Bolt Spacing = 75 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 48 * 450 = 194,4x10^2 N/mm

Design Strength = Nt *(Fbe + Fbs * (Nl - 1))*t
= 2 * (147,8x10^2 + 194,4x10^2 * (5 - 1)) * 25
= 462,7x10^4 >_ 960,8x10^3 N (OK)

Plate Tension Design Strength:

Tension Yielding:

ØRn = 0,9 *Fy*b*t
= 0,9 *345 * 250 * 15
= 116,4x10^4 >_ 960,8x10^3 N (OK)

Tension Rupture:

ØRn = 0,75 *Fu*(b-Max(0,15*b;Nt*(dh+ 2)))*t
= 0,75 * 450 * (250 - Max(0,15*250 ; 2 *(27 + 2)))* 15
= 972,0x10^3 >_ 960,8x10^3 N (OK)

Block shear rupture of the Plate:

Agt = Min(g,2*e)*t = 90 * 15
= 1350 mm^2

Ant = Agt - (dh+ 2)*t
= 1350 - (29) * 15
= 915 mm^2

Agv = 2 * ((nl - 1) * s + Le) * t
= 2 * ((5 - 1) * 75 + 42) * 15
= 102,6x10^2 mm^2

Anv = Agv - 2 * (nl - 0,5) * (dh + 2) * t
=102,6x10^2 - 2*(5 - 0,5)*(29)*15
= 6345 mm^2
ØRn = 0,75 * Min((0,6 * Fu * Anv + Ubs * Fu * Ant); (0,6 * Fy * Agv + Ubs * Fu * Ant))
= 0,75* Min((0,6 * 450 * 6345 + 1 * 450 * 915); (0,6 * 345 * 102,6x10^2 + 1 * 450 * 915))
= 159,4x10^4 >_ 960,8x10^3 N (OK)

Top Plate Compressive Strength:

Unbraced Length, L = gap + efR + efL = 26 + 50 + 50 = 126 mm
Effective Length Factor, K = 0,65

KL/r = k*L/(t/3,464) = 0,65 * 126/(15/3,464) = 18,914

kL/r <_ 25
Fcr = Fy = 345 N/mm^2

ØcPn = 0,9*Fcr*Ag = 0,9*345*250*15 = 116,4x10^4 >_ 960,8x10^3 N (OK)

Block shear rupture of the Column Top Flange:

Agt = (bf-g)*t = (300 - 160)* 25
= 3500 mm^2

Ant = Agt - (nt-1)*(dh+ 2)*t
= 3500 - (2 - 1)*(29) * 25
= 2775 mm^2

Agv = 2 * ((nl - 1) * s + ef) * t
= 2 * ((5 - 1) * 75 + 42) * 25
= 175,0x10^2 mm^2

Anv = Agv - 2 * (nl - 0,5) * (dh + 2) * t
=175,0x10^2 - 2*(5 - 0,5)*(29)*25
= 109,8x10^2 mm^2
ØRn = 0,75 * Min((0,6 * Fu * Anv + Ubs * Fu * Ant); (0,6 * Fy * Agv + Ubs * Fu * Ant))
= 0,75* Min((0,6 * 450 * 109,8x10^2 + 1 * 450 * 2775); (0,6 * 345 * 175,0x10^2 + 1 * 450 *
2775))
= 315,9x10^4 >_ 960,8x10^3 N (OK)

Bottom Flange Connection:

Bottom Plate: 810 mm   X 250 mm   X 15 mm

Bolts on Flange: 10 Bolts - 24Ø A325M- -STD in 2 Lines
Bolt Holes on Plate: 27 mm   Lateral X 27 mm   Longitudinal
Bolt Holes on Flange: 27 mm   Lateral X 27 mm   Longitudinal

Bolts

Spacing, s = 75 >_ Minimum Spacing = 65 mm (OK)

Edge Distance on Plate:

Parallel to Column Axis, el:
= 42 >_ 42 mm (OK)

Transverse to Column, et:
= 42 >_ 42 mm (OK)

Edge Distance on Column Flange:

Parallel to Column Axis, el:
= 50 >_ 42 mm (OK)

Transverse to Column, et:
= 70 >_ 30 mm (OK)

Bolt Shear:

Capacity = n*Fv = 10 * 112,0x10^3
= 112,0x10^4 >_ 960,8x10^3 N (OK)

Bolt Bearing:

Bolt Bearing on Plate:

Bearing Strength/Bolt/Thickness Using Bolt Edge Distance = Fbe
Edge Dist. = 42 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 28,5 * 450 = 115,4x10^2 N/mm
Bearing Strength/Bolt/Thickness Using Bolt Spacing = Fbs
Bolt Spacing = 75 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 48 * 450 = 194,4x10^2 N/mm

Capcity = Nt *(Fbe + Fbs * (Nl - 1))*t
= 2 * (115,4x10^2 + 194,4x10^2 * (5 - 1)) * 15
= 267,9x10^4 >_ 960,8x10^3 N (OK)

Bolt Bearing on Flange:

Bearing Strength/Bolt/Thickness Using Bolt Edge Distance = Fbe
Edge Dist. = 50 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 36,5 * 450 = 147,8x10^2 N/mm
Bearing Strength/Bolt/Thickness Using Bolt Spacing = Fbs
Bolt Spacing = 75 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 48 * 450 = 194,4x10^2 N/mm

Capacity = Nt *(Fbe + Fbs * (Nl - 1))*t
= 2 * (147,8x10^2 + 194,4x10^2 * (5 - 1)) * 25
= 462,7x10^4 >_ 960,8x10^3 N (OK)

Plate Tension Design Strength:

Tension Yielding:

ØRn = 0,9 *Fy*b*t
= 0,9 *345 * 250 * 15
= 116,4x10^4 >_ 960,8x10^3 N (OK)

Tension Rupture:

ØRn = 0,75 *Fu*(b-Max(0,15*b;Nt*(dh+ 2)))*t
= 0,75 * 450 * (250 - Max(0,15*250 ; 2 *(27 + 2)))* 15
= 972,0x10^3 >_ 960,8x10^3 N (OK)

Block shear rupture of the Plate:

Agt = Min(g,2*e)*t = 90 * 15
= 1350 mm^2

Ant = Agt - (dh+ 2)*t
= 1350 - (29) * 15
= 915 mm^2

Agv = 2 * ((nl - 1) * s + Le) * t
= 2 * ((5 - 1) * 75 + 42) * 15
= 102,6x10^2 mm^2

Anv = Agv - 2 * (nl - 0,5) * (dh + 2) * t
=102,6x10^2 - 2*(5 - 0,5)*(29)*15
= 6345 mm^2
ØRn = 0,75 * Min((0,6 * Fu * Anv + Ubs * Fu * Ant); (0,6 * Fy * Agv + Ubs * Fu * Ant))
= 0,75* Min((0,6 * 450 * 6345 + 1 * 450 * 915); (0,6 * 345 * 102,6x10^2 + 1 * 450 * 915))
= 159,4x10^4 >_ 960,8x10^3 N (OK)

Block shear rupture of the Column Bottom Flange:

Agt = (bf-g)*t = (300 - 160)* 25
= 3500 mm^2

Ant = Agt - (nt-1)*(dh+ 2)*t
= 3500 - (2 - 1)*(29) * 25
= 2775 mm^2

Agv = 2 * ((nl - 1) * s + ef) * t
= 2 * ((5 - 1) * 75 + 42) * 25
= 175,0x10^2 mm^2

Anv = Agv - 2 * (nl - 0,5) * (dh + 2) * t
=175,0x10^2 - 2*(5 - 0,5)*(29)*25
= 109,8x10^2 mm^2
ØRn = 0,75 * Min((0,6 * Fu * Anv + Ubs * Fu * Ant); (0,6 * Fy * Agv + Ubs * Fu * Ant))
= 0,75* Min((0,6 * 450 * 109,8x10^2 + 1 * 450 * 2775); (0,6 * 345 * 175,0x10^2 + 1 * 450 *
2775))
= 315,9x10^4 >_ 960,8x10^3 N (OK)

Bottom Plate Compressive Strength:

Unbraced Length, L = gap + efR + efL = 26 + 50 + 50 = 126 mm
Effective Length Factor, K = 0,65

KL/r = k*L/(t/3,464) = 0,65 * 126/(15/3,464) = 18,914

kL/r <_ 25
Fcr = Fy = 345 N/mm^2

ØcPn = 0,9*Fcr*Ag = 0,9*345*250*15 = 116,4x10^4 >_ 960,8x10^3 N (OK)

Right Side Column - HE600A

Shear Connection Using One Plate:

Plate: 315 mm   X 197 mm   X 15 mm
Plate Material: A572M-345
Column Setback: 13 mm
Bolts: (4) 24Ø A325M- -STD
Bolt Holes on Column Web: 27 mm   Vert. X 27 mm   Horiz.
Bolt Holes on Plate: 27 mm   Vert. X 27 mm   Horiz.

Loading:

Vertical Shear, V = 197,6x10^3 N
Axial Load, H = 0 N
Resultant, R = (V^2 + H^2)^0,5
= ((197,6x10^3)^2 + 0^2)^0,5
= 197,6x10^3 N

Check Bolt Spacing and Edge Distance:

Spacing, s = 75 >_ Minimum Spacing = 65 mm (OK)

Distance to Horiz. Edge of PL, ev:
= 42 >_ 42 mm (OK)

Distance to Vert. Edge of PL, eh:
= 45 >_ 42 mm (OK)

Bolt Strength:

Design Shear Strength of Bolts:

Number of Vertical Bolt Lines = 1
Number of Rows of Bolts = 4
Horizontal Spacing = 75 mm
Vertical Spacing = 75 mm
Eccentricity = 55 mm
C = 3,2186

Design Strength = Npl*C*Fv
= 1 * 3,2186 * 112,0x10^3
= 360,4x10^3 >_ 197,6x10^3 N (OK)

Design Shear Strength of the Column:

Shear Rupture Strength, ØRn
= (d - n*(dh+ 2))*tw*0,75 *0,6*Fu
= (590 - 4 * 29) * 13 * 0,75 *0,6 * 450
= 124,8x10^4 N

A = dw*tw = 590 * 13 = 7670 mm^2

Design Shear Yield Strength:

Rn = 0,6*Fy*A
= 0,6 * 345 * 7670
= 158,8x10^4 N

ØRn = 1*158,8x10^4 = 158,8x10^4 N

Anv = (dw - N*(dh + 2)) * tw
= (590 - 4 * (27 + 2)) * 13
= 6162mm^2

Design Shear Rupture Strength:

Rn = 0,6*Fu*Anv
= 0,6 * 450 * 6162
= 166,4x10^4 N

ØRn = 0,75*166,4x10^4 = 124,8x10^4 N

Column Design Shear Strength:

= Min(ØRn_block_shear, ØRn_yielding, ØRn_rupture)
= 124,8x10^4 >_ 197,6x10^3 N (OK)

Design Shear Strength of the Plate:

Design Shear Yield Strength:

Rn = 0,6*Fy*A
= 0,6 * 345 * 4725
= 978,1x10^3 N

ØRn = 1*978,1x10^3 = 978,1x10^3 N
ØVn = 978,1x10^3 >_ 197,6x10^3N (OK)

Design Shear Rupture Strength:

Net Area, An = (L - nL* (dh+ 2))*t
= (315 - 4 * 29) * 15 = 2985 mm^2

Shear Rupture Strength = Npl*An*0,75 *0,6*Fu = 1 * 2985 * 0,75 *0,6 * 450
= 604,5x10^3 >_ 197,6x10^3N (OK)

Block Shear Strength of the Plate:

Gross Area with Tension Resistance, Agt
= (et + (Nh - 1) * sh) * t
= (39 + (1 - 1) * 75) * 15
= 585 mm^2

Net Area with Tension Resistance, Ant
= Agt - (Nh - 0,5) * (dh + 2) * t
= 585 - (1 - 0,5) * (27 + 2) * 15
= 367,5 mm^2

Gross Area with Shear Resistance, Agv
= (L-el)*t = (315 - 42) * 15 = 4095 mm^2

Net Area with Shear Resistance, Anv
= Agv - (Nv - 0,5) * (dv + 2)* t
= 4095 - (4 - 0,5) * (27 + 2)* 15
= 2573 mm^2
ØRn = 0,75 * Min((0,6 * Fu * Anv + Ubs * Fu * Ant); (0,6 * Fy * Agv + Ubs * Fu * Ant))
= 0,75* Min((0,6 * 450 * 2573 + 1 * 450 * 367,5); (0,6 * 345 * 4095 + 1 * 450 * 367,5))
= 645,0x10^3 >_ 197,6x10^3 N (OK)

Check Flexure with Shear:

Required Strength, M_Req
= V*e = 197,6x10^3 * 55 = 108,7x10^5 N-mm
fv = V/(tp*L)= 197,6x10^3/(15 * 315)= 41,82 N/mm^2

Fcr = (Fy^2 - 3*fv^2)^0,5 = (345^2 - 3*41,82^2)^0,5 = 337,3 N/mm^2
ØMn = 0,9 * Fcr * Z = 0,9*337,3 * 372,1x10^3
= 113,0x10^6 >_ 108,7x10^5 N-mm (OK)

Design Shear Strength Based on Bending of the Plate:
(Assume inflection point at midpoint
between Columns)

Flexural Rupture:

Net Section Modulus, Znet = 241,6x10^3mm^3, Eccentricity, e = 55 mm

Shear Strength = Ø * Znet*Fu/e = 0,75 *241,6x10^3 * 450/55
= 148,3x10^4 >_ 197,6x10^3 N (OK)

Check Plate Buckling:

c = 55 mm
h0 = 315 mm

Lambda = h0*Fy^0,5/(10*t*(475+280*(h0/cp)^2)^0,5)
= 315*345^0,5/(10*15*(475+280*(315/55)^2)^0,5)
= 0,3969
Q = 1
ØFcr = 0,9 *Fy*Q = 0,9   * 345 * 1 = 310,5 N/mm^2

ØRn = ØFcr * Snet/c = 310,5 * 170,4x10^3/55
= 961,9x10^3 >_ 197,6x10^3 N (OK)

Bolt Bearing on Plate:

Bearing Strength/Bolt/Thickness Using Bolt Edge Distance = Fbe
Edge Dist. = 42 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 28,5 * 450 = 115,4x10^2 N/mm
Bearing Strength/Bolt/Thickness Using Bolt Spacing = Fbs
Bolt Spacing = 75 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 48 * 450 = 194,4x10^2 N/mm
Design Strength = nL * (Fbe + Fbs * (nR - 1)) * t * Npl * ef
= 1 * (115,4x10^2 + 194,4x10^2 * (4 - 1)) * 15 * 1 * 0,8047
= 843,2x10^3 >_ 197,6x10^3 N (OK)

Bolt Bearing on Column Web:

Bearing Strength/Bolt/Thickness Using Bolt Spacing = Fbs
Bolt Spacing = 75 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 48 * 450 = 194,4x10^2 N/mm
Design Strength = nL * Fbs * nR * t * ef
= 1 * 194,4x10^2 * 4 * 13 * 0,8047
= 813,4x10^3 >_ 197,6x10^3 N (OK)

Left Side Column - HE600A

Shear Connection Using One Plate:

Plate: 315 mm   X 197 mm   X 15 mm
Plate Material: A572M-345
Column Setback: 13 mm
Bolts: (4) 24Ø A325M- -STD
Bolt Holes on Column Web: 27 mm   Vert. X 27 mm   Horiz.
Bolt Holes on Plate: 27 mm   Vert. X 27 mm   Horiz.

Loading:

Vertical Shear, V = 197,6x10^3 N
Axial Load, H = 0 N
Resultant, R = (V^2 + H^2)^0,5
= ((197,6x10^3)^2 + 0^2)^0,5
= 197,6x10^3 N

Check Bolt Spacing and Edge Distance:

Spacing, s = 75 >_ Minimum Spacing = 65 mm   (OK)

Distance to Horiz. Edge of PL, ev:
= 42 >_ 42 mm   (OK)

Distance to Vert. Edge of PL, eh:
= 42 >_ 42 mm   (OK)

Bolt Strength:

Design Shear Strength of Bolts:

Number of Vertical Bolt Lines = 1
Number of Rows of Bolts = 4
Horizontal Spacing = 75 mm
Vertical Spacing = 75 mm
Eccentricity = 55 mm
C = 3,2186

Design Strength = Npl*C*Fv
= 1 * 3,2186 * 112,0x10^3
= 360,4x10^3 >_ 197,6x10^3 N (OK)

Design Shear Strength of the Column:

Shear Rupture Strength, ØRn
= (d - n*(dh+ 2))*tw*0,75 *0,6*Fu
= (590 - 4 * 29) * 13 * 0,75 *0,6 * 450
= 124,8x10^4 N

A = dw*tw = 590 * 13 = 7670 mm^2

Design Shear Yield Strength:

Rn = 0,6*Fy*A
= 0,6 * 345 * 7670
= 158,8x10^4 N

ØRn = 1*158,8x10^4 = 158,8x10^4 N

Anv = (dw - N*(dh + 2)) * tw
= (590 - 4 * (27 + 2)) * 13
= 6162mm^2

Design Shear Rupture Strength:

Rn = 0,6*Fu*Anv
= 0,6 * 450 * 6162
= 166,4x10^4 N

ØRn = 0,75*166,4x10^4 = 124,8x10^4 N

Column Design Shear Strength:
= Min(ØRn_block_shear, ØRn_yielding, ØRn_rupture)
= 124,8x10^4 >_ 197,6x10^3 N (OK)

Design Shear Strength of the Plate:

Design Shear Yield Strength:

Rn = 0,6*Fy*A
= 0,6 * 345 * 4725
= 978,1x10^3 N

ØRn = 1*978,1x10^3 = 978,1x10^3 N
ØVn = 978,1x10^3 >_ 197,6x10^3N (OK)

Design Shear Rupture Strength:

Net Area, An = (L - nL* (dh+ 2))*t
= (315 - 4 * 29) * 15 = 2985 mm^2

Shear Rupture Strength = Npl*An*0,75 *0,6*Fu = 1 * 2985 * 0,75 *0,6 * 450
= 604,5x10^3 >_ 197,6x10^3N (OK)

Block Shear Strength of the Plate:

Gross Area with Tension Resistance, Agt
= (et + (Nh - 1) * sh) * t
= (36 + (1 - 1) * 75) * 15
= 540 mm^2

Net Area with Tension Resistance, Ant
= Agt - (Nh - 0,5) * (dh + 2) * t
= 540 - (1 - 0,5) * (27 + 2) * 15
= 322,5 mm^2

Gross Area with Shear Resistance, Agv
= (L-el)*t = (315 - 42) * 15 = 4095 mm^2

Net Area with Shear Resistance, Anv
= Agv - (Nv - 0,5) * (dv + 2)* t
= 4095 - (4 - 0,5) * (27 + 2)* 15
= 2573 mm^2
ØRn = 0,75 * Min((0,6 * Fu * Anv + Ubs * Fu * Ant); (0,6 * Fy * Agv + Ubs * Fu * Ant))
= 0,75* Min((0,6 * 450 * 2573 + 1 * 450 * 322,5); (0,6 * 345 * 4095 + 1 * 450 * 322,5))
= 629,8x10^3 >_ 197,6x10^3 N (OK)

Check Flexure with Shear:

Required Strength, M_Req
= V*e = 197,6x10^3 * 55 = 108,7x10^5 N-mm
fv = V/(tp*L)= 197,6x10^3/(15 * 315)= 41,82 N/mm^2

Fcr = (Fy^2 - 3*fv^2)^0,5 = (345^2 - 3*41,82^2)^0,5 = 337,3 N/mm^2
ØMn = 0,9 * Fcr * Z = 0,9*337,3 * 372,1x10^3
= 113,0x10^6 >_ 108,7x10^5 N-mm (OK)

Design Shear Strength Based on Bending of the Plate:
(Assume inflection point at midpoint
between Columns)

Flexural Rupture:

Net Section Modulus, Znet = 241,6x10^3mm^3, Eccentricity, e = 55 mm

Shear Strength = Ø * Znet*Fu/e = 0,75 *241,6x10^3 * 450/55
= 148,3x10^4 >_ 197,6x10^3 N (OK)

Check Plate Buckling:

c = 55 mm
h0 = 315 mm

Lambda = h0*Fy^0,5/(10*t*(475+280*(h0/cp)^2)^0,5)
= 315*345^0,5/(10*15*(475+280*(315/55)^2)^0,5)
= 0,3969
Q = 1
ØFcr = 0,9 *Fy*Q = 0,9   * 345 * 1 = 310,5 N/mm^2

ØRn = ØFcr * Snet/c = 310,5 * 170,4x10^3/55
= 961,9x10^3 >_ 197,6x10^3 N (OK)

Bolt Bearing on Plate:

Bearing Strength/Bolt/Thickness Using Bolt Edge Distance = Fbe
Edge Dist. = 42 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 28,5 * 450 = 115,4x10^2 N/mm
Bearing Strength/Bolt/Thickness Using Bolt Spacing = Fbs
Bolt Spacing = 75 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 48 * 450 = 194,4x10^2 N/mm
Design Strength = nL * (Fbe + Fbs * (nR - 1)) * t * Npl * ef

= 1 * (115,4x10^2 + 194,4x10^2 * (4 - 1)) * 15 * 1 * 0,8047
= 843,2x10^3 >_ 197,6x10^3 N (OK)

Bolt Bearing on Column Web:

Bearing Strength/Bolt/Thickness Using Bolt Spacing = Fbs
Bolt Spacing = 75 mm , Hole Size = 27 mm
= 0,75 * 1,2 * Lc * Fu <_ 0,75 * 2,4 * d * Fu = 194,4x10^2 N/mm
= 0,75 * 1,2 * 48 * 450 = 194,4x10^2 N/mm
Design Strength = nL * Fbs * nR * t * ef
= 1 * 194,4x10^2 * 4 * 13 * 0,8047
= 813,4x10^3 >_ 197,6x10^3 N (OK)