Connection Design for Piperack PR-01

Calculation No: 540001-CAL-STR-0002

Rev	Date	Purpose	Prepared By	Reviewed By	Approved By
2	01-09-2023	Issued for Construction	Jim	Aravind	Samir
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Contents

1 PURPOSE AND SCOPE

The purpose of this calculation is to design the shear connections for the Big Steel Plantproject.

2 GEOMETRY

Beam shear connections are designed to transfer negligible moments across joints. The connection may be between beam and beam or between beam and column. The connection is made using a clip angle that is welded to the connecting beam and bolted on to the supporting member. This detail is chosen because of the ease with which it can be fabricated and erected. A typical beam to beam shear connection is shown in figure 1.
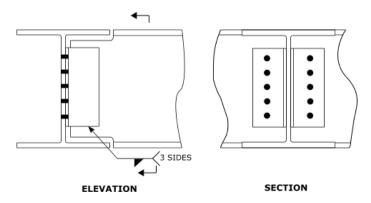

Figure 1: A shear connection

3 MATERIAL SPECIFICATIONS

The material specifications considered for the design of the shear connections are as shown in the table 1.

Element	Specification
Beams	ASTM A992
Columns	ASTM A992
Clip angles	ASTM A36
Bolts	ASTM F3125
Weld	FEXX 70

Table 1: Material specification

4 DESIGN PHILOSOPHY

The connection design is done using the open source connection design software Osoconn developed by Roshn Noronha, and available at `https://osoconn.com`. The connections are designed in accordance to the 14th edition AISC 360 specifications using the ASD method to determine the allowable strength of a connecting element. The value of the allowable strenght is compared against the required strength, and the ratio between the two is calculated as the interaction ratio. If the interaction ratio obtained is less that 1.0 then the design is considered satisfactory.

$$I = \frac{R}{R_a} \tag{1}$$

where,

I,is the interaction ratio

R, is the required strength

R_a, is the allowable strength

The output of the connection design software is provided in Attachment 1.

5 DESIGN RESULTS

ID	Transfer force (N)	Shear force(N)	Support type	Beam	Support	Max Ratio	Result
SBC1	15000	90000	BEAM	W410X67	W410X67	0.608	OK
SBC2	13000	34000	BEAM	W310X52	W360X51	0.472	OK
SBC3	11000	45000	BEAM	W250X32.7	W250X67	0.822	OK
SBC4	34000	15000	COLUMN FLANGE	W310X60	W360X64	0.680	OK
SBC5	45000	90000	COLUMN WEB	W410X67	W360X91	0.889	OK

Table 2: Design Results

6 ATTACHMENT 1: OUTPUT FILES

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---------------------------------------------------------------+--------------------
Design Summary                                                 |
---------------------------------------------------------------+--------------------
   Connection is OK                                            |
   Maximum utility ratio for connection                        | 0.608
---------------------------------------------------------------+--------------------
Design Inputs                                                  |
---------------------------------------------------------------+--------------------
   Design method                                               | ASD
   Young's modulus of elasticity                               | 200000.000 MPa
   Poisson's ratio                                             | 0.300
                                                               |
Connection forces:                                             |
   Transfer force (TF)                                         | 15000.000 N
   Shear force (SF)                                            | 90000.000 N
                                                               |
Bolt Details:                                                  |
   Bolt Diameter                                               | 22.000 mm
   Number of bolts per clip angle (n)                          | 2.000
   Bolt Gage                                                   | 140.000 mm
   Bolt Spacing                                                | 70.000 mm
   Nominal tensile capacity of bolt                            | 620.000 MPa
   Nominal shear capacity of bolt                              | 372.000 MPa
                                                               |
Weld Details:                                                  |
   Weld thickness                                              | 6.000 mm
   Weld tensile strength                                       | 482.000 MPa
                                                               |
Clip angle dimensions:                                         |
   Clip angle  size (li x lo x ta)                             | 102x102x9.53 mm
   Clip angle length                                           | 140.000 mm
   Yield strength of clip angle                                | 250.000 MPa
   Tensile strenght of clip angle                              | 400.000 MPa
                                                               |
Connecting beam properties:                                    |
   Section size                                                |
      Depth                                                    | 409.000 mm
      Flange width                                             | 179.000 mm
      Flange thickness                                         | 14.400 mm
      Web thickness (tw)                                       | 8.760 mm
   Yield strength of beam                                      | 345.000 MPa
   Tensile strength of beam                                    | 450.000 MPa
   Beam setback from connection member (s)                     | 12.000 mm
   Top cope depth                                              | 50.000 mm
   Bottom cope depth                                           | 50.000 mm
   Cope length (c)                                             | 150.000 mm
                                                               |
Supporting member properties:                                  |
   Support type                                                | Beam Web
   Section size                                                | W410X67
      Depth                                                    | 409.000 mm
      Flange width                                             | 179.000 mm
      Flange thickness                                         | 14.400 mm
      Web thickness                                            | 8.760 mm
---------------------------------------------------------------+--------------------
Design Calculations                                            |
---------------------------------------------------------------+--------------------
                                                               |
Bolt Shear Check:                                              |
   Shear per bolt                                              |
      [Vb=SF/(2*n)]                                            | 22500.000 N
   Nominal shear strength of bolt (Rn)                         | 141337.680 N
   ASD factor in bolt shear (omega)                            | 2.000
   Allowable shear strength of bolt                            |
      [Ra=Rn/omega]                                            | 70668.840 N
   Utility ratio in bolt shear                                 |
      [Vb/Ra]                                                  | 0.318
                                                               |
Bolt Bearing at Clip Angle Check:                              |
   Nominal strength in bearing at clip angle (Rn)              | 105211.200 N
   ASD factor in bolt bearing (omega)                          | 2.000
   Allowable strength in bearing at clip angle                 |
      [Ra=Rn/omega]                                            | 52605.600 N
   Utility ratio in bearing at clip angle                      |
      [Vb/Ra]                                                  | 0.428
                                                               |
Bolt Bearing at Support Check:                                 |
   Nominal strength in bearing at support (Rn)                 | 208137.600 N
   ASD factor in bolt bearing (omega)                          | 2.000
   Allowable strength in bearing at support                    |
      [Ra=Rn/omega]                                            | 104068.800 N
   Strength reduction factor to account for backing beam (r)   | 0.500
   Utility ratio in bearing at support                         |
      [Vb/(Ra*r)]                                              | 0.432
                                                               |
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Bolt Tension Check (without prying:                    |
   Tension per bolt without prying                     |
      [Tb=TF/(2*n)]                                     | 3750.000 N
   Nominal bolt strength in tension (Rn)               | 231231.640 N
   ASD factor in bolt tension (omega)                  | 2.000
   Allowable bolt strength in tension                  |
      [B=Rn/omega]                                      | 115615.820 N
   Utility ratio in bolt tension                       |
      [Tb/B]                                            | 0.032
                                                        |
Clip angle prying action check:                        |
   Bolt strength reduction factor due to clip prying (Q)| 0.109
   Interaction ratio in clip prying                    |
      [Tb/(Q*B)]                                        | 0.296
                                                        |
Weld Check:                                             |
   Maximum stress in weld group (fw)                   | 359.777 N/mm
   Nominal strength of weld (Rn)                       | 1226.786 N/mm
   ASD factor for weld (omega)                         | 2.000
   Allowable weld strength                             |
      [Ra=Rn/omega]                                     | 613.393 N/mm
   Utility ratio for weld                              |
      [fw/Ra]                                           | 0.587
                                                        |
Web Rupture at Weld Check:                              |
   Minimum thickness of web at weld (tw`)              | 5.330 mm
   Utility ratio in rupture at weld                    |
      [tw`/tw]                                          | 0.608
                                                        |
Clip Angle Shear Yielding Check:                        |
   Shear in clip angle                                 |
      [Va=sqrt(TF^2+SF^2)/2]                            | 45620.719 N
   Nominal shear yeilding strength of clip angle (Rn)  | 200130.000 N
   ASD factor for shear yielding (omega)               | 1.500
   Allowable shear yielding strength of clip angle     |
      [Ra=Rn/omega]                                     | 133420.000 N
   Utility ratio in shear yielding                     |
      [Va/Ra]                                           | 0.342
                                                        |
Clip Angle Shear Rupture Check:                         |
   Nominal shear rupture strength of clip angle (Rn)   | 210422.400 N
   ASD factor for shear rupture (omega)                | 2.000
   Shear rupture strength of clip angle                |
      [Ra=Rn/omega]                                     | 105211.200 N
   Utility ratio in shear rupture                      |
      [Va/Ra]                                           | 0.434
                                                        |
Beam Cope Flexure Check:                                |
   Eccetricity of applied transfer force from centroid of cope (e) | 74.000 mm
   Bending moment in coped section                     |
      [M=SF*(s+c)+TF*e]                                 | 15690000.000 N mm
   Section modulus of coped section about major axis (Sx) | 139402.260 mm^3
   Critical stress in coped section (Fcr)              | 345.000 MPa
   Nominal flexural strength of coped section          |
      [Mn=Fcr*Sx]                                       | 48093779.700 N mm
   ASD factor in flexure (omega)                       | 1.670
   Allowable flexural strength of coped section        |
      [Ma=Mn/omega]                                     | 28798670.479 N mm
   Utility ratio in coped section flexure              |
      [M/Ma]                                            | 0.545
                                                        |
Beam Cope Compression Check:                            |
   Cross section area of coped section (Ac)            | 2706.840 mm^2
   Critical compressive stress in coped section (fcr)  | 255.526 MPa
   Nominal strength of coped section in compression (Pn)|
      [Pn=fcr*Ac]                                       | 691667.931 N
   ASD factor in compression (omega)                   | 1.670
   Allowable compression strength of coped section     |
      [Pa=Pn/omega]                                     | 414172.414 N
   Utility ratio in coped section compression          |
      [TF/Pa]                                           | 0.036
                                                        |
Beam Cope Shear Check:                                  |
   Nominal strength of cope in shear (Rn)              | 560315.880 N
   ASD factor in shear (omega)                         | 1.500
   Allowable shear strength of coped section           |
      [Ra=Rn/omega]                                     | 373543.920 N
   Utility ratio in coped section shear                |
      [SF/Ra]                                           | 0.241
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Design Summary                                                  |
----------------------------------------------------------------+--------------------
   Connection is OK                                             |
   Maximum utility ratio for connection                         | 0.472
----------------------------------------------------------------+--------------------
Design Inputs                                                   |
----------------------------------------------------------------+--------------------
   Design method                                                | ASD
   Young's modulus of elasticity                                | 200000.000 MPa
   Poisson's ratio                                              | 0.300
                                                                |
Connection forces:                                             |
   Transfer force (TF)                                          | 13000.000 N
   Shear force (SF)                                             | 34000.000 N
                                                                |
Bolt Details:                                                  |
   Bolt Diameter                                                | 22.000 mm
   Number of bolts per clip angle (n)                           | 2.000
   Bolt Gage                                                    | 140.000 mm
   Bolt Spacing                                                 | 70.000 mm
   Nominal tensile capacity of bolt                             | 620.000 MPa
   Nominal shear capacity of bolt                               | 372.000 MPa
                                                                |
Weld Details:                                                  |
   Weld thickness                                               | 6.000 mm
   Weld tensile strength                                        | 482.000 MPa
                                                                |
Clip angle dimensions:                                         |
   Clip angle  size (li x lo x ta)                              | 102x102x9.53 mm
   Clip angle length                                            | 140.000 mm
   Yield strength of clip angle                                 | 250.000 MPa
   Tensile strenght of clip angle                               | 400.000 MPa
                                                                |
Connecting beam properties:                                    |
   Section size                                                 |
      Depth                                                     | 318.000 mm
      Flange width                                              | 167.000 mm
      Flange thickness                                          | 13.200 mm
      Web thickness (tw)                                        | 7.620 mm
   Yield strength of beam                                       | 345.000 MPa
   Tensile strength of beam                                     | 450.000 MPa
   Beam setback from connection member (s)                      | 12.000 mm
   Top cope depth                                               | 50.000 mm
   Bottom cope depth                                            | 50.000 mm
   Cope length (c)                                              | 150.000 mm
                                                                |
Supporting member properties:                                  |
   Support type                                                 | Beam Web
   Section size                                                 | W360X51
      Depth                                                     | 356.000 mm
      Flange width                                              | 171.000 mm
      Flange thickness                                          | 11.600 mm
      Web thickness                                             | 7.240 mm
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Design Calculations                                            |
----------------------------------------------------------------+--------------------
                                                                |
Bolt Shear Check:                                              |
   Shear per bolt                                               |
      [Vb=SF/(2*n)]                                             | 8500.000 N
   Nominal shear strength of bolt (Rn)                          | 141337.680 N
   ASD factor in bolt shear (omega)                             | 2.000
   Allowable shear strength of bolt                             |
      [Ra=Rn/omega]                                             | 70668.840 N
   Utility ratio in bolt shear                                  |
      [Vb/Ra]                                                   | 0.120
                                                                |
Bolt Bearing at Clip Angle Check:                              |
   Nominal strength in bearing at clip angle (Rn)               | 105211.200 N
   ASD factor in bolt bearing (omega)                           | 2.000
   Allowable strength in bearing at clip angle                  |
      [Ra=Rn/omega]                                             | 52605.600 N
   Utility ratio in bearing at clip angle                       |
      [Vb/Ra]                                                   | 0.162
                                                                |
Bolt Bearing at Support Check:                                 |
   Nominal strength in bearing at support (Rn)                  | 181051.200 N
   ASD factor in bolt bearing (omega)                           | 2.000
   Allowable strength in bearing at support                     |
      [Ra=Rn/omega]                                             | 90525.600 N
   Strength reduction factor to account for backing beam (r)    | 0.500
   Utility ratio in bearing at support                          |
      [Vb/(Ra*r)]                                               | 0.188
                                                                |
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Bolt Tension Check (without prying:                       |
   Tension per bolt without prying                        |
      [Tb=TF/(2*n)]                                        | 3250.000 N
   Nominal bolt strength in tension (Rn)                  | 235562.800 N
   ASD factor in bolt tension (omega)                     | 2.000
   Allowable bolt strength in tension                     |
      [B=Rn/omega]                                         | 117781.400 N
   Utility ratio in bolt tension                          |
      [Tb/B]                                               | 0.028
                                                           |
Clip angle prying action check:                            |
   Bolt strength reduction factor due to clip prying (Q)  | 0.106
   Interaction ratio in clip prying                       |
      [Tb/(Q*B)]                                           | 0.260
                                                           |
Weld Check:                                                |
   Maximum stress in weld group (fw)                      | 142.514 N/mm
   Nominal strength of weld (Rn)                          | 1226.786 N/mm
   ASD factor for weld (omega)                            | 2.000
   Allowable weld strength                                |
      [Ra=Rn/omega]                                        | 613.393 N/mm
   Utility ratio for weld                                 |
      [fw/Ra]                                              | 0.232
                                                           |
Web Rupture at Weld Check:                                 |
   Minimum thickness of web at weld (tw`)                 | 2.111 mm
   Utility ratio in rupture at weld                       |
      [tw`/tw]                                             | 0.277
                                                           |
Clip Angle Shear Yielding Check:                           |
   Shear in clip angle                                    |
      [Va=sqrt(TF^2+SF^2)/2]                               | 18200.275 N
   Nominal shear yeilding strength of clip angle (Rn)     | 200130.000 N
   ASD factor for shear yielding (omega)                  | 1.500
   Allowable shear yielding strength of clip angle        |
      [Ra=Rn/omega]                                        | 133420.000 N
   Utility ratio in shear yielding                        |
      [Va/Ra]                                              | 0.136
                                                           |
Clip Angle Shear Rupture Check:                            |
   Nominal shear rupture strength of clip angle (Rn)      | 210422.400 N
   ASD factor for shear rupture (omega)                   | 2.000
   Shear rupture strength of clip angle                   |
      [Ra=Rn/omega]                                        | 105211.200 N
   Utility ratio in shear rupture                         |
      [Va/Ra]                                              | 0.173
                                                           |
Beam Cope Flexure Check:                                   |
   Eccetricity of applied transfer force from centroid of cope (e) | 29.000 mm
   Bending moment in coped section                        |
      [M=SF*(s+c)+TF*e]                                    | 5885000.000 N mm
   Section modulus of coped section about major axis (Sx) | 60355.480 mm^3
   Critical stress in coped section (Fcr)                 | 345.000 MPa
   Nominal flexural strength of coped section             |
      [Mn=Fcr*Sx]                                          | 20822640.600 N mm
   ASD factor in flexure (omega)                          | 1.670
   Allowable flexural strength of coped section           |
      [Ma=Mn/omega]                                        | 12468647.066 N mm
   Utility ratio in coped section flexure                 |
      [M/Ma]                                               | 0.472
                                                           |
Beam Cope Compression Check:                               |
   Cross section area of coped section (Ac)               | 1661.160 mm^2
   Critical compressive stress in coped section (fcr)     | 232.009 MPa
   Nominal strength of coped section in compression (Pn)  |
      [Pn=fcr*Ac]                                          | 385403.550 N
   ASD factor in compression (omega)                      | 1.670
   Allowable compression strength of coped section        |
      [Pa=Pn/omega]                                        | 230780.569 N
   Utility ratio in coped section compression             |
      [TF/Pa]                                              | 0.056
                                                           |
Beam Cope Shear Check:                                     |
   Nominal strength of cope in shear (Rn)                 | 343860.120 N
   ASD factor in shear (omega)                            | 1.500
   Allowable shear strength of coped section              |
      [Ra=Rn/omega]                                        | 229240.080 N
   Utility ratio in coped section shear                   |
      [SF/Ra]                                              | 0.148
```

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Design Summary                                                   |
-----------------------------------------------------------------+--------------------
   Connection is OK                                              |
   Maximum utility ratio for connection                         | 0.822
-----------------------------------------------------------------+--------------------
Design Inputs                                                    |
-----------------------------------------------------------------+--------------------
   Design method                                                 | ASD
   Young's modulus of elasticity                                 | 200000.000 MPa
   Poisson's ratio                                               | 0.300
                                                                 |
Connection forces:                                              |
   Transfer force (TF)                                           | 11000.000 N
   Shear force (SF)                                              | 45000.000 N
                                                                 |
Bolt Details:                                                   |
   Bolt Diameter                                                 | 22.000 mm
   Number of bolts per clip angle (n)                            | 2.000
   Bolt Gage                                                     | 140.000 mm
   Bolt Spacing                                                  | 70.000 mm
   Nominal tensile capacity of bolt                              | 620.000 MPa
   Nominal shear capacity of bolt                                | 372.000 MPa
                                                                 |
Weld Details:                                                   |
   Weld thickness                                                | 6.000 mm
   Weld tensile strength                                         | 482.000 MPa
                                                                 |
Clip angle dimensions:                                          |
   Clip angle  size (li x lo x ta)                               | 102x102x9.53 mm
   Clip angle length                                             | 140.000 mm
   Yield strength of clip angle                                  | 250.000 MPa
   Tensile strenght of clip angle                                | 400.000 MPa
                                                                 |
Connecting beam properties:                                     |
   Section size                                                  |
      Depth                                                      | 259.000 mm
      Flange width                                               | 146.000 mm
      Flange thickness                                           | 9.140 mm
      Web thickness (tw)                                         | 6.100 mm
   Yield strength of beam                                        | 345.000 MPa
   Tensile strength of beam                                      | 450.000 MPa
   Beam setback from connection member (s)                       | 12.000 mm
   Top cope depth                                                | 40.000 mm
   Bottom cope depth                                             | 40.000 mm
   Cope length (c)                                               | 110.000 mm
                                                                 |
Supporting member properties:                                   |
   Support type                                                  | Beam Web
   Section size                                                  | W250X67
      Depth                                                      | 257.000 mm
      Flange width                                               | 204.000 mm
      Flange thickness                                           | 15.700 mm
      Web thickness                                              | 8.890 mm
-----------------------------------------------------------------+--------------------
Design Calculations                                             |
-----------------------------------------------------------------+--------------------
                                                                 |
Bolt Shear Check:                                               |
   Shear per bolt                                                |
      [Vb=SF/(2*n)]                                              | 11250.000 N
   Nominal shear strength of bolt (Rn)                           | 141337.680 N
   ASD factor in bolt shear (omega)                              | 2.000
   Allowable shear strength of bolt                              |
      [Ra=Rn/omega]                                              | 70668.840 N
   Utility ratio in bolt shear                                   |
      [Vb/Ra]                                                    | 0.159
                                                                 |
Bolt Bearing at Clip Angle Check:                               |
   Nominal strength in bearing at clip angle (Rn)                | 105211.200 N
   ASD factor in bolt bearing (omega)                            | 2.000
   Allowable strength in bearing at clip angle                   |
      [Ra=Rn/omega]                                              | 52605.600 N
   Utility ratio in bearing at clip angle                        |
      [Vb/Ra]                                                    | 0.214
                                                                 |
Bolt Bearing at Support Check:                                  |
   Nominal strength in bearing at support (Rn)                   | 144936.000 N
   ASD factor in bolt bearing (omega)                            | 2.000
   Allowable strength in bearing at support                      |
      [Ra=Rn/omega]                                              | 72468.000 N
   Strength reduction factor to account for backing beam (r)     | 0.500
   Utility ratio in bearing at support                           |
      [Vb/(Ra*r)]                                                | 0.310
                                                                 |
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Bolt Tension Check (without prying:                         |
    Tension per bolt without prying                         |
        [Tb=TF/(2*n)]                                       | 2750.000 N
    Nominal bolt strength in tension (Rn)                   | 235562.800 N
    ASD factor in bolt tension (omega)                      | 2.000
    Allowable bolt strength in tension                      |
        [B=Rn/omega]                                        | 117781.400 N
    Utility ratio in bolt tension                           |
        [Tb/B]                                              | 0.023
                                                            |
Clip angle prying action check:                             |
    Bolt strength reduction factor due to clip prying (Q)   | 0.105
    Interaction ratio in clip prying                        |
        [Tb/(Q*B)]                                          | 0.223
                                                            |
Weld Check:                                                 |
    Maximum stress in weld group (fw)                       | 182.941 N/mm
    Nominal strength of weld (Rn)                           | 1226.786 N/mm
    ASD factor for weld (omega)                             | 2.000
    Allowable weld strength                                 |
        [Ra=Rn/omega]                                       | 613.393 N/mm
    Utility ratio for weld                                  |
        [fw/Ra]                                             | 0.298
                                                            |
Web Rupture at Weld Check:                                  |
    Minimum thickness of web at weld (tw`)                  | 2.710 mm
    Utility ratio in rupture at weld                        |
        [tw`/tw]                                            | 0.444
                                                            |
Clip Angle Shear Yielding Check:                            |
    Shear in clip angle                                     |
        [Va=sqrt(TF^2+SF^2)/2]                              | 23162.470 N
    Nominal shear yeilding strength of clip angle (Rn)      | 200130.000 N
    ASD factor for shear yielding (omega)                   | 1.500
    Allowable shear yielding strength of clip angle         |
        [Ra=Rn/omega]                                       | 133420.000 N
    Utility ratio in shear yielding                         |
        [Va/Ra]                                             | 0.174
                                                            |
Clip Angle Shear Rupture Check:                             |
    Nominal shear rupture strength of clip angle (Rn)       | 210422.400 N
    ASD factor for shear rupture (omega)                    | 2.000
    Shear rupture strength of clip angle                    |
        [Ra=Rn/omega]                                       | 105211.200 N
    Utility ratio in shear rupture                          |
        [Va/Ra]                                             | 0.220
                                                            |
Beam Cope Flexure Check:                                    |
    Eccetricity of applied transfer force from centroid of cope (e) | 4.000 mm
    Bending moment in coped section                         |
        [M=SF*(s+c)+TF*e]                                   | 5534000.000 N mm
    Section modulus of coped section about major axis (Sx)  | 32575.017 mm^3
    Critical stress in coped section (Fcr)                  | 345.000 MPa
    Nominal flexural strength of coped section              |
        [Mn=Fcr*Sx]                                         | 11238380.750 N mm
    ASD factor in flexure (omega)                           | 1.670
    Allowable flexural strength of coped section            |
        [Ma=Mn/omega]                                       | 6729569.311 N mm
    Utility ratio in coped section flexure                  |
        [M/Ma]                                              | 0.822
                                                            |
Beam Cope Compression Check:                                |
    Cross section area of coped section (Ac)                | 1091.900 mm^2
    Critical compressive stress in coped section (fcr)      | 242.841 MPa
    Nominal strength of coped section in compression (Pn)   |
        [Pn=fcr*Ac]                                         | 265157.857 N
    ASD factor in compression (omega)                       | 1.670
    Allowable compression strength of coped section         |
        [Pa=Pn/omega]                                       | 158777.160 N
    Utility ratio in coped section compression              |
        [TF/Pa]                                             | 0.069
                                                            |
Beam Cope Shear Check:                                      |
    Nominal strength of cope in shear (Rn)                  | 226023.300 N
    ASD factor in shear (omega)                             | 1.500
    Allowable shear strength of coped section               |
        [Ra=Rn/omega]                                       | 150682.200 N
    Utility ratio in coped section shear                    |
        [SF/Ra]                                             | 0.299
```

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Design Summary                                                   |
-----------------------------------------------------------------+--------------------
   Connection is OK                                              |
   Maximum utility ratio for connection                         | 0.680
-----------------------------------------------------------------+--------------------
Design Inputs                                                    |
-----------------------------------------------------------------+--------------------
   Design method                                                 | ASD
   Young's modulus of elasticity                                 | 200000.000 MPa
   Poisson's ratio                                               | 0.300
                                                                 |
Connection forces:                                               |
   Transfer force (TF)                                           | 34000.000 N
   Shear force (SF)                                              | 15000.000 N
                                                                 |
Bolt Details:                                                    |
   Bolt Diameter                                                 | 22.000 mm
   Number of bolts per clip angle (n)                            | 2.000
   Bolt Gage                                                     | 140.000 mm
   Bolt Spacing                                                  | 70.000 mm
   Nominal tensile capacity of bolt                              | 620.000 MPa
   Nominal shear capacity of bolt                                | 372.000 MPa
                                                                 |
Weld Details:                                                    |
   Weld thickness                                                | 6.000 mm
   Weld tensile strength                                         | 482.000 MPa
                                                                 |
Clip angle dimensions:                                           |
   Clip angle  size (li x lo x ta)                               | 102x102x9.53 mm
   Clip angle length                                             | 140.000 mm
   Yield strength of clip angle                                  | 250.000 MPa
   Tensile strenght of clip angle                                | 400.000 MPa
                                                                 |
Connecting beam properties:                                      |
   Section size                                                  |
      Depth                                                      | 302.000 mm
      Flange width                                               | 203.000 mm
      Flange thickness                                           | 13.100 mm
      Web thickness (tw)                                         | 7.490 mm
   Yield strength of beam                                        | 345.000 MPa
   Tensile strength of beam                                      | 450.000 MPa
   Beam setback from connection member (s)                       | 12.000 mm
                                                                 |
Supporting member properties:                                    |
   Support type                                                  | Column Flange
   Section size                                                  | W360X64
      Depth                                                      | 348.000 mm
      Flange width                                               | 203.000 mm
      Flange thickness                                           | 13.500 mm
      Web thickness                                              | 7.750 mm
-----------------------------------------------------------------+--------------------
Design Calculations                                              |
-----------------------------------------------------------------+--------------------
                                                                 |
Bolt Shear Check:                                                |
   Shear per bolt                                                |
      [Vb=SF/(2*n)]                                              | 3750.000 N
   Nominal shear strength of bolt (Rn)                           | 141337.680 N
   ASD factor in bolt shear (omega)                              | 2.000
   Allowable shear strength of bolt                              |
      [Ra=Rn/omega]                                              | 70668.840 N
   Utility ratio in bolt shear                                   |
      [Vb/Ra]                                                    | 0.053
                                                                 |
Bolt Bearing at Clip Angle Check:                                |
   Nominal strength in bearing at clip angle (Rn)                | 105211.200 N
   ASD factor in bolt bearing (omega)                            | 2.000
   Allowable strength in bearing at clip angle                   |
      [Ra=Rn/omega]                                              | 52605.600 N
   Utility ratio in bearing at clip angle                        |
      [Vb/Ra]                                                    | 0.071
                                                                 |
Bolt Bearing at Support Check:                                   |
   Nominal strength in bearing at support (Rn)                   | 320760.000 N
   ASD factor in bolt bearing (omega)                            | 2.000
   Allowable strength in bearing at support                      |
      [Ra=Rn/omega]                                              | 160380.000 N
   Strength reduction factor to account for backing beam (r)     | 1.000
   Utility ratio in bearing at support                           |
      [Vb/(Ra*r)]                                                | 0.023
                                                                 |
Bolt Tension Check (without prying:                              |
   Tension per bolt without prying                               |
      [Tb=TF/(2*n)]                                              | 8500.000 N
```

```
    Nominal bolt strength in tension (Rn)              | 235562.800 N
    ASD factor in bolt tension (omega)                | 2.000
    Allowable bolt strength in tension                |
        [B=Rn/omega]                                  | 117781.400 N
    Utility ratio in bolt tension                     |
        [Tb/B]                                        | 0.072
                                                      |
Clip angle prying action check:                       |
    Bolt strength reduction factor due to clip prying (Q) | 0.106
    Interaction ratio in clip prying                  |
        [Tb/(Q*B)]                                    | 0.680
                                                      |
Weld Check:                                           |
    Maximum stress in weld group (fw)                 | 96.179 N/mm
    Nominal strength of weld (Rn)                     | 1226.786 N/mm
    ASD factor for weld (omega)                       | 2.000
    Allowable weld strength                           |
        [Ra=Rn/omega]                                 | 613.393 N/mm
    Utility ratio for weld                            |
        [fw/Ra]                                       | 0.157
                                                      |
Web Rupture at Weld Check:                            |
    Minimum thickness of web at weld (tw`)            | 1.425 mm
    Utility ratio in rupture at weld                  |
        [tw`/tw]                                      | 0.190
                                                      |
Clip Angle Shear Yielding Check:                      |
    Shear in clip angle                               |
        [Va=sqrt(TF^2+SF^2)/2]                        | 18580.904 N
    Nominal shear yeilding strength of clip angle (Rn)| 200130.000 N
    ASD factor for shear yielding (omega)             | 1.500
    Allowable shear yielding strength of clip angle   |
        [Ra=Rn/omega]                                 | 133420.000 N
    Utility ratio in shear yielding                   |
        [Va/Ra]                                       | 0.139
                                                      |
Clip Angle Shear Rupture Check:                       |
    Nominal shear rupture strength of clip angle (Rn) | 210422.400 N
    ASD factor for shear rupture (omega)              | 2.000
    Shear rupture strength of clip angle              |
        [Ra=Rn/omega]                                 | 105211.200 N
    Utility ratio in shear rupture                    |
        [Va/Ra]                                       | 0.177
                                                      |
Column flange prying action check:                    |
    Bolt strength reduction factor due to column flange prying (Q) | 0.599
    Interaction ratio in column flange prying         |
        [Tb/(Q*B)]                                    | 0.120
                                                      |
Column web yielding check:                            |
    Nominal strength of column web yielding (Rn)      | 564161.250 N
    ASD factor in web yielding (omega)                | 1.500
    Allowable strength of column in web yielding      |
        [Ra=Rn/omega]                                 | 376107.500 N
    Interaction ratio in column web yielding          |
        [TF/Ra]                                       | 0.090
                                                      |
Column web crippling check:                           |
    Nominal strength of column in web crippling (Rn)  | 424838.773 N
    ASD factor in web crippling (omega)               | 2.000
    Allowable strength of column in web crippling     |
        [Ra=Rn/omega]                                 | 212419.386 N
    Interaction ratio in column web crippling         |
        [TF/Ra]                                       | 0.160
```

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------------------------------------------------------------------+--------------------
Design Summary                                                    |
------------------------------------------------------------------+--------------------
   Connection is OK                                               |
   Maximum utility ratio for connection                          | 0.889
------------------------------------------------------------------+--------------------
Design Inputs                                                     |
------------------------------------------------------------------+--------------------
   Design method                                                 | ASD
   Young's modulus of elasticity                                 | 200000.000 MPa
   Poisson's ratio                                               | 0.300
                                                                 |
Connection forces:                                               |
   Transfer force (TF)                                           | 45000.000 N
   Shear force (SF)                                              | 90000.000 N
                                                                 |
Bolt Details:                                                    |
   Bolt Diameter                                                 | 22.000 mm
   Number of bolts per clip angle (n)                            | 2.000
   Bolt Gage                                                     | 140.000 mm
   Bolt Spacing                                                  | 70.000 mm
   Nominal tensile capacity of bolt                              | 620.000 MPa
   Nominal shear capacity of bolt                                | 372.000 MPa
                                                                 |
Weld Details:                                                    |
   Weld thickness                                                | 6.000 mm
   Weld tensile strength                                         | 482.000 MPa
                                                                 |
Clip angle dimensions:                                           |
   Clip angle  size (li x lo x ta)                               | 102x102x9.53 mm
   Clip angle length                                             | 140.000 mm
   Yield strength of clip angle                                  | 250.000 MPa
   Tensile strenght of clip angle                                | 400.000 MPa
                                                                 |
Connecting beam properties:                                      |
   Section size                                                  |
      Depth                                                      | 409.000 mm
      Flange width                                               | 179.000 mm
      Flange thickness                                           | 14.400 mm
      Web thickness (tw)                                         | 8.760 mm
   Yield strength of beam                                        | 345.000 MPa
   Tensile strength of beam                                      | 450.000 MPa
   Beam setback from connection member (s)                       | 12.000 mm
                                                                 |
Supporting member properties:                                    |
   Support type                                                  | Column Web
   Section size                                                  | W360X91
      Depth                                                      | 353.000 mm
      Flange width                                               | 254.000 mm
      Flange thickness                                           | 16.400 mm
      Web thickness                                              | 9.530 mm
------------------------------------------------------------------+--------------------
Design Calculations                                              |
------------------------------------------------------------------+--------------------
                                                                 |
Bolt Shear Check:                                                |
   Shear per bolt                                                |
      [Vb=SF/(2*n)]                                              | 22500.000 N
   Nominal shear strength of bolt (Rn)                           | 141337.680 N
   ASD factor in bolt shear (omega)                              | 2.000
   Allowable shear strength of bolt                              |
      [Ra=Rn/omega]                                              | 70668.840 N
   Utility ratio in bolt shear                                   |
      [Vb/Ra]                                                    | 0.318
                                                                 |
Bolt Bearing at Clip Angle Check:                                |
   Nominal strength in bearing at clip angle (Rn)                | 105211.200 N
   ASD factor in bolt bearing (omega)                            | 2.000
   Allowable strength in bearing at clip angle                   |
      [Ra=Rn/omega]                                              | 52605.600 N
   Utility ratio in bearing at clip angle                        |
      [Vb/Ra]                                                    | 0.428
                                                                 |
Bolt Bearing at Support Check:                                   |
   Nominal strength in bearing at support (Rn)                   | 226432.800 N
   ASD factor in bolt bearing (omega)                            | 2.000
   Allowable strength in bearing at support                      |
      [Ra=Rn/omega]                                              | 113216.400 N
   Strength reduction factor to account for backing beam (r)     | 0.500
   Utility ratio in bearing at support                           |
      [Vb/(Ra*r)]                                                | 0.397
                                                                 |
Bolt Tension Check (without prying:                              |
   Tension per bolt without prying                               |
      [Tb=TF/(2*n)]                                              | 11250.000 N
```

```
    Nominal bolt strength in tension (Rn)          | 231231.640 N
    ASD factor in bolt tension (omega)             | 2.000
    Allowable bolt strength in tension             |
        [B=Rn/omega]                               | 115615.820 N
    Utility ratio in bolt tension                  |
        [Tb/B]                                     | 0.097
                                                   |
Clip angle prying action check:                    |
    Bolt strength reduction factor due to clip prying (Q) | 0.109
    Interaction ratio in clip prying               |
        [Tb/(Q*B)]                                 | 0.889
                                                   |
Weld Check:                                         |
    Maximum stress in weld group (fw)              | 387.437 N/mm
    Nominal strength of weld (Rn)                  | 1226.786 N/mm
    ASD factor for weld (omega)                    | 2.000
    Allowable weld strength                        |
        [Ra=Rn/omega]                              | 613.393 N/mm
    Utility ratio for weld                         |
        [fw/Ra]                                    | 0.632
                                                   |
Web Rupture at Weld Check:                          |
    Minimum thickness of web at weld (tw`)         | 5.740 mm
    Utility ratio in rupture at weld               |
        [tw`/tw]                                   | 0.655
                                                   |
Clip Angle Shear Yielding Check:                   |
    Shear in clip angle                            |
        [Va=sqrt(TF^2+SF^2)/2]                     | 50311.529 N
    Nominal shear yeilding strength of clip angle (Rn) | 200130.000 N
    ASD factor for shear yielding (omega)          | 1.500
    Allowable shear yielding strength of clip angle |
        [Ra=Rn/omega]                              | 133420.000 N
    Utility ratio in shear yielding                |
        [Va/Ra]                                    | 0.377
                                                   |
Clip Angle Shear Rupture Check:                    |
    Nominal shear rupture strength of clip angle (Rn) | 210422.400 N
    ASD factor for shear rupture (omega)           | 2.000
    Shear rupture strength of clip angle           |
        [Ra=Rn/omega]                              | 105211.200 N
    Utility ratio in shear rupture                 |
        [Va/Ra]                                    | 0.478
```