STEEL TUBE INSTITUTE

BOLTED HSS SPLICE PLATE CONNECTION EXAMPLE

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BOLTED SPLICE PLATE CONNECTION WITH ACCESS HOLE

This example will step through the design of a square HSS column or truss chord bolted splice plate connection with access holes in the HSS members. The access hole in the HSS allows for access to the interior of the HSS for field installation of standard bolts.

The access hole should be placed at a noncritical location. If there are two splice plates, the access hole should be placed in a wall without bolt holes. Access holes can be placed in only one HSS member if the opposite member shall utilize shop bolts. Alternately, access holes can be placed in both members of a splice for full field installation.

Access holes shall have rounded corners to mitigate initiation of cracks. Although a round shape is used in this example, they are typically an oval shape.

It is not required to seal the access hole in the permanent condition, however, it can be sealed or reinforced if the HSS is exposed to the exterior or to develop the full strength of the member.
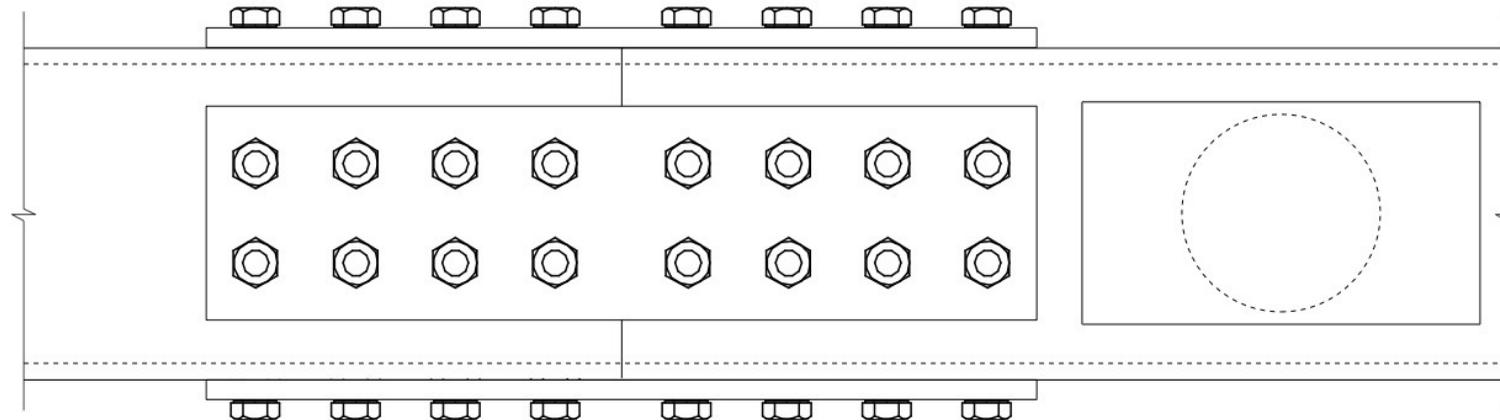

Fig. 4-1. Splice in a double-chord truss where the bolts have been installed with the aid of access hole

AISC Design Guide 24, 2nd Edition, Packer and Olson

BOLTED SPLICE PLATE EXAMPLE

- HSS column or HSS truss chord splice connection

- Install plate and bolts in shop for one side of the splice

- HSS axial load:

  - P_u = +/- 550 k

  - $M_u = V_u\,e$ = (20 k)(2.5 in) = 50 k-in

BOLTED SPLICE PLATE EXAMPLE

- HSS 10x10x1/2 column or chord members

- Design to AISC 360-22 and 16th Ed. Manual

- Axial load resisted by four shear plates

- Shop bolt one side of connection

- Provide access hole for field installation of bolts

- Check HSS for limit states due to:

  ➢ Bolts

  ➢ Welds

  ➢ Connection geometry
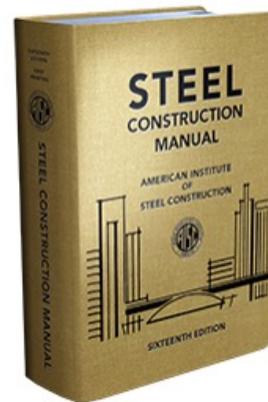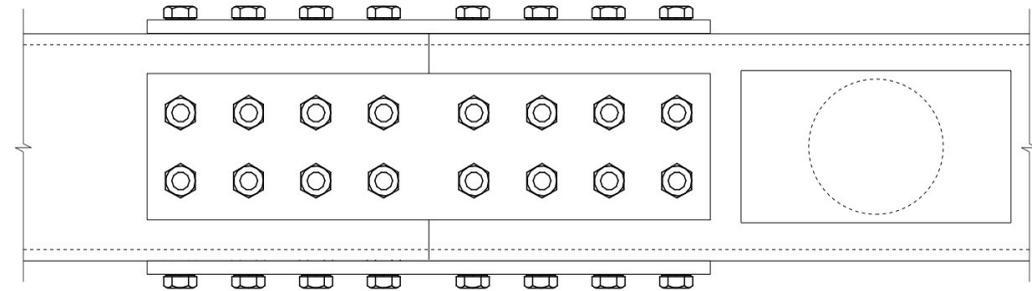
HSS

ASTM A500 Gr.C
F_y = 50ksi
F_u = 62ksi

Column:
HSS10x10x1/2
H=10"
B=10"
t_{nom}=0.5"
t_{des}=0.465"

PLATES

ASTM A572 Gr. 50
F_y = 50ksi
F_u = 65ksi

BOLTS

ASTM A325-N:
D=3/4"

BOLTED SPLICE PLATE EXAMPLE

- Determine:
  - ➢ Number of bolts required
  - ➢ Splice plate size
  - ➢ Access hole and cover plate size

- 3/4 in diameter A325-N bolts
  - ○ $\phi r_n = 17.9 \frac{k}{bolt}$ [Manual Table 7-1]
  - ○ $P_u = 550k/4walls = 137.5k/wall$
  - ○ $n = 137.5k/17.9 \frac{k}{bolt} = 7.7bolts$
  - ○ $\phi R_n = 17.9 \frac{k}{bolt} * 8bolts * 4sides = 572.8\ k > 550k$

SPLICE PLATE DESIGN

Determine splice plate size

- Try $t_{plate} = \frac{5}{8} in$
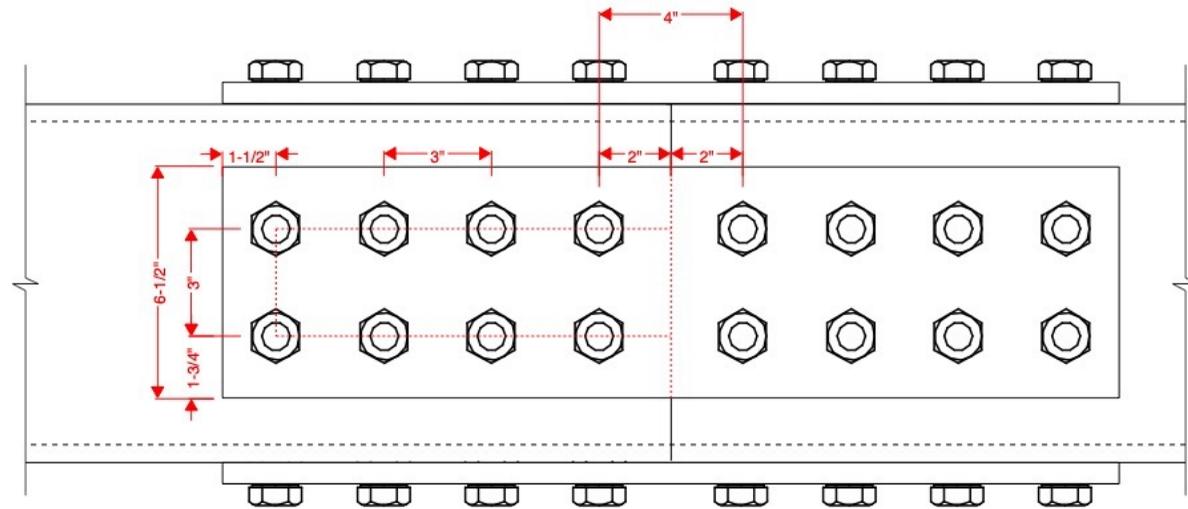
- Plate Tension:

  - $\phi P_n = \phi(F_y A_g) = 0.9(50ksi)(0.625")(6.5") = 182.8 \frac{k}{plate} * 4\ plates = 731k$ [360-22 Eq. J4-1]

  - $\phi P_n = \phi(F_u A_e) = 0.75(65ksi)(0.625")(6.5" - (2)(0.875")) = 144.7 \frac{k}{plate} = 579k$ [360-22 Eq. J4-2]

- Plate Compression:

  - $L_c = 4\ in,\ \frac{L_c}{r} < 25$

  - $\phi P_n = \phi(F_y A_g) = 0.9(50ksi)(0.625")(6.5") = 182.8 \frac{k}{plate} * 4\ plates = 731k$ [360-22 Eq. J4-6]

SPLICE PLATE DESIGN

Determine splice plate size

- Try $t_{plate} = \frac{5}{8}in$

- Bolt Bearing and Tearout:

  - Bolt Bearing:

    - $\phi P_n = \phi 2.4 d t_{plate} F_u = 0.75 * 2.4 * \frac{3}{4}in * \frac{5}{8}in * 65ksi = 54.8\frac{k}{bolt}$ [360-22 Eq. J3-6a]

  - Bolt Tearout:

    - $d_{hole} = 3/4in + 1/16in = 13/16in$

    - $L_{c,space} = s - d_{hole} = 3in - 13/16in = 2\frac{3}{16}in$

    - $L_{c,edge} = L_{edge} - \frac{d_{hole}}{2} = 1\frac{1}{2}in - \frac{13/16in}{2} = 1\frac{3}{32}in$
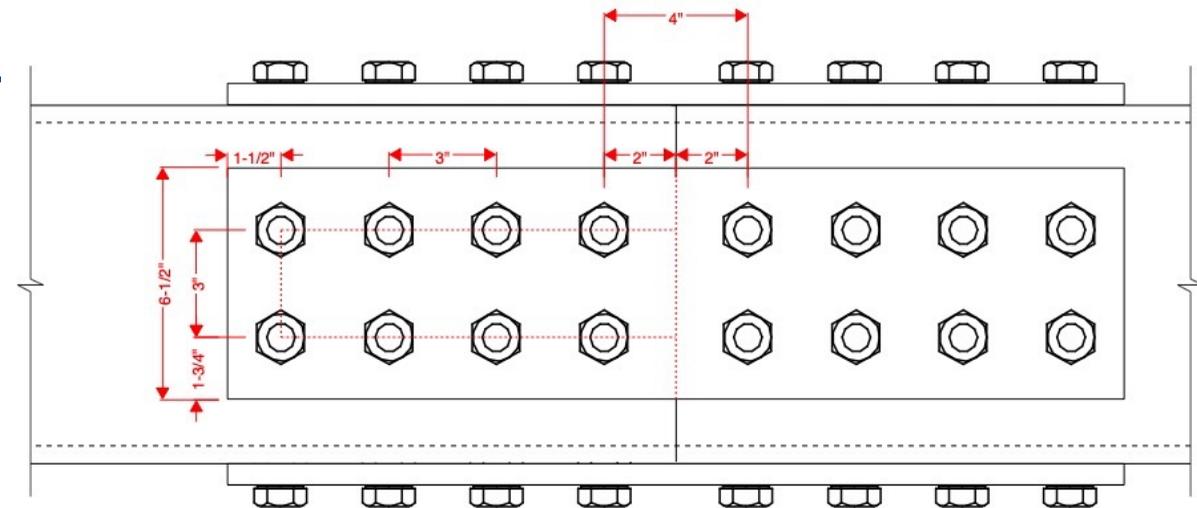
    - Bolt Spacing $\phi r_n = \phi 1.2 L_{c,space} t_{plate} F_u = 0.75 * 1.2 * 2\frac{3}{16}in * \frac{5}{8}in * 65ksi = 80.0\frac{k}{bolt}$ [360-22 Eq. J3-6c]

    - Edge Bolt $\phi r_n = \phi 1.2 L_{c,space} t_{plate} F_u = 0.75 * 1.2 * 1\frac{3}{32}in * \frac{5}{8}in * 65ksi = 40.0\frac{k}{bolt}$ [360-22 Eq. J3-6c]

- $\phi P_n = \left(6bolts * 54.8\frac{k}{bolt} + 2bolts * 40.0\frac{k}{bolt}\right) * 4plates = 1636k$

SPLICE PLATE DESIGN

- Block Shear:

  - $L_{gt} = 3in$

  - $A_{gt} = L_{gt}t_{plate} = 3in * \frac{5}{8}in = 1.88in^2$

  - $n_{t,holes} = 2 - 0.5 * 2 = 1hole$

  - $A_{nt} = A_{gt} - t_{plate}\left(d_{hole} + \frac{1}{16}in\right)n_{t,holes} = 1.88in^2 - \frac{5}{8}in * \left(\frac{13}{16}in + \frac{1}{16}in\right) * 1hole = 1.33in^2$

  - $L_{gv} = (3 * 3in + 1.5in) * 2 = 21in$

  - $A_{gv} = L_{gv}t_{plate} = 21in * \frac{5}{8}in = 13.1in^2$
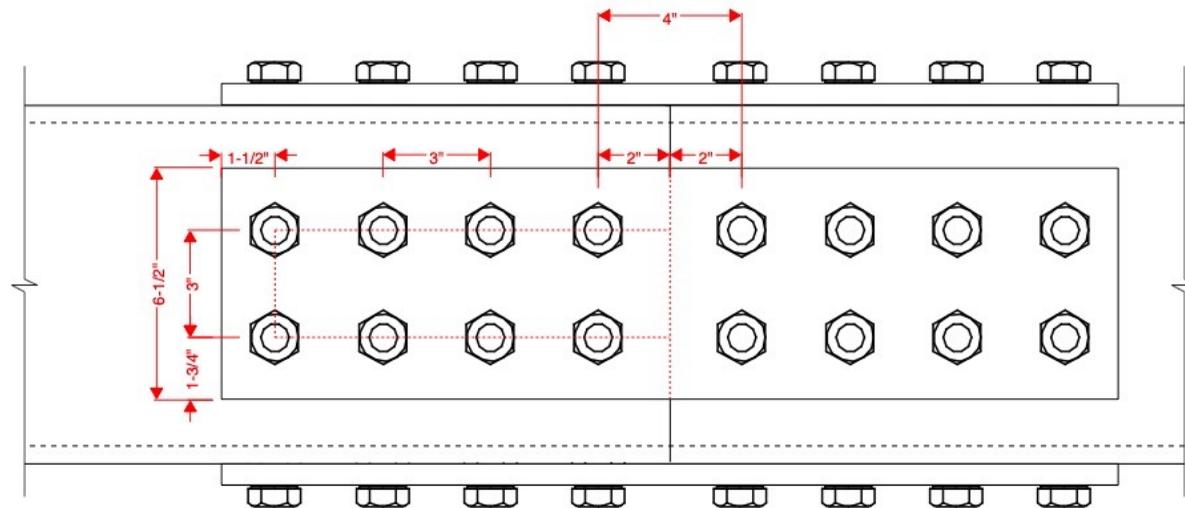
  - $n_{v,holes} = (4 - 0.5) * 2 = 7holes$

  - $A_{nv} = A_{gv} - t_{plate}\left(d_{hole} + \frac{1}{16}in\right)n_{holes} = 13.1in^2 - \frac{5}{8}in * \left(\frac{13}{16}in + \frac{1}{16}in\right) * 7holes = 9.30in^2$

  - $U_{bs} = 1.0$

  - $P_n = (0.6F_uA_{nv} + U_{bs}F_uA_{nt})n_{plates} = (0.6 * 65ksi * 9.30in^2 + 1.0 * 65ksi * 1.33in^2) * 4plates = 1796k$ [360-22 Eq. J4-5]

  - $P_{n,max} = \left(0.6F_yA_{gv} + U_{bs}F_uA_{nt}\right)n_{plates} = (0.6 * 50ksi * 13.1in^2 + 1.0 * 65ksi * 1.33in^2) * 4plates = 1920k$ [360-22 Eq. J4-5]

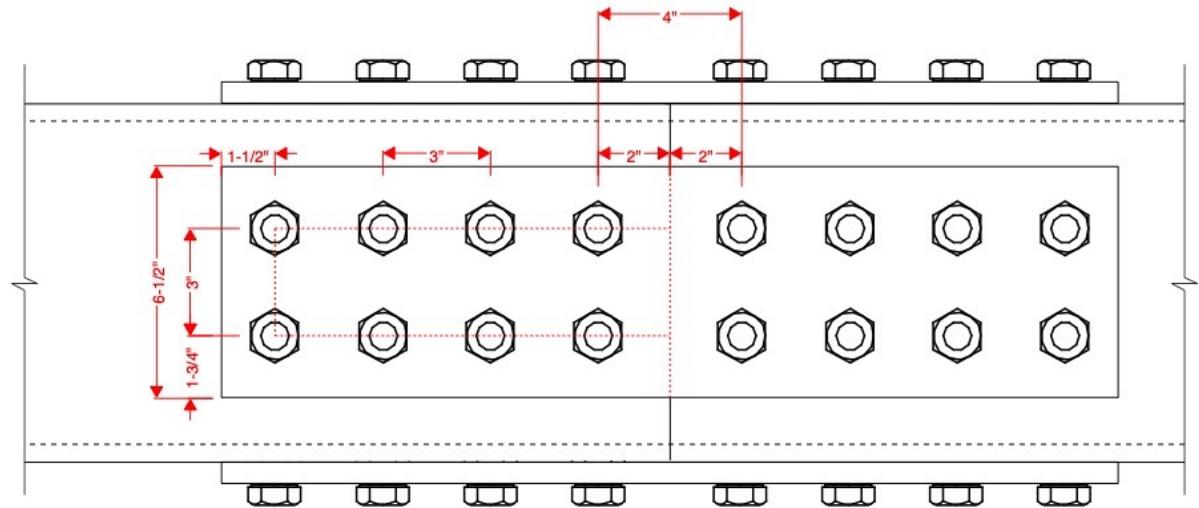 - $\phi P_n = 0.75 * 1796k = 1347k$

HSS CHECK AT CONNECTION

Verify HSS capacity at connection

- $t_{design} = 0.465in$

- $A_g = 17.2in^2$

- HSS Tension:

  - $\phi P_n = \phi(F_y A_g) = 0.9(50ksi)(17.2in^2) = 774k$ [360-22 Eq. J4-1]

  - $\phi P_n = \phi(F_u A_e) = 0.75(62ksi)(17.2in^2 - (4)(2)(0.875")(0.465in) = 648k$ [360-22 Eq. J4-2]

HSS CHECK AT CONNECTION

- HSS $t_{design} = 0.465\ in$

- Bolt Bearing and Tearout:
  - Bolt Bearing:
    - $\phi P_n = \phi 2.4 d t_{design} F_u = 0.75 * 2.4 * \frac{3}{4} in * 0.465 in * 62 ksi = 38.9\ \frac{k}{bolt}$ [360-22 Eq. J3-6a]
  - Bolt Tearout:
    - $d_{hole} = 3/4 in + 1/16 in = 13/16 in$
    - $L_{c,space} = s - d_{hole} = 3 in - 13/16 in = 2\frac{3}{16} in$
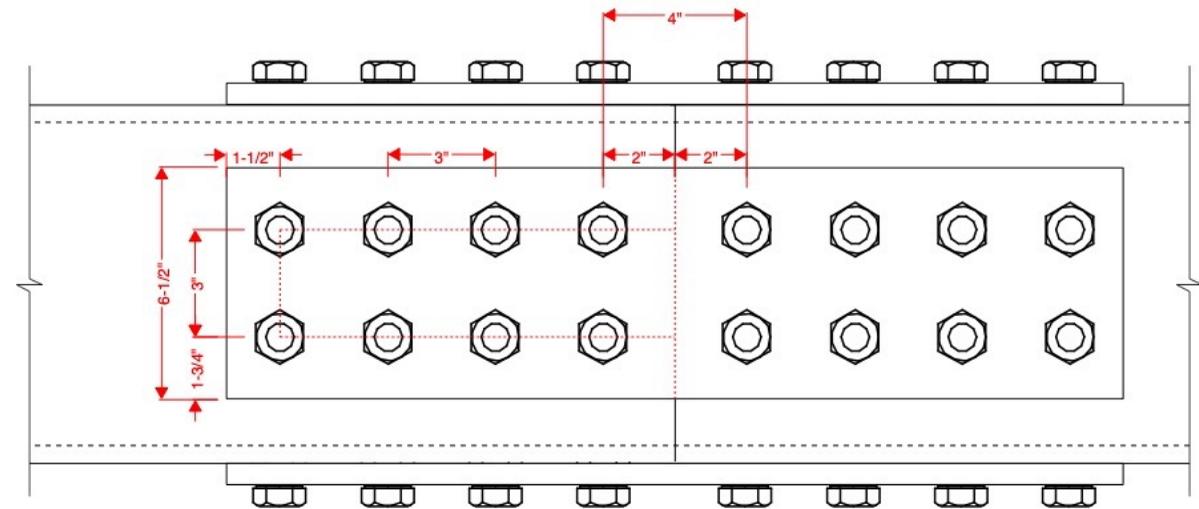   - $L_{c,edge} = L_{edge} - \frac{d_{hole}}{2} = 2 in - \frac{13/16 in}{2} = 1\frac{19}{32} in$
    - Bolt Spacing $\phi r_n = \phi 1.2 L_{c,space} t_{design} F_u = 0.75 * 1.2 * 2\frac{3}{16} in * 0.465 in * 62 ksi = 56.8\ \frac{k}{bolt}$ [360-22 Eq. J3-6c]
    - Edge Bolt $\phi r_n = \phi 1.2 L_{c,space} t_{design} F_u = 0.75 * 1.2 * 1\frac{19}{32} in * 0.465 in * 62 ksi = 41.4\ \frac{k}{bolt}$ [360-22 Eq. J3-6c]

- $\phi P_n = 8 bolts * 38.9\ \frac{k}{bolt} * 4 walls = 1245 k$

HSS CHECK AT CONNECTION

- Block Shear:

  - $L_{gt} = 3in$

  - $A_{gt} = L_{gt}t_{design} = 3in * 0.465in = 1.40in^2$

  - $n_{t,holes} = 2 - 0.5 * 2 = 1hole$

  - $A_{nt} = A_{gt} - t_{design}\left(d_{hole} + \frac{1}{16}in\right)n_{t,holes} = 1.40in^2 - 0.465in * \left(\frac{13}{16}in + \frac{1}{16}in\right) * 1hole = 0.99in^2$

  - $L_{gv} = (3 * 3in + 2in) * 2 = 22in$

  - $A_{gv} = L_{gv}t_{design} = 21in * 0.465in = 10.2in^2$
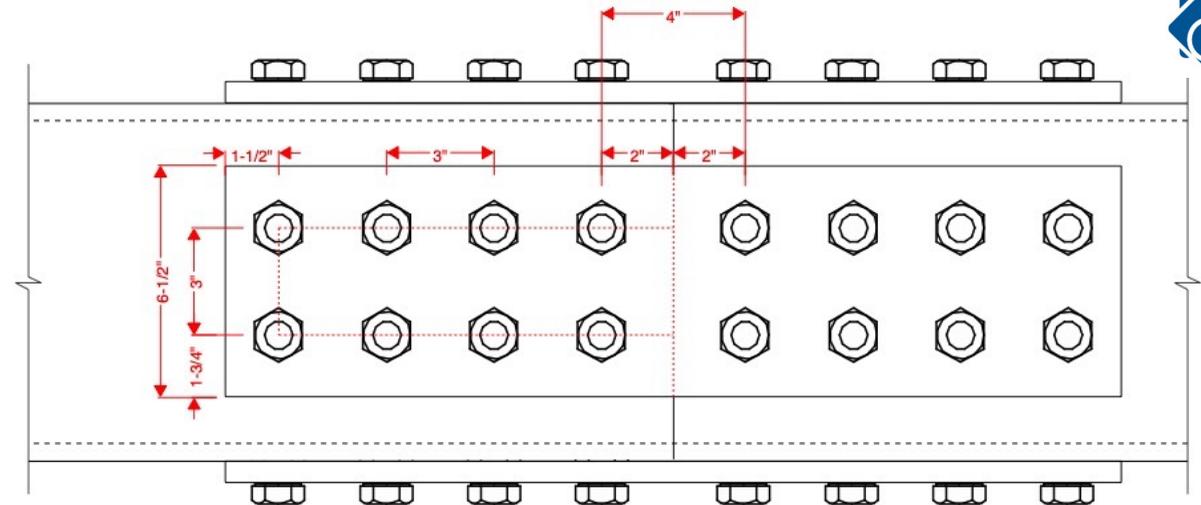
  - $n_{v,holes} = (4 - 0.5) * 2 = 7holes$

  - $A_{nv} = A_{gv} - t_{design}\left(d_{hole} + \frac{1}{16}in\right)n_{holes} = 10.2in^2 - 0.465in * \left(\frac{13}{16}in + \frac{1}{16}in\right) * 7holes = 7.38in^2$

  - $U_{bs} = 1.0$

  - $P_n = (0.6F_uA_{nv} + U_{bs}F_uA_{nt})n_{plates} = (0.6 * 62ksi * 7.38in^2 + 1.0 * 62ksi * 0.99in^2) * 4plates = 1344k$ [360-22 Eq. J4-5]

  - $P_{n,max} = (0.6F_yA_{gv} + U_{bs}F_uA_{nt})n_{plates} = (0.6 * 50ksi * 10.2in^2 + 1.0 * 65ksi * 0.99in^2) * 4plates = 1473k$ [360-22 Eq. J4-5]

  - $\phi P_n = 0.75 * 1344k = 1008k$

ACCESS HOLE DESIGN

Determine Access hole and cover plate size

- 6 in diameter per AISC DG24 Second Edition

- Try 5/8 in plate

- Assume $P_u = \frac{550k}{4} = 137.5k$ (conservative)

- Plate Compression:

  - $L_c = 10\ in$
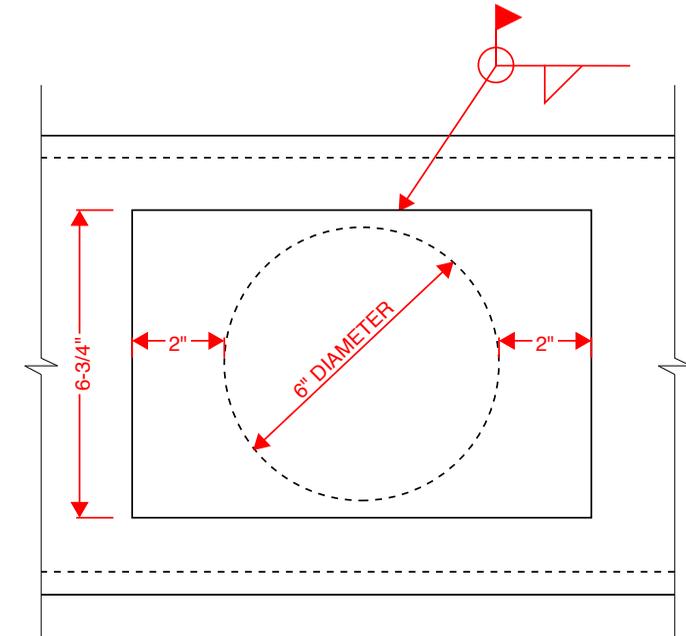
  - $r = \frac{5/8in}{\sqrt{12}} = 0.18in$

  - $\frac{L_c}{r} = 55.4 < 4.71\sqrt{\frac{E}{F_y}} = 4.71\sqrt{\frac{29,000ksi}{50ksi}} = 113.4$

  - $F_e = \frac{\pi^2 E}{\left(\frac{L_c}{r}\right)^2} = \frac{\pi^2 29000ksi}{(55.4)^2} = 93.2ksi$

  - $F_n = \left(0.658^{\left(\frac{F_y}{F_e}\right)}\right)F_y = \left(0.658^{\left(\frac{50ksi}{93.2ksi}\right)}\right) * 50ksi = 39.9ksi$ [360-22 Eq. E3-2]

  - $\phi P_n = \phi F_n A_g = 0.90 * 39.9ksi * \frac{5}{8}in * 6\frac{3}{4}in = 151.7k$ [360-22 Eq. E3-1]

Special consideration is needed when connecting directly to the sidewall of the HSS away from its end, such as with axially loaded single-plate connections or lap-splice connections. The use of an access hole in one of the walls in which the bolt is not installed (Figure 4-1) can allow for the ability to properly install the bolt. The access hole should be rounded so as not to introduce locations for potential crack initiation. Access hole size should be coordinated with the fabricator, with a minimum of 4½ to 6 in. considered.

ACCESS HOLE DESIGN

Determine Access cover plate weld size

- Fillet weld group concentrically loaded [360-22 Section J2-4b]

  - Try $\frac{5}{16} in$ fillet weld (D = 5)

  - Transverse $L_{weld,t} = 6\frac{3}{4} in$

  - Longitudinal $L_{weld,l} = 4 in$ assumed

    - $\phi R_{n,l} = 1.392 * 5 * 4in * 2welds = 55.7k$ [Manual Eq. 8-2a]

    - $\phi R_{n,t} = 1.392 * 5 * 6\frac{3}{4}in = 47.0k$ [Manual Eq. 8-2a]

    - $\phi R_{n1} = 27.8k + 47.0k = 74.8\ k$ with $k_{ds} = 1.0$ per user note   [360-22 Eq. J2-4]

    - $\phi R_{n2} = 0.85 * 27.8k + 1.5 * 47.0k = 94.1\ k$ [360-22 Eq. J2-6]

    - Use maximum $\phi R_n = 94.1 < P_u = 137.5k$ ➜ Try $\frac{3}{8}in$ fillet weld (D = 6)

      - $\phi R_{n1} = 123.2k, \phi R_{n2} = 141.4k, \phi R_n = 141.4k > 137.5$ OK