STEEL TUBE INSTITUTE

HSS

HSS SPLICES

PRESENTED BY KIM OLSON, PE

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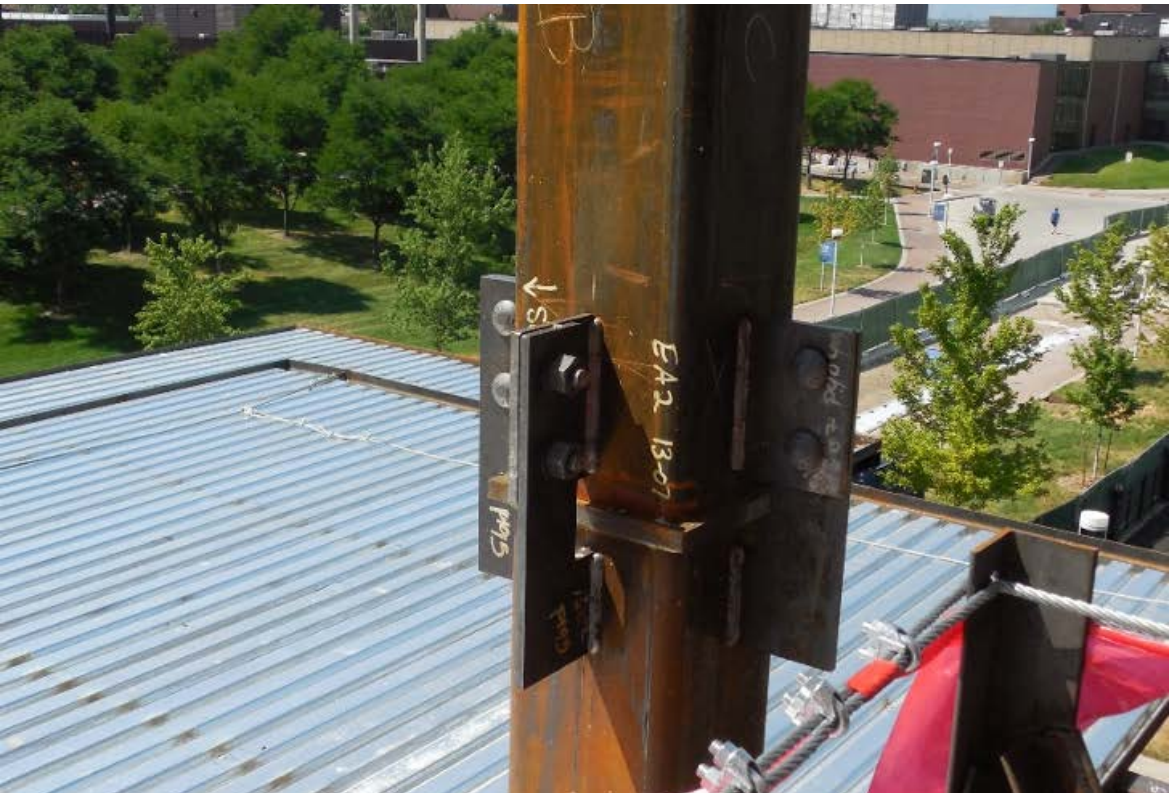
AGENDA

- End Plates
- Splice Plates
- Welded Splices

SPLICES



- Columns
- Truss Chords
- Welded and Bolted
- Seismic

BOLTED SPLICES

End Plates

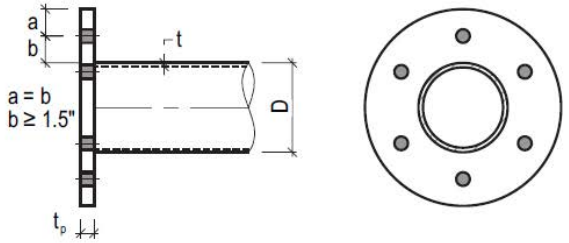


FIG. 4-1.15(a) Round HSS

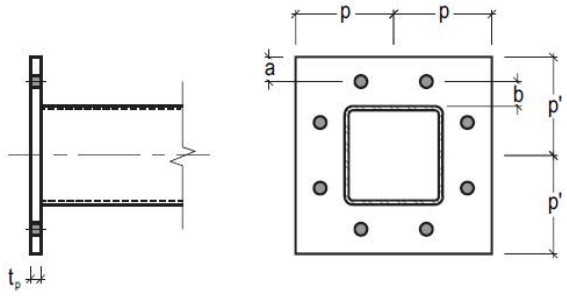


FIG. 4-1.15(b) Rectangular HSS with bolts on four sides

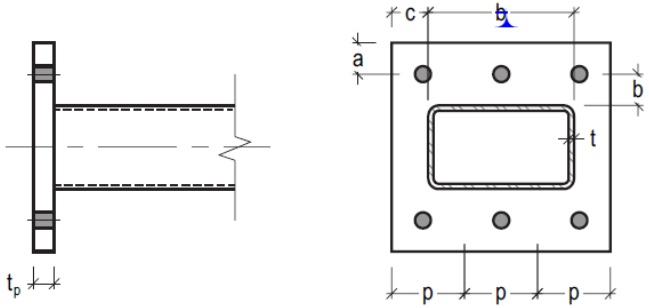


FIG. 4-1.15(c) Rectangular HSS with bolts on two sides

Splice Plates

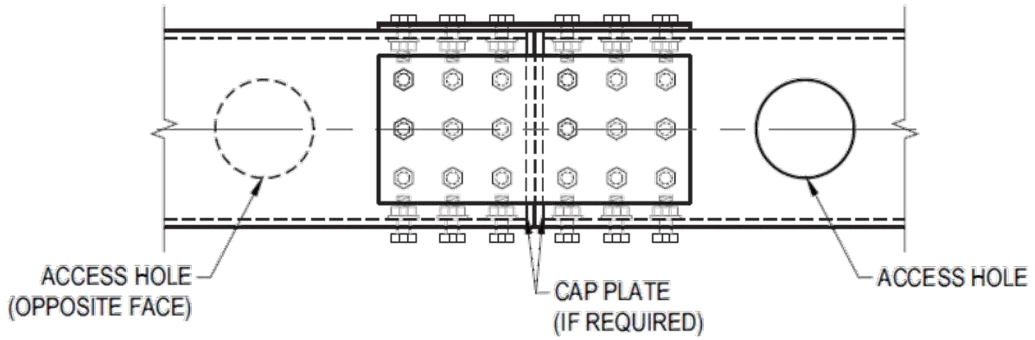


FIG. 4-1.18 SPLICE WITH BOLTED FACE PLATES

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END PLATES

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END PLATES

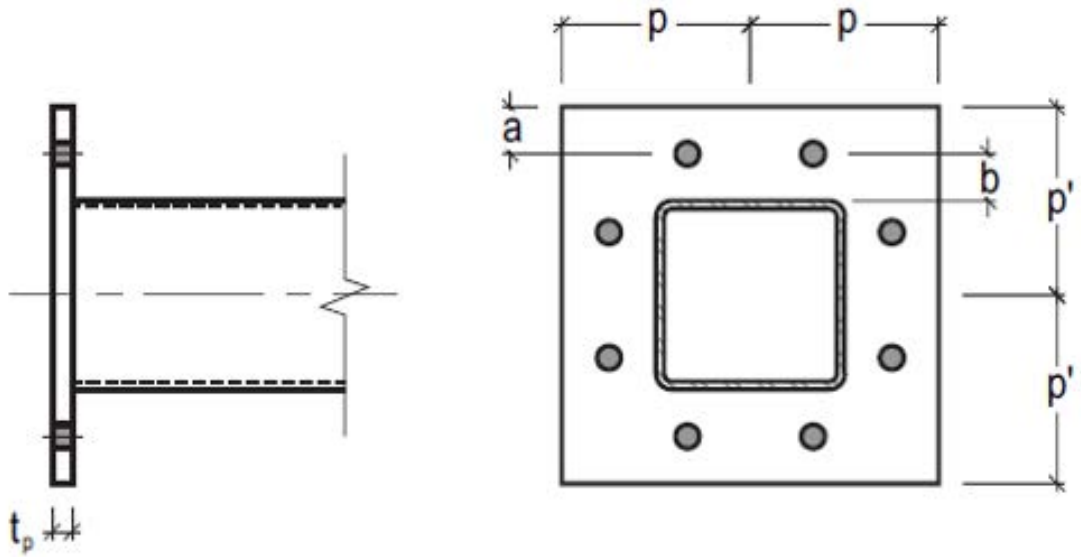


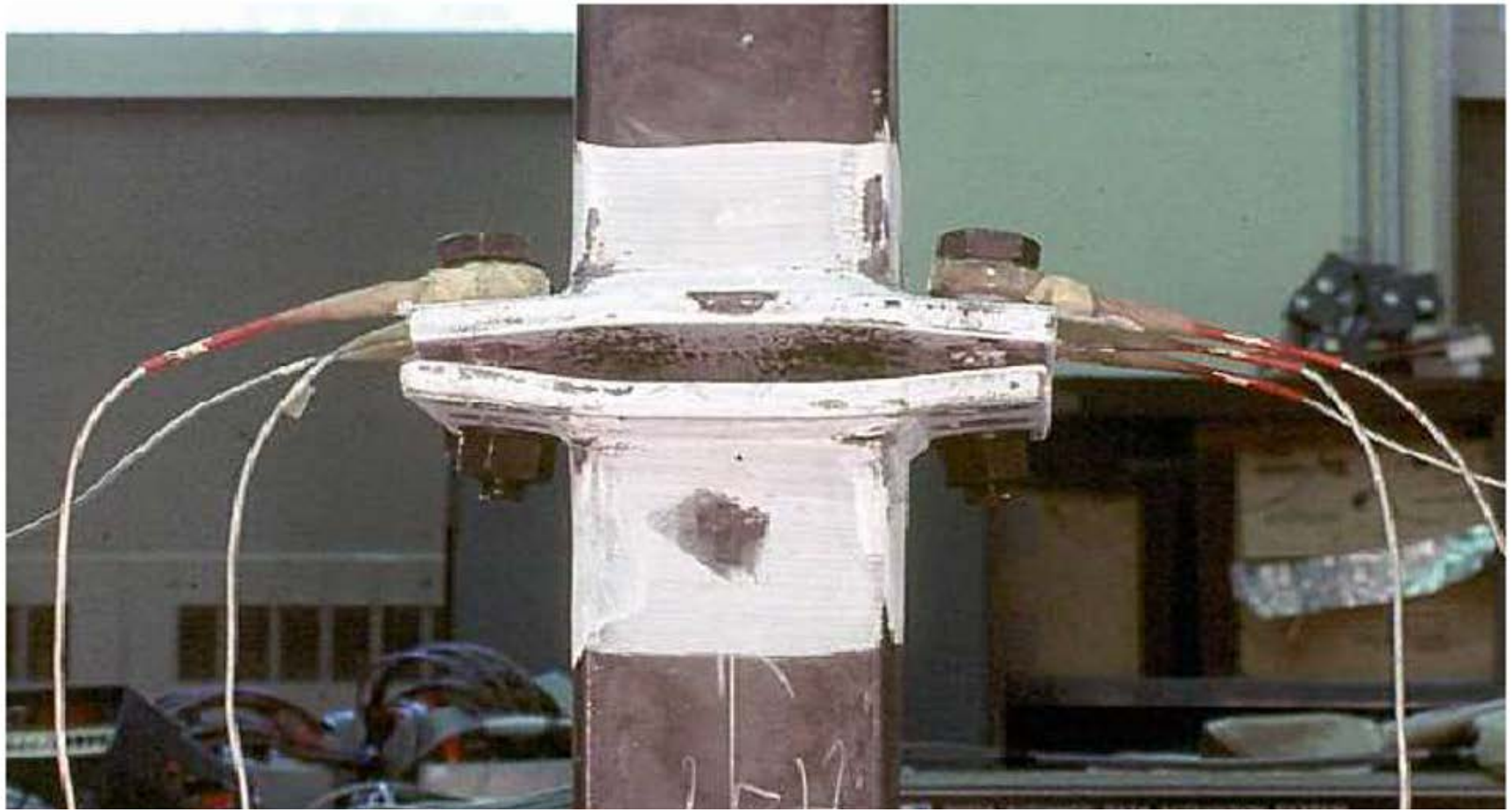
FIG. 4-1.15(b) Rectangular HSS with bolts on four sides

- Design procedures found in AISC Design Guide #24
- Examples in STI HSS Manual V4
- Additional information:
  - CIDECT Design Guide #9: Column Connections
  - CIDECT Design Guide #3: Rectangular HSS Joints
  - CIDECT Design Guide #1: Round HSS Joints

END PLATES WITH COMPRESSION

- Compressive force is uniformly distributed through the end plate
- No special design requirements exist for end plates in compression
- Care must be taken to position the end plates squarely on the HSS ends so that full contact is provided and the bearing assumed in calculations actually occurs

END PLATES IN TENSION



Packer (1989), CIDECT Design Guide #3

END PLATES WITH BOLTS ON FOUR SIDES

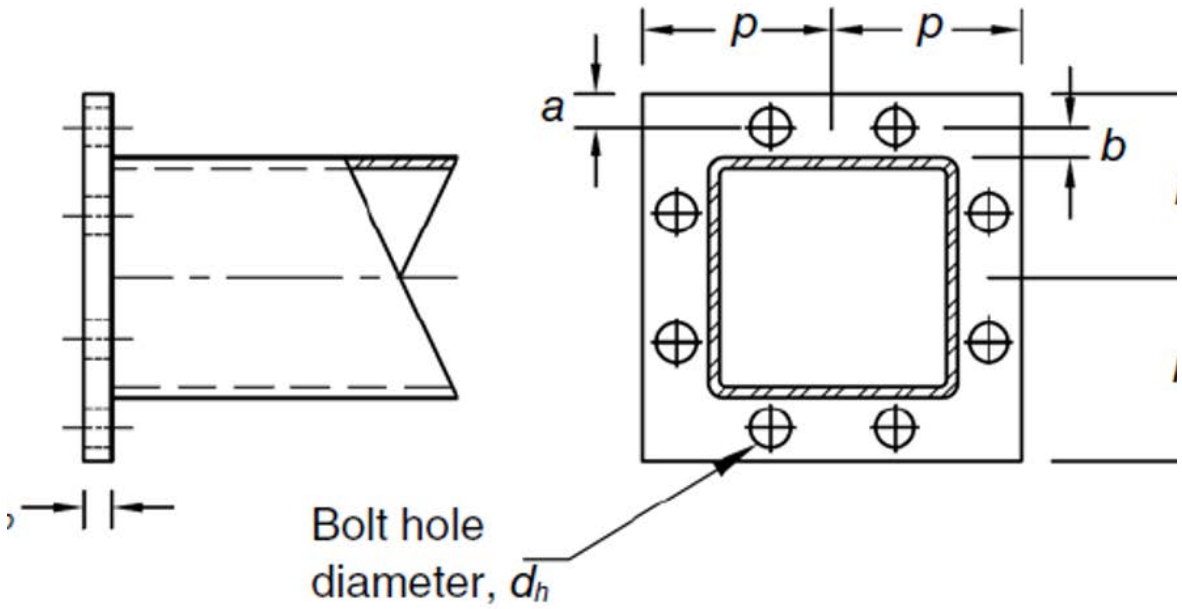
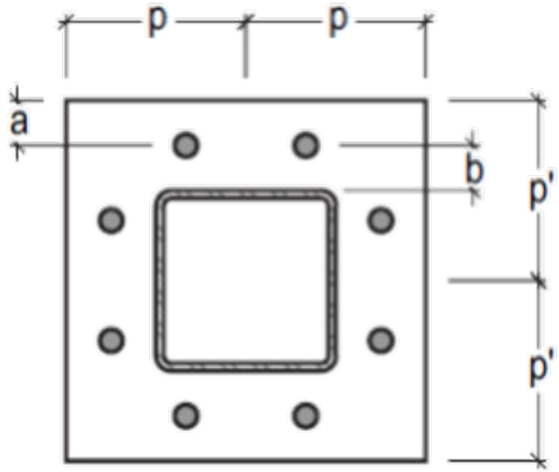


Fig. 5-8. Rectangular end plate with bolts on four sides.

- AISC Design Guide #24:

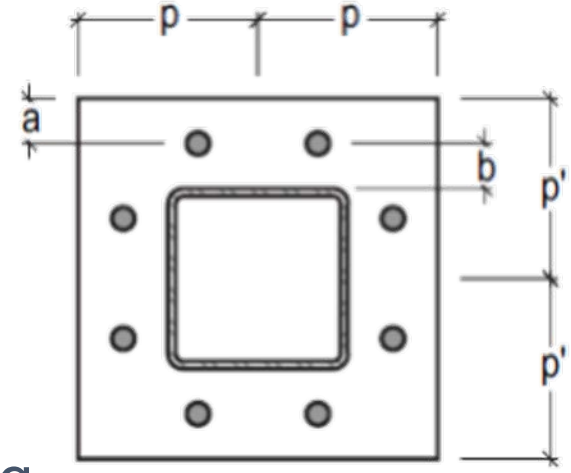
  Section 5.6

END PLATES WITH BOLTS ON FOUR SIDES



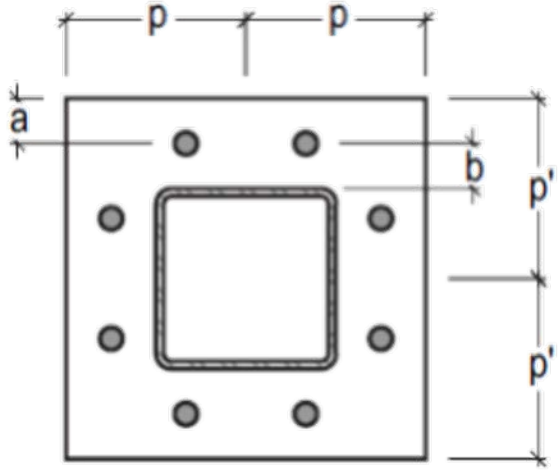
- AISC Design Guide #24: Section 5.6
  - More common than bolts on two sides
  - Centerline of bolts not positioned beyond the corner of HSS
  - Limit states
    - Yielding of end plate
    - Tensile strength of the bolts, including prying action
    - Strength of weld (end plate to HSS)

END PLATES WITH BOLTS ON FOUR SIDES



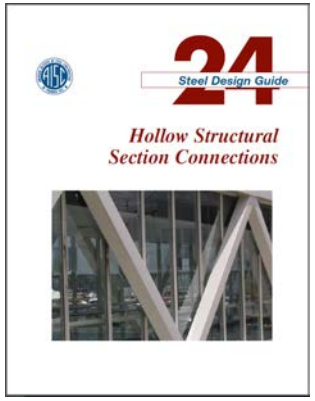
- AISC Design Guide #24: Section 5.6
  - Complex analysis required to account for prying action and the position of the yield lines in the plate
    - Difficult to directly determine nominal resistances according to AISC 360
    - Modified hanger connection design procedure (Manual)

END PLATES WITH BOLTS ON FOUR SIDES



- AISC Design Guide #24: Section 5.6
  - Simplified equations from AISC Manual, 15th Edition (pages 9-11 to 9-14)
  - Force in one bolt $T = {}^{P_r}/_{n}$
  - F_{yp} used instead of F_{up}
    - Willibald et al. 2003
  - Bolt pitch, p, is calculated differently
    - Uses full width of plate
    - Not limited to s or 2b

DESIGN GUIDE #24: SECTION 5.6



- Plate thickness with no prying $t_p \geq \sqrt{\frac{4(P_r/n)b'}{pF_{np}}}$ (5-23)
- Number of bolts $\frac{P_r}{n} \leq r_a$ (5-24)
  - r_a = available bolt strength from Manual Table 7-2
- Weld size $w \geq \frac{P_r\sqrt{2}}{F_{wc}L_w}$ (5-25)
  - F_{wc} from J2.4

END PLATES WITH BOLTS ON TWO SIDES

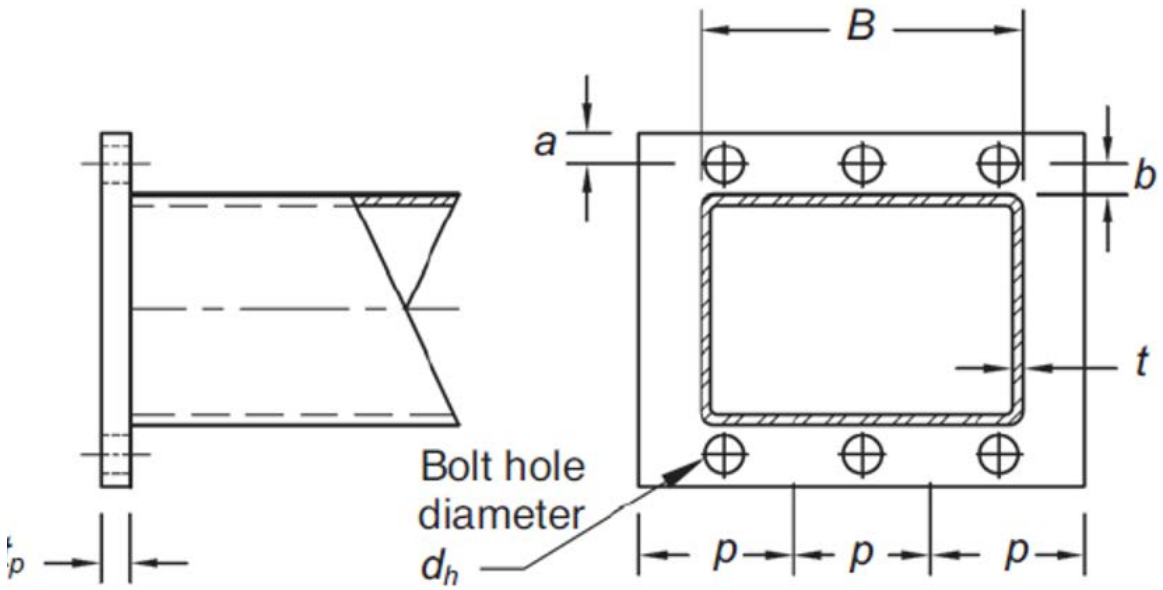
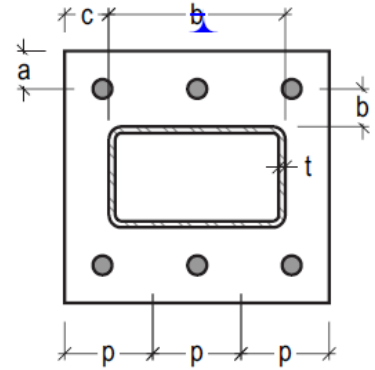


Fig. 5-7. Rectangular end plate with bolts on two sides.

- AISC Design Guide #24: Section 5.5

END PLATES WITH BOLTS ON TWO SIDES



- AISC Design Guide #24: Section 5.5
  - Centerline of bolts not positioned beyond corner of HSS
  - Limit states
    - Yielding of end plate
    - Tensile strength of the bolts, incl prying action
    - Strength of weld (end plate to HSS)

END PLATES WITH BOLTS ON TWO SIDES

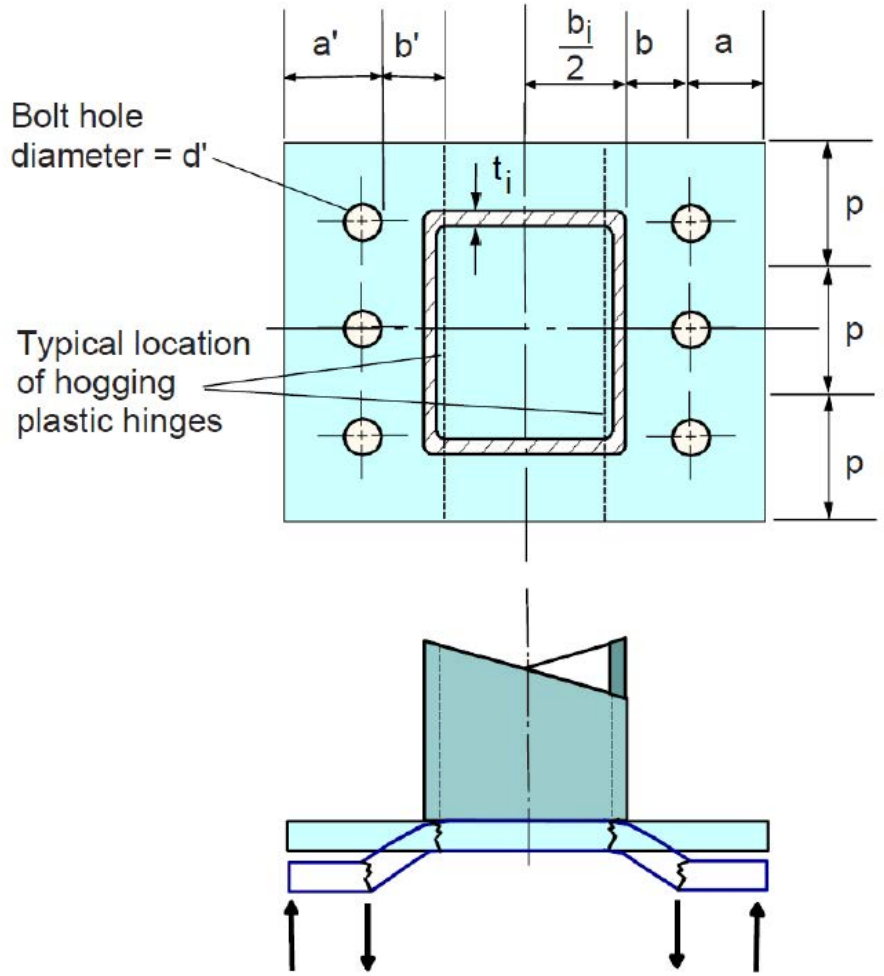
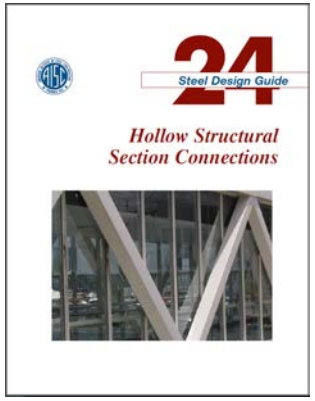


Fig. 13.4 RHS flange plate joint with bolts at two sides of the RHS

- AISC Design Guide #24: Section 5.5
  - Complex analysis required to account for prying action and the position of the yield lines in the plate
    - Modified T-stub design procedure

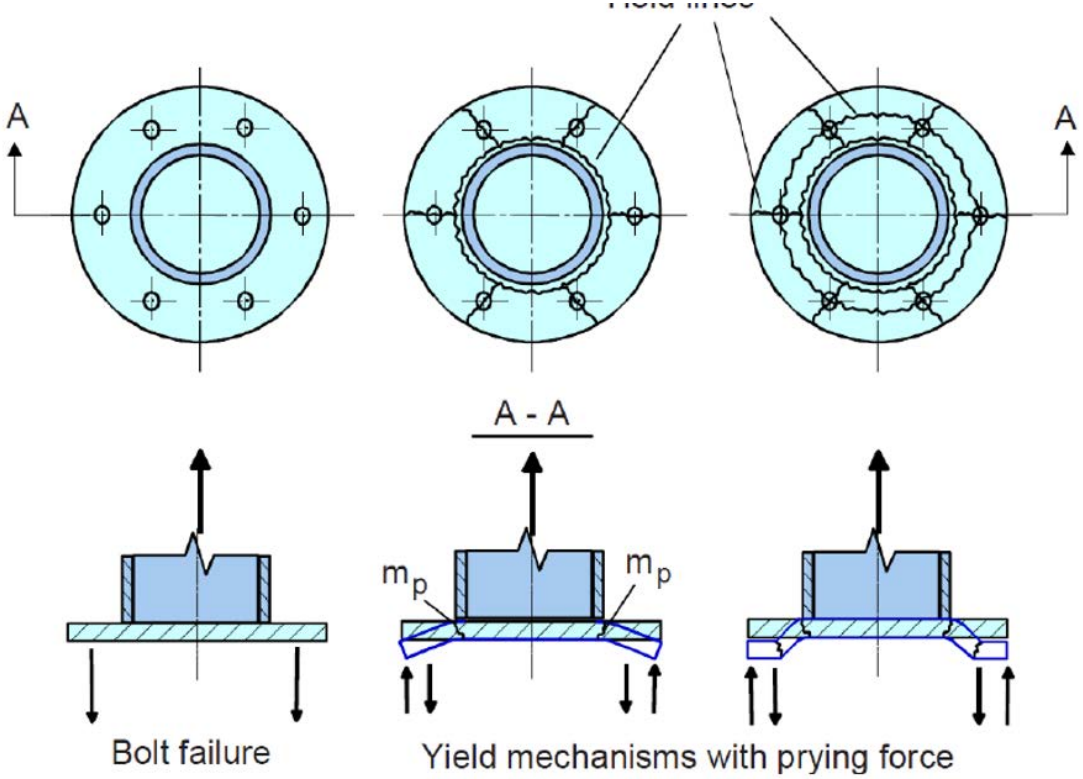
Packer, J.A. and Henderson, J.E. (1997), *Hollow Structural Section Connections and Trusses—A Design Guide*, 2nd ed., Canadian Institute of Steel Construction, Toronto, Canada.

DESIGN GUIDE #24: SECTION 5.5



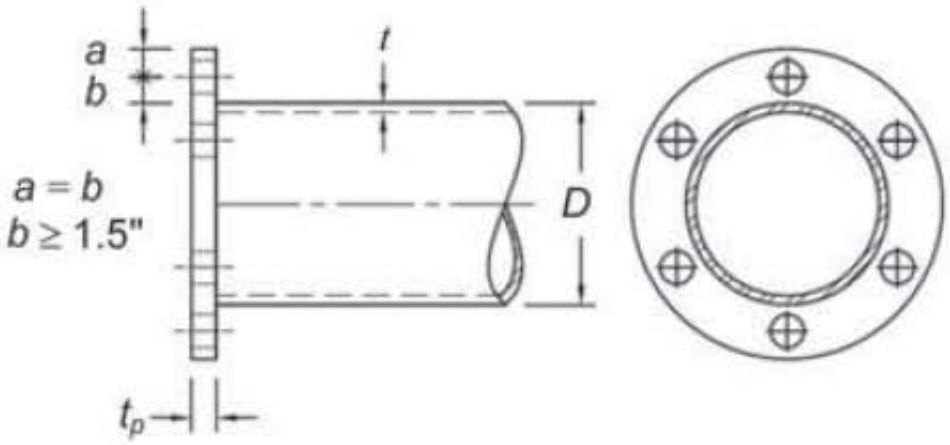
- Plate yielding $R_n = \frac{t_p^2[1+\delta\alpha]n}{K}$ (5-14)
- Bolt tension $T_n = \frac{P_r}{n}\left[1 + \left(\frac{b'}{a'}\right)\left(\frac{\alpha}{1+\alpha}\right)\right] \leq r_a$ (5-15)
  - r_a = available bolt strength from Manual Table 7-2
- Weld size $w \geq \frac{P_r\sqrt{2}}{2BF_{wc}}$ (5-16)
  - F_{wc} from J2.4

END PLATES WITH ROUND HSS



- AISC Design Guide #24: Section 5.4
  - Bolts equally spaced
  - Distance, b, as small as practical
  - a = b

END PLATES WITH ROUND HSS

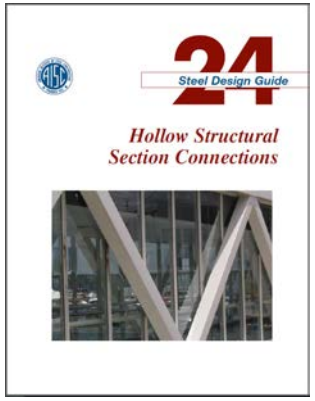


(a) Round HSS.

- AISC Design Guide #24: Section 5.4
- Limit states
  - Yielding of end plate
  - Tensile strength of the bolts, including prying action
  - Strength of weld (end plate to HSS)
- Complex analysis required to account for prying action and the position of the yield lines in the plate

Packer, J.A. and Henderson, J.E. (1997), *Hollow Structural Section Connections and Trusses—A Design Guide*, 2nd ed., Canadian Institute of Steel Construction, Toronto, Canada.

DESIGN GUIDE #24: SECTION 5.4



- Plate thickness $t_p \geq \sqrt{\frac{2P_r}{cF_{yp}\pi f_3}}$ (5-5)
- Number of bolts $n \geq \frac{P_r}{R_c}\left[1 - \left(\frac{1}{f_3}\right) + \left(\frac{1}{f_3 \ln(r_1/r_2)}\right)\right]$ (5-6)
  - R_c = available bolt strength from Manual Table 7-2
- Weld size $w \geq \frac{P_r\sqrt{2}}{F_{wc}\pi D}$ (5-7)
  - F_{wc} from J2.4

EXAMPLES

- End Plates

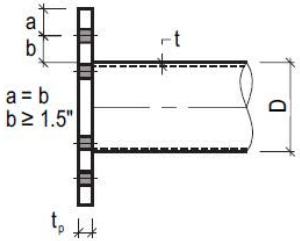


FIG. 4-1.15(a) Round HSS

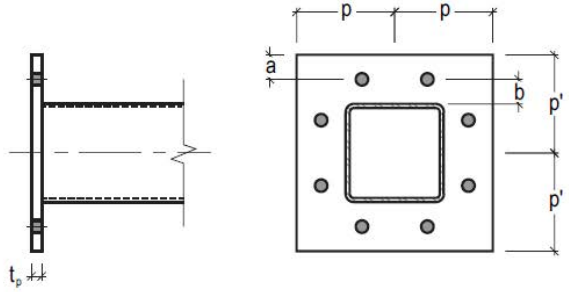


FIG. 4-1.15(b) Rectangular HSS with bolts on four sides

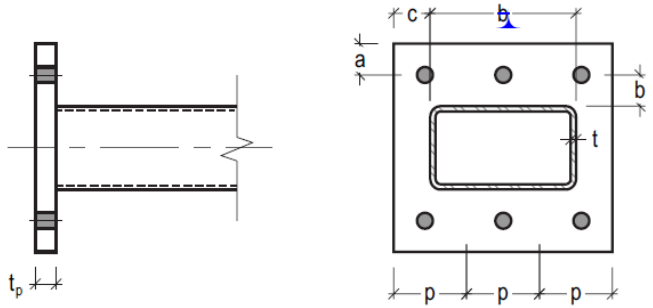


FIG. 4-1.15(c) Rectangular HSS with bolts on two sides

- Example 4-11.F.1
- Example 4-11.F.2
- Example 4-11.F.3

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POLL QUESTION

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SPLICE PLATES

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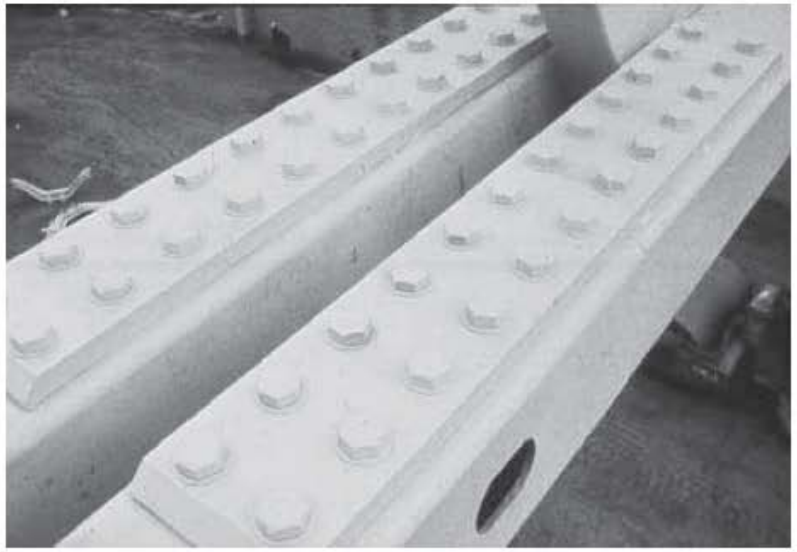
SPLICE PLATES



(a) A splice in a double chord truss where the bolts are loaded in shear, and have been installed with the aid of access holes.

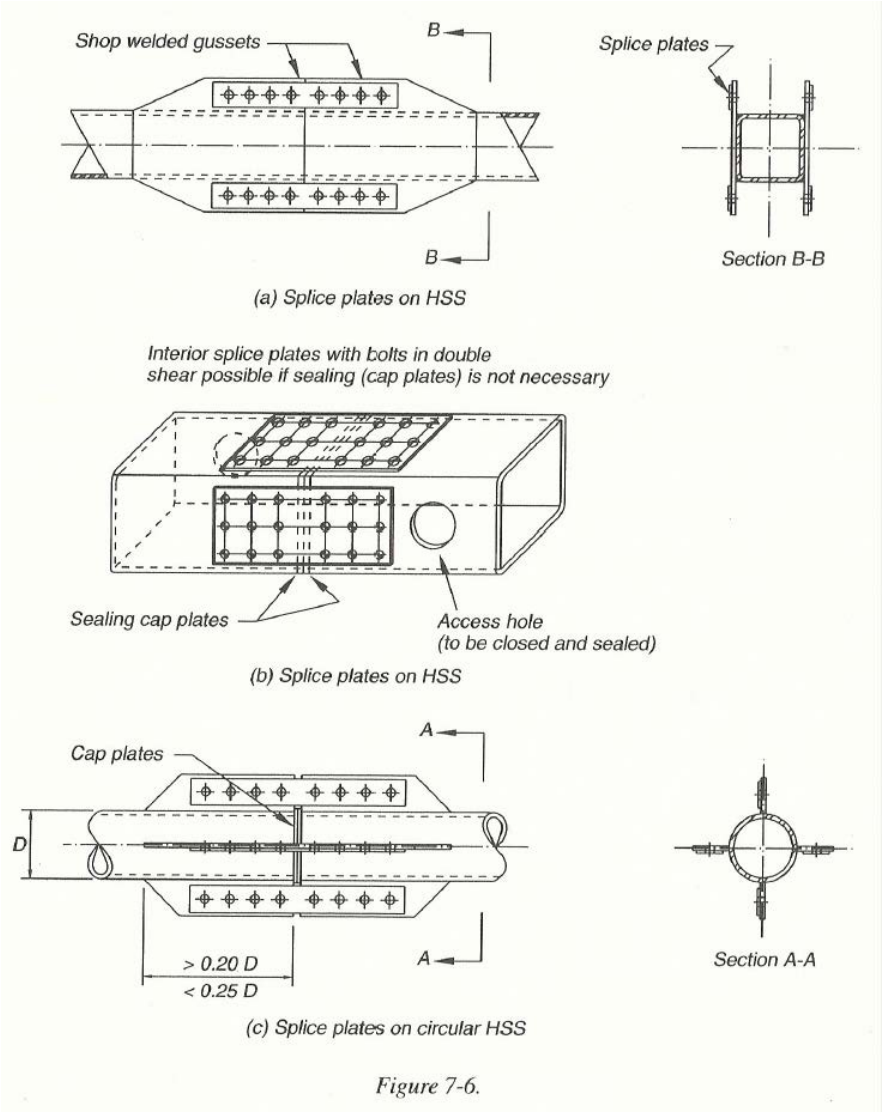
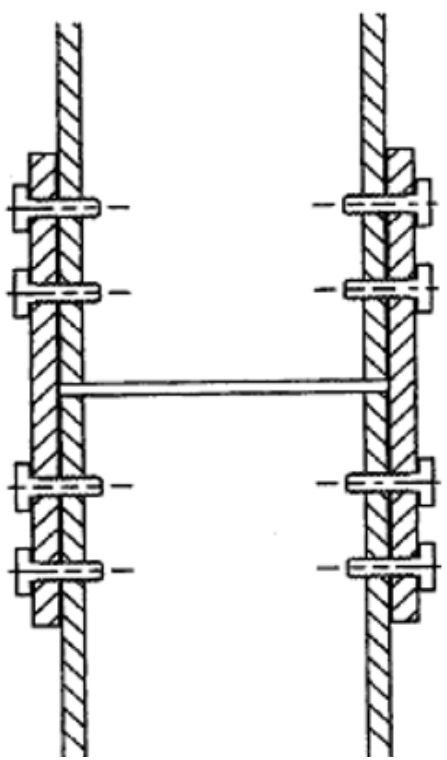
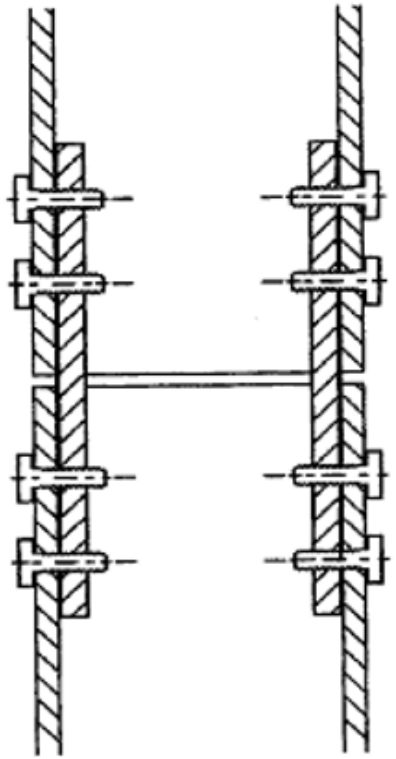


Figure 7-6.

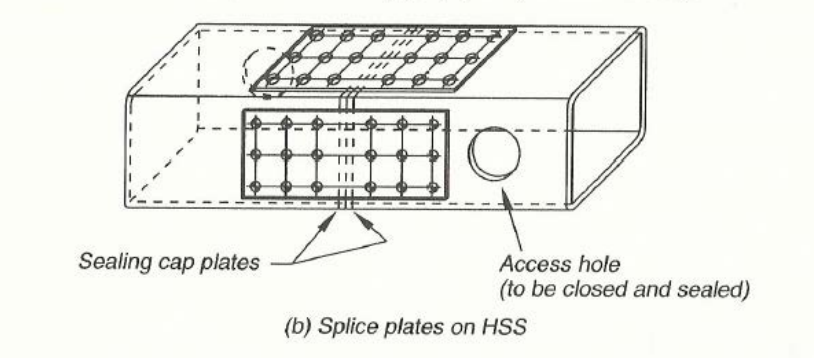
SPLICE PLATES WITH RECTANGULAR HSS



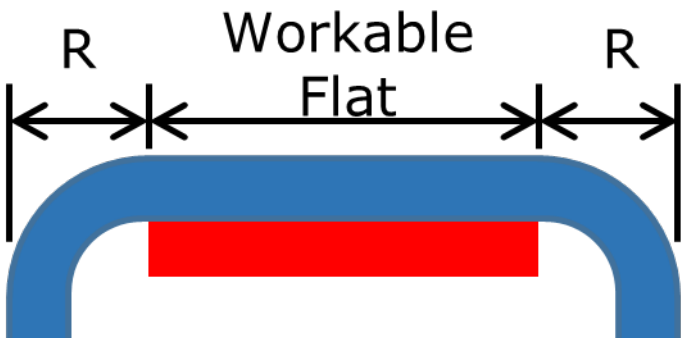


- Plates can be on two or four sides
- Plates can be inside or outside
- Plates could be welded to one column

SPLICE PLATES WITH RECTANGULAR HSS

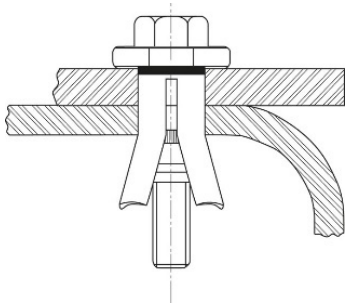


(b) Splice plates on HSS



Make sure interior plates fit

- Tack weld nuts to interior
- Access holes
- One sided bolts



ONE SIDED BOLTS

BLINDBOLT

lindapter®

CE

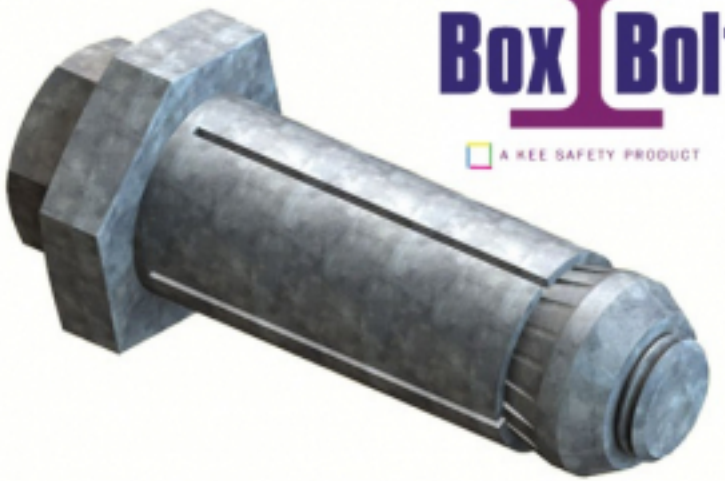
Hollo-Bolt®

LNA SOLUTIONS

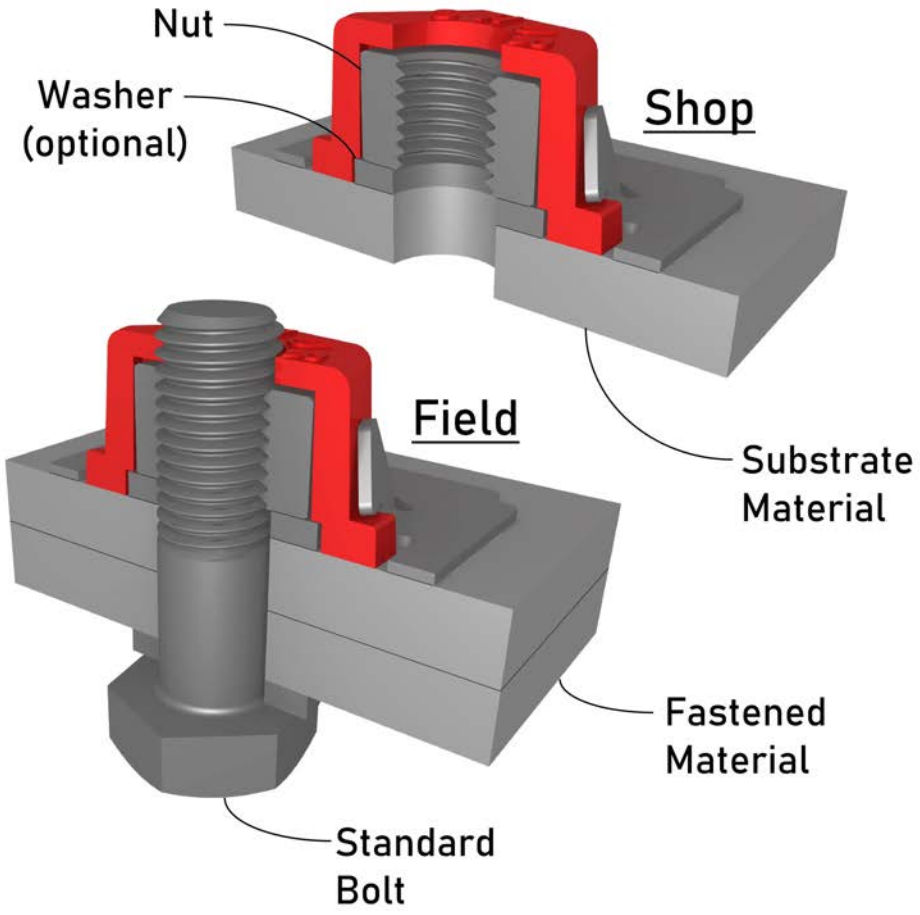
A KEE SAFETY COMPANY

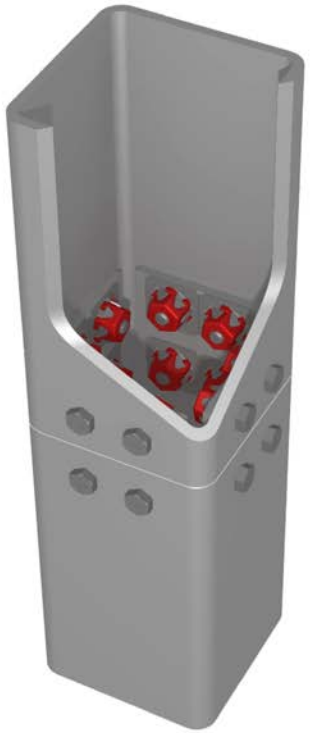
Box Bolt®

A KEE SAFETY PRODUCT



SHURIKEN – TubularConnect.com





HSS Splice

SHURIKEN – TubularConnect.com

SPLICE PLATES WITH RECTANGULAR HSS

- Longitudinal Plate Splices

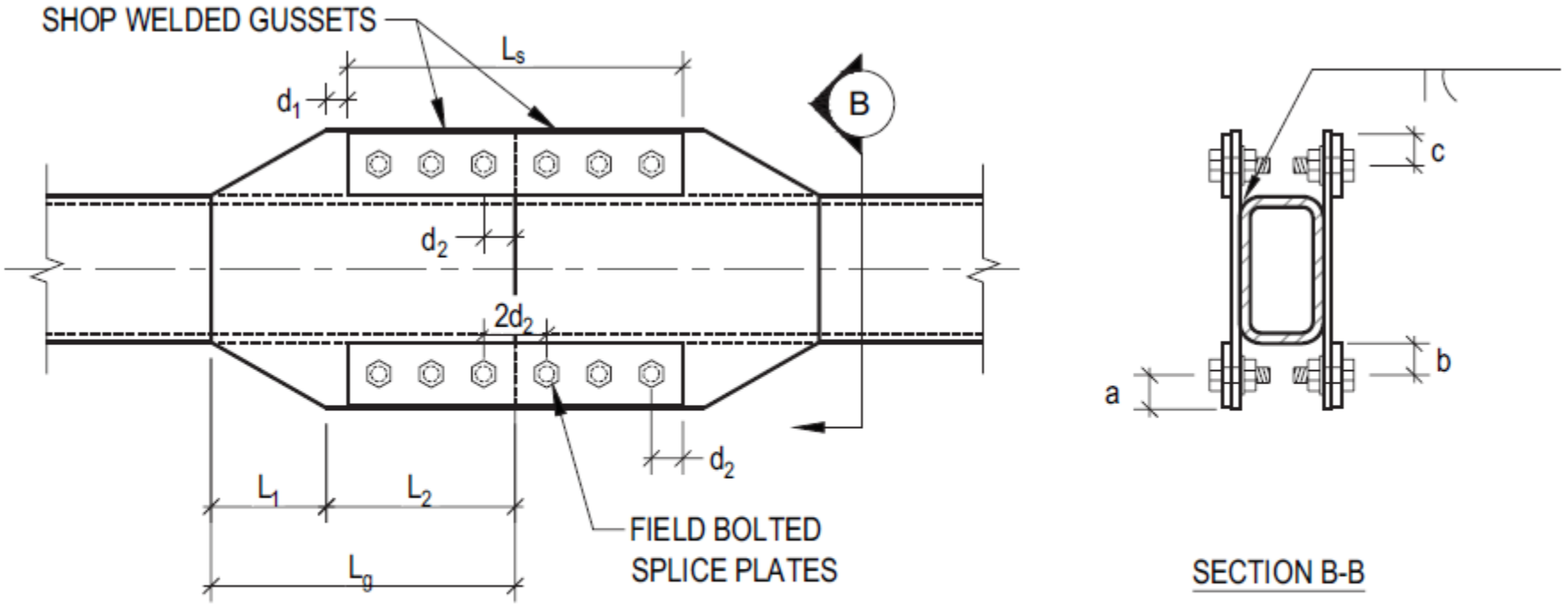


FIG. 4-1.17 RECTANGULAR HSS WITH EXTERNAL BOLTED SPLICE PLATES

SPLICE PLATES WITH ROUND HSS

- Longitudinal Plate Splices

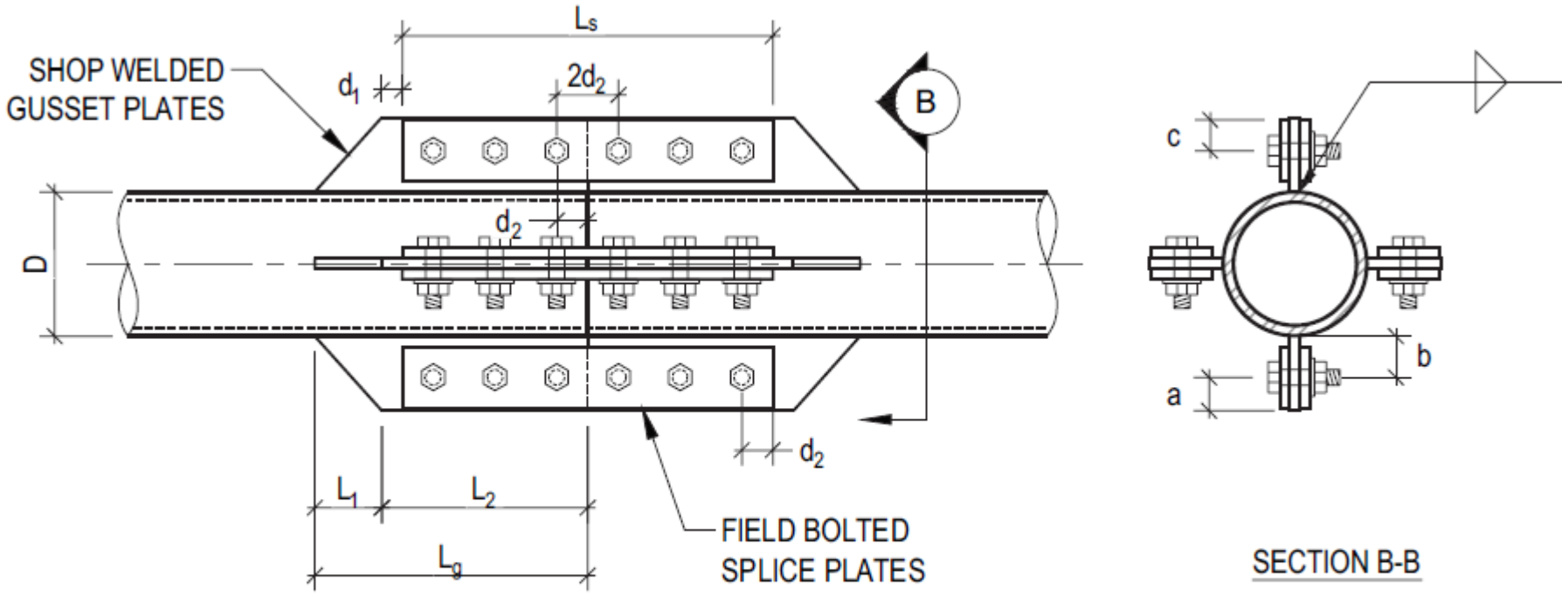


FIG. 4-1.16 ROUND HSS WITH EXTERNAL BOLTED SPLICE PLATES

HIDDEN / INTERNAL SPLICE PLATE

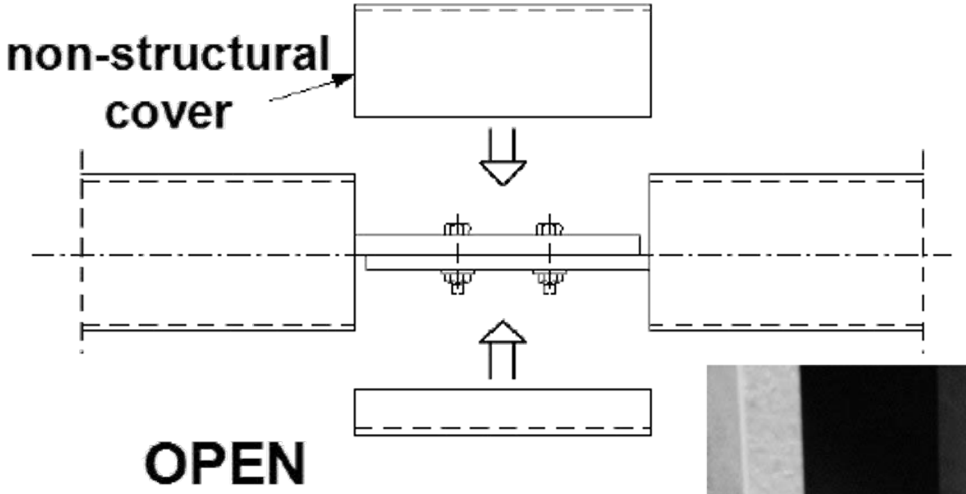
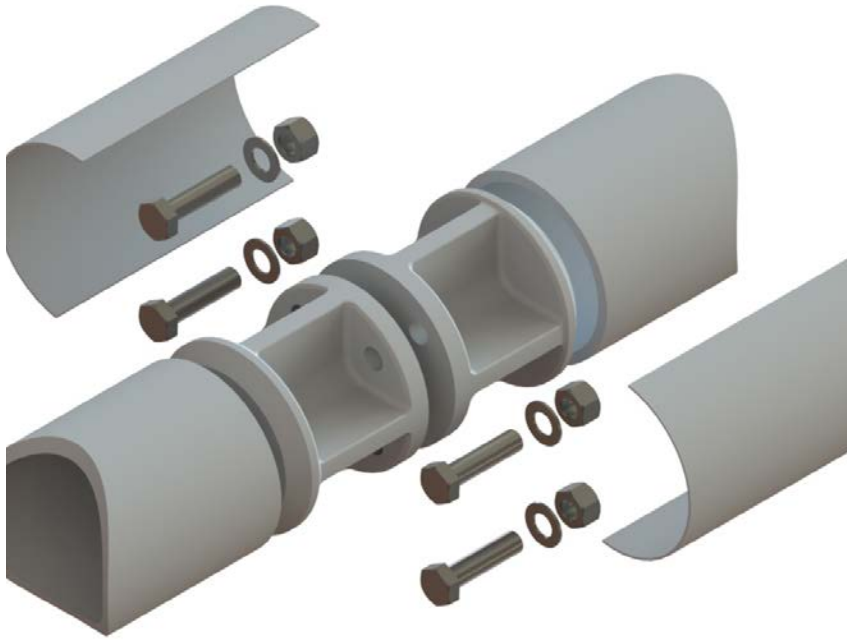


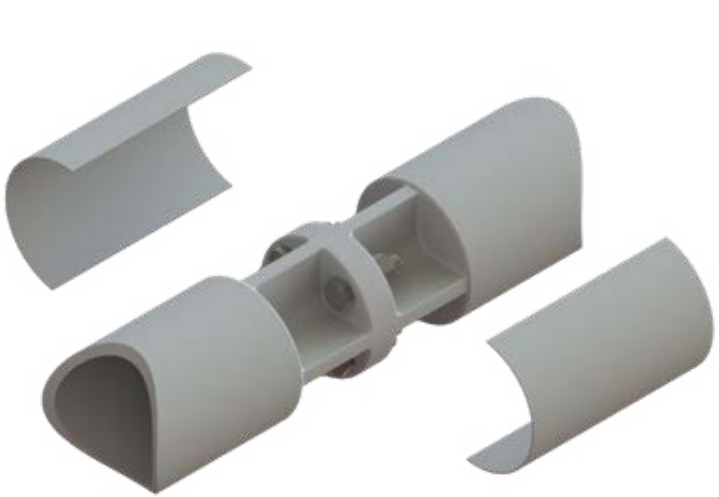
FIG. 4-1.19 HIDDEN BOLTED CONNECTIONS – PACKER (2016)

HIDDEN / INTERNAL SPLICE PLATE

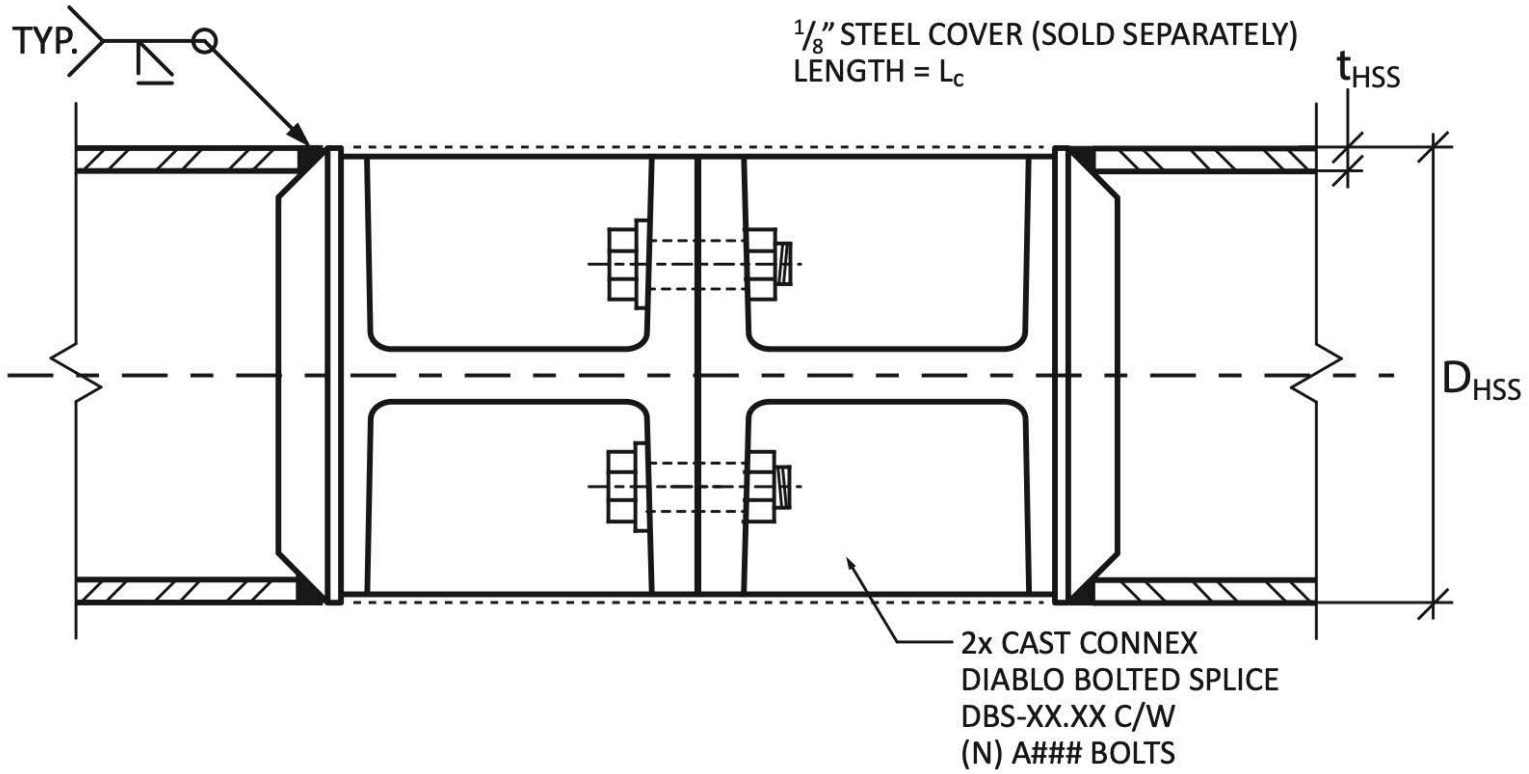
DIABLO™ BOLTED SPLICE



- Cast steel fittings that provide a hidden splice
- HSS5.563 thru HSS12.75



DIABLO™ BOLTED SPLICE



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WELDED SPLICES

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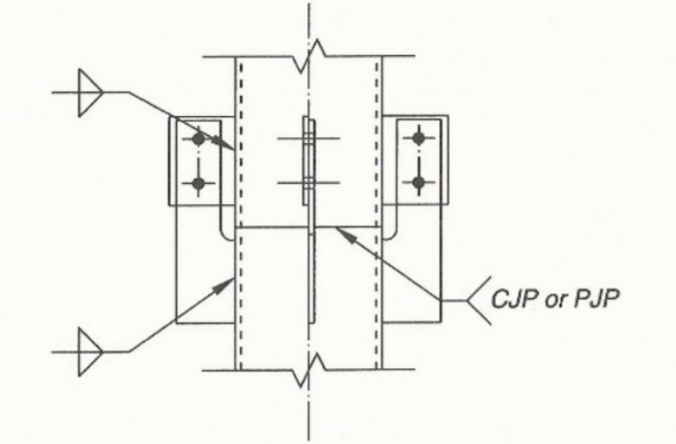
WELDED SPLICES

- Generally for columns only

WELDED SPLICES



NOTE: If the erection plates are to be removed the contract documents must so indicate.

Figure 7-4.

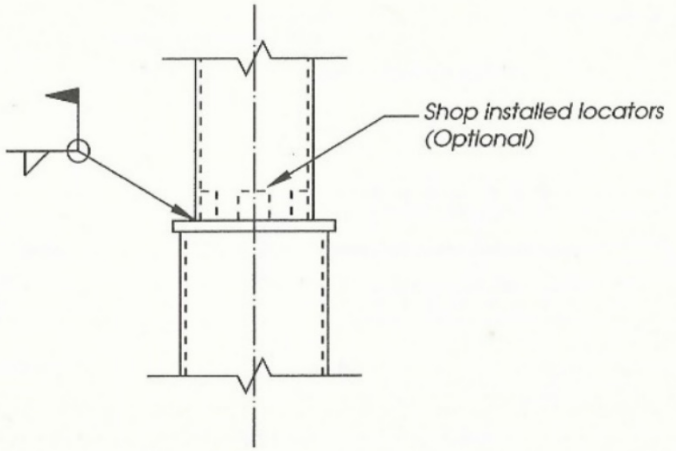


Fig. 7-5. HSS splice connections.

- CJP
  - Backing may be difficult
  - ($$$) Don't over specify
- PJP
  - Design for required strength
- Fillet weld (with cap pl)
  - No directional increase

WELDED SPLICES

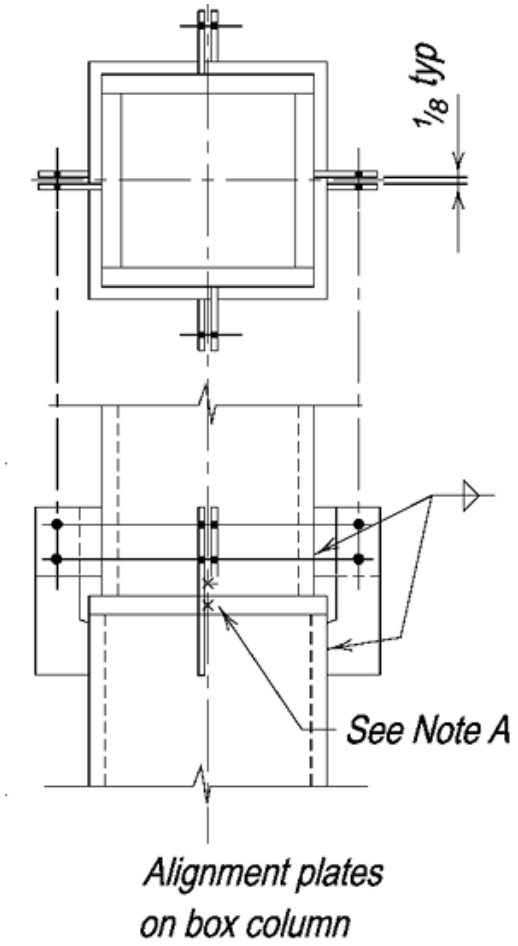


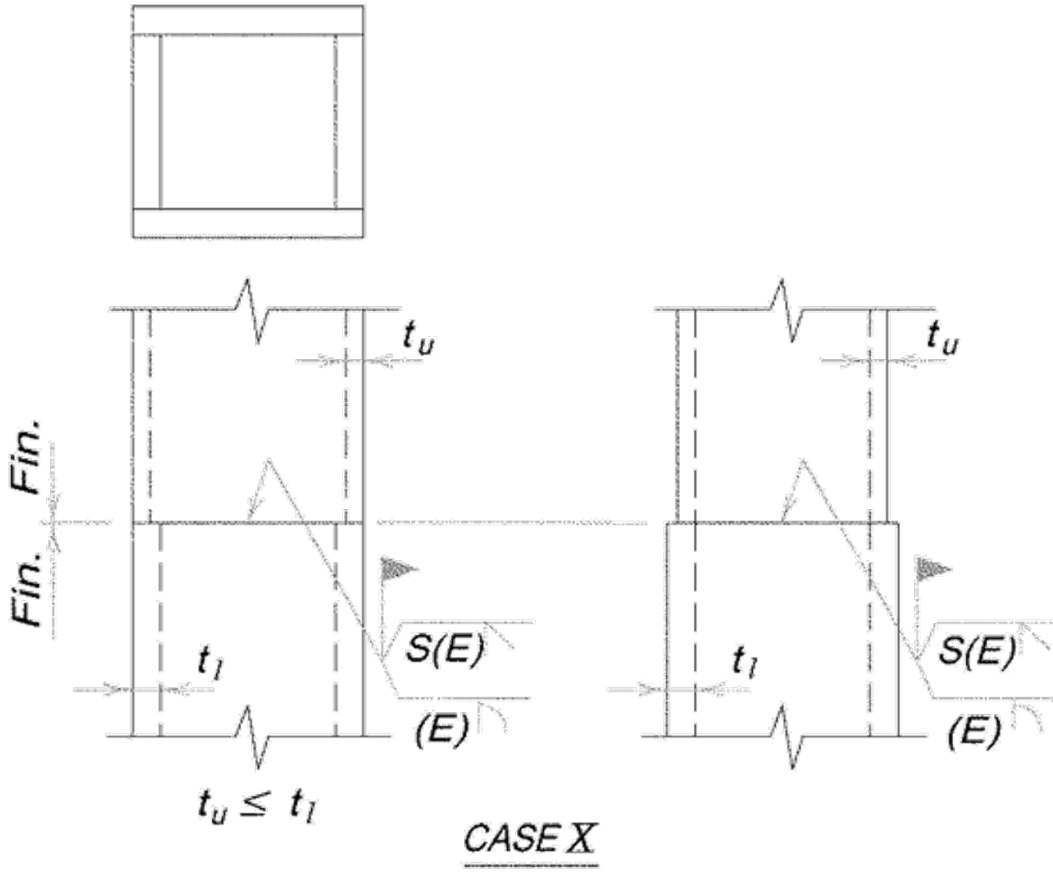
Fig. 14-11. Column stability and alignment devices.

- Manual Part 14

WELDED SPLICES

Table 14-3 (continued)
Typical Column Splices
Cases X, XI, XII
Special column splices.

Case X: Directly welded splice between tubular and/or box-shaped columns.	Welds may be either partial-joint- or complete-joint-penetration. The strength of partial-joint-penetration welds is a function of the column wall thickness and appropriate guidelines for minimum land width and effective weld size must be observed. This type of splice usually requires lifting and alignment devices. For lifting devices see Figure 14-10. For alignment devices see Figure 14-11.
Case XI: Butt-plated splices between tubular and/or box-shaped columns.	The butt-plate thickness is selected based on the AISC Specification. Welds may be either partial- or complete-penetration-groove welds, or, if adequate space is provided, fillet welds may be used. Weld strength is based on the thickness of connected material. See comments under Case X above regarding lifting and alignment devices.



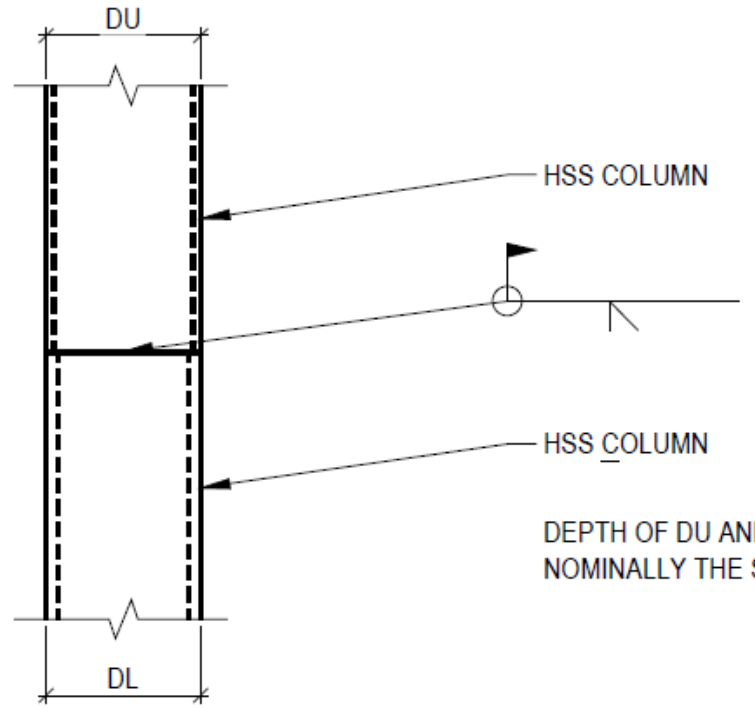
WELDED SPLICES – CJP OR PJP

- Welding can only be done from one side
- Any groove-welded joint detail that requires penetration and welding on both sides is not possible
- PJPs are preferable when possible and designed for applicable loads

- CJP – steel backing should be used, where possible, with a detailed root dimension to allow placement of sound weld metal in the full depth of the joint
- Special inserts may be required to accommodate the HSS geometry
- Discussion of backing and joint details given by Post (1990)

Post, J.W. (1990), "Box-Tube Connections; Choices of Joint Details and their Influence on Costs," *Proceedings,* National Steel Construction Conference, American Institute of Steel Construction, Kansas City, MO, pp. 22.1–22.26.

HSS TO HSS END BEARING



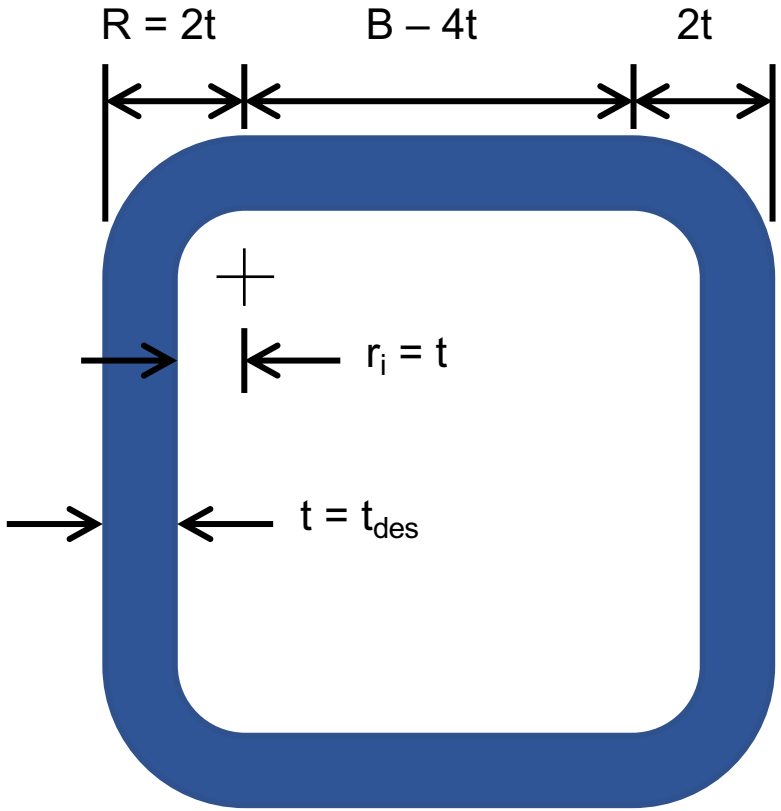
ERECTION ALIGNMENT PLATES
NOT SHOWN

DEPTH OF DU AND DL
NOMINALLY THE SAME

DETAIL - HSS COLUMN SPLICE

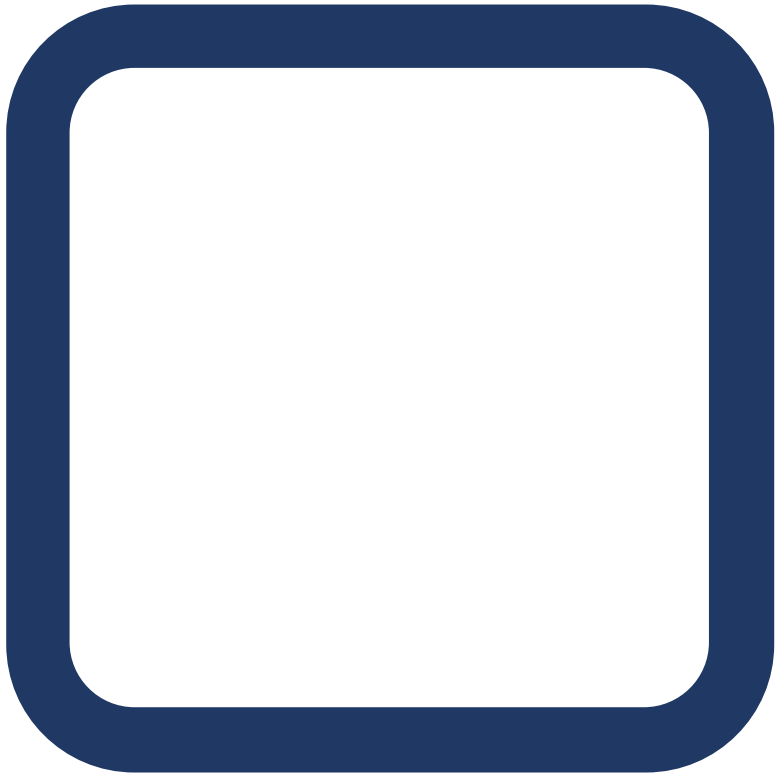
SCALE : 1" = 1'-0"

HSS TO HSS END BEARING

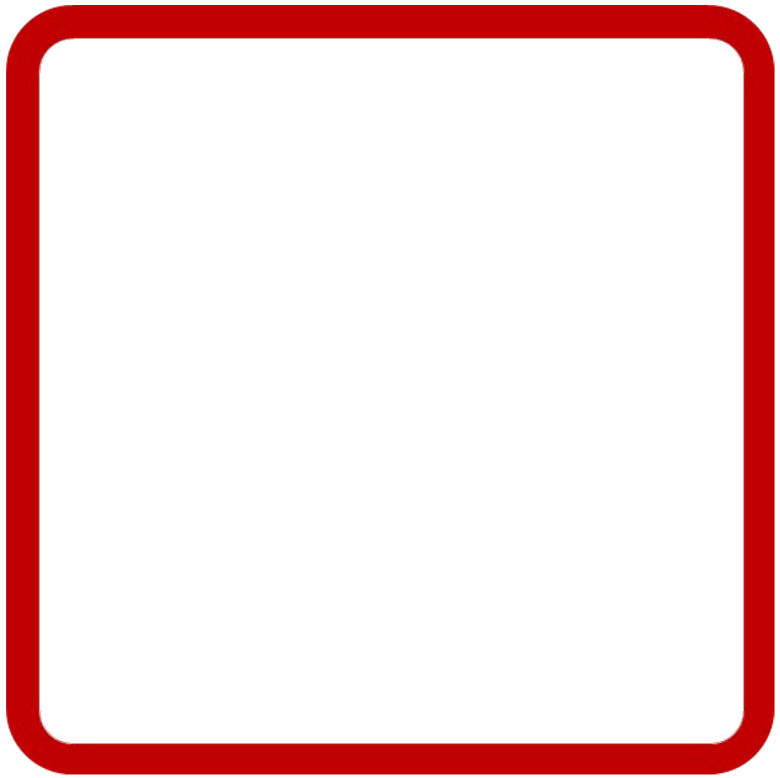


- Section Properties for Detailing
- Note:
  - (b/t) → $R=1.5t_{des}$
  - Workable flat → $R=2.25t_{nom}$

HSS TO HSS END BEARING

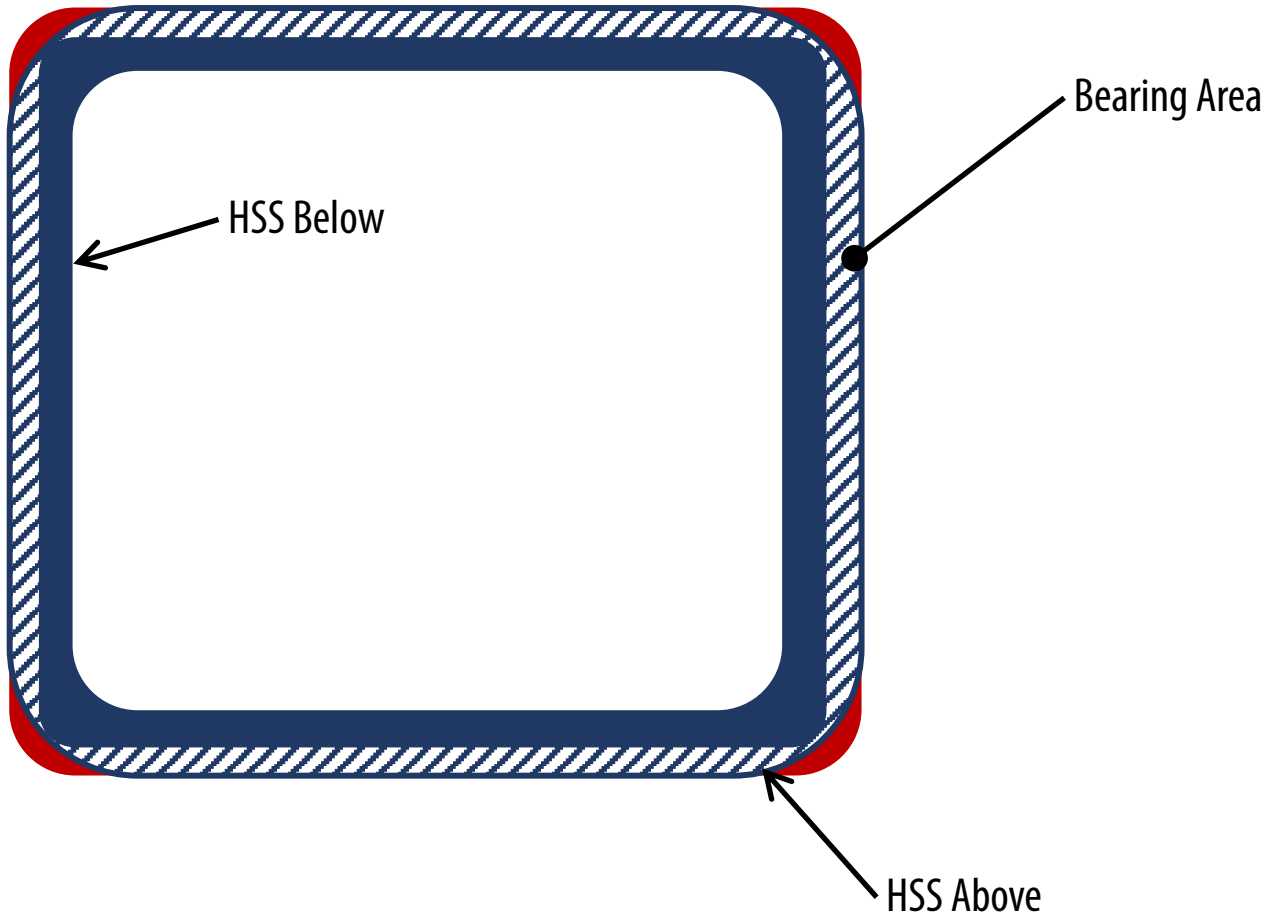


HSS6x6x1/2

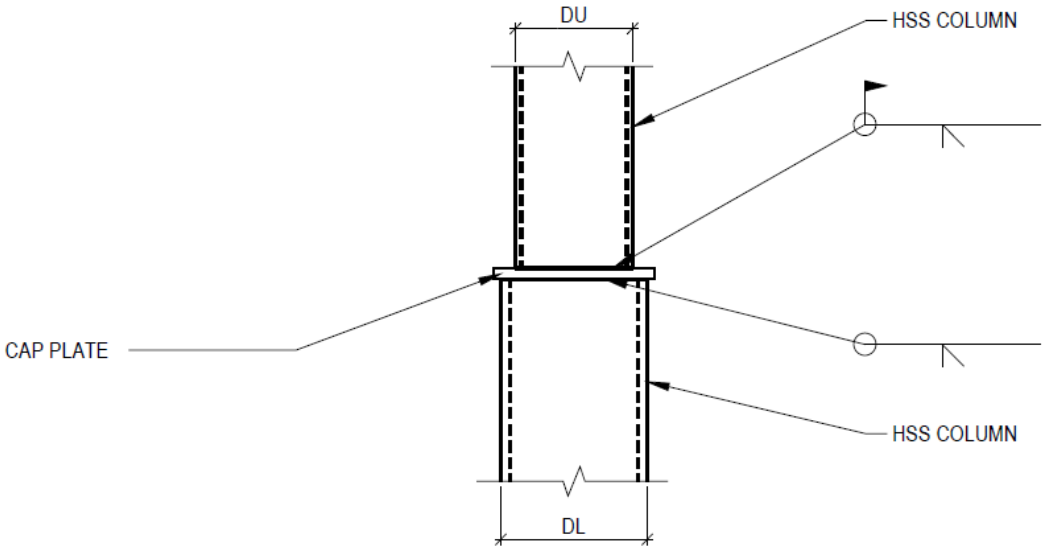


HSS6x6x1/4

HSS TO HSS END BEARING

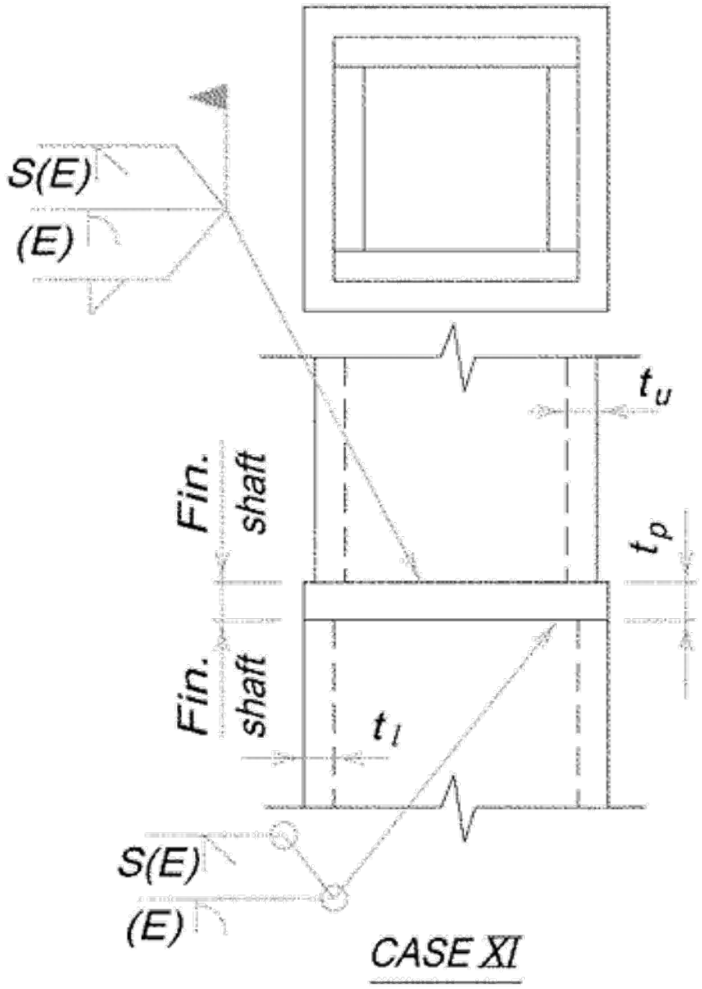


WELDED SPLICE WITH CAP PLATE



DETAIL - COLUMN SPLICE

SCALE : 1" = 1'-0"



WELDED SPLICE PLATES

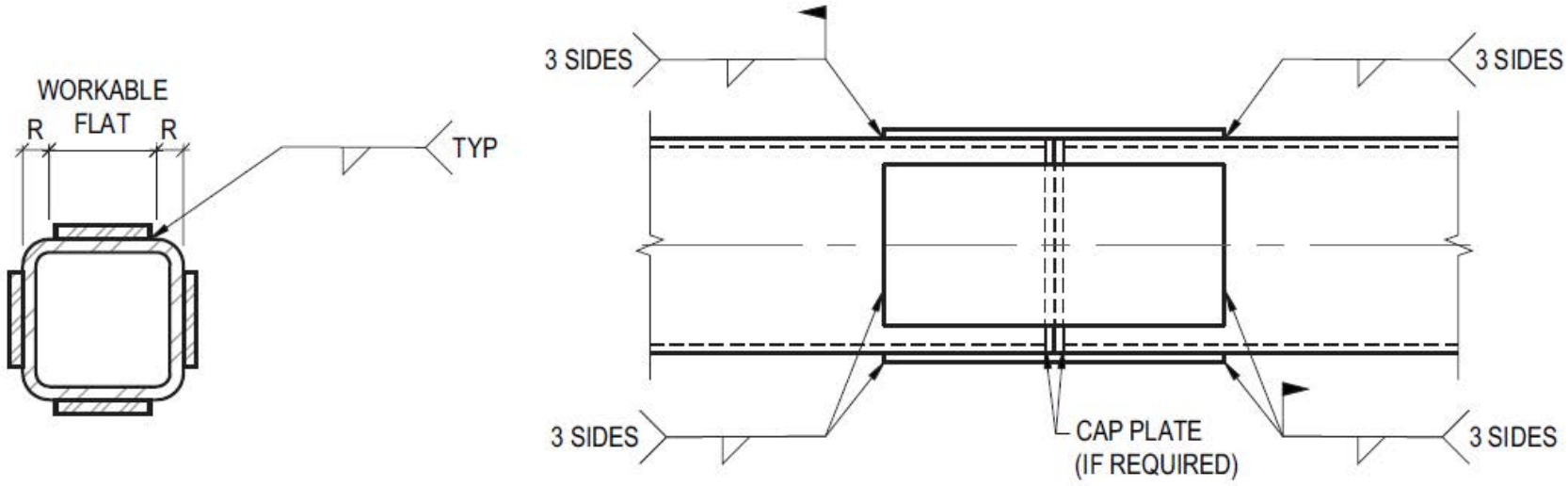


FIG. 4-1.23

WELDED SPLICE PLATES

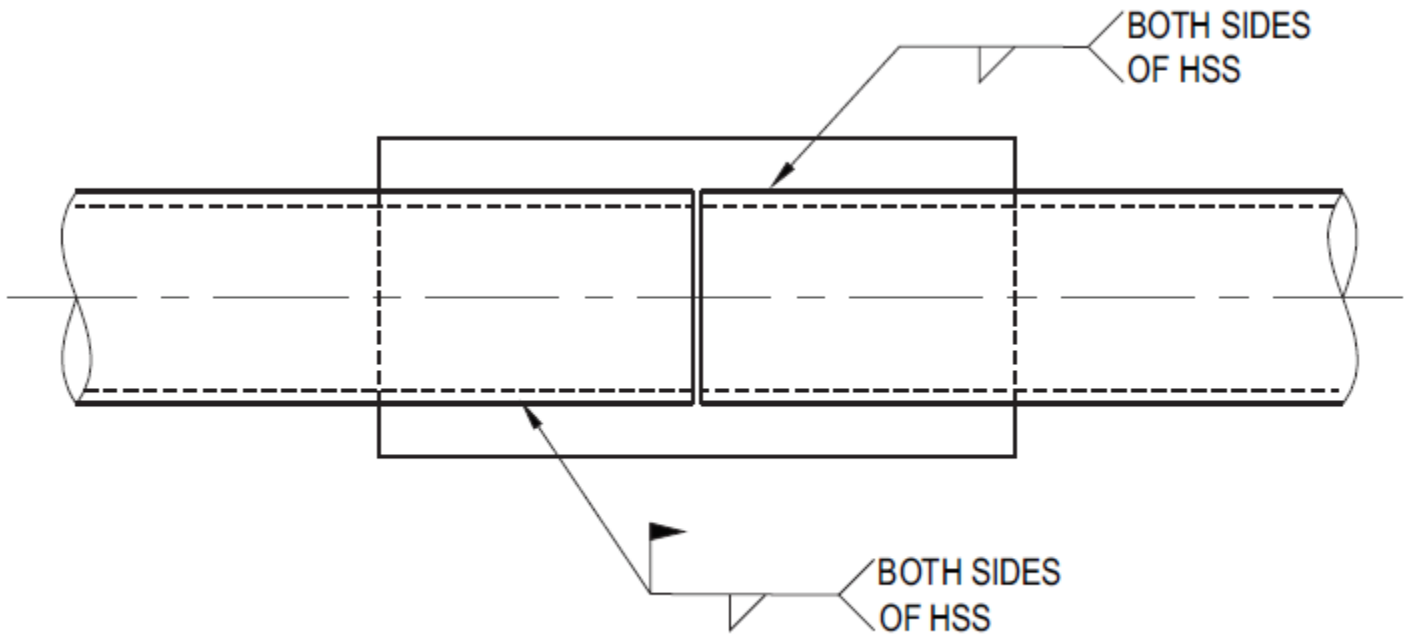


FIG. 4-1.24

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THANK YOU

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