ENCE 455
Design of Steel Structures

VIII. Simple Shear Connection

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Review Bolts and Welds

Design bolt bearing strength ($L_e \geq 1.5d$, $s \geq 3d$)

- $\Phi R_n = \Phi(2.4dtF_u)$

Design bolt shear strength – no threads in shear planes

- $\Phi R_n = 0.75(0.50F_u^b)mA_b$

Design bolt shear strength – threads in shear planes

$\Phi R_n = 0.75(0.40F_u^b)mA_b$

Design bolt tensile strength

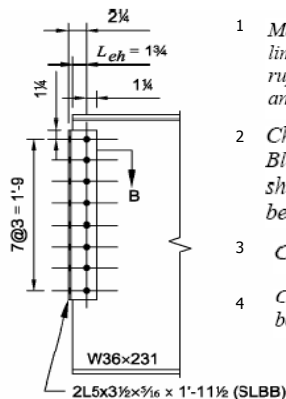$\Phi R_n = 0.75(0.75F_u^b)A_b$

Design strength of the weld

- $\varphi R_n = 0.707wL(\varphi F_w) = 0.707wL(0.75[0.6F_{EXX}]) = 0.32wLF_{EXX}$

Double-Angle Connection

Example II.A-1   All-Bolted Double-Angle Connection
Example II.A-2   Bolted/Welded Double-Angle Connection

For bolted connection (AISC Tables 10-1 or -2)

1   Manual Table 10-1 includes checks for the limit states of bearing, shear yielding, shear rupture, and block shear rupture on the angles, and shear on the bolts.

2   Check the beam web for bolt bearing. Block shear rupture, shear yielding and shear rupture will not control, since the beam is uncoped.

3   Check beam web for bolt bearing.

4   Check supporting member flange for bolt bearing

W36×231

2L5x3½×⁵⁄₁₆ x 1'-11½ (SLBB)

Double-Angle Connection
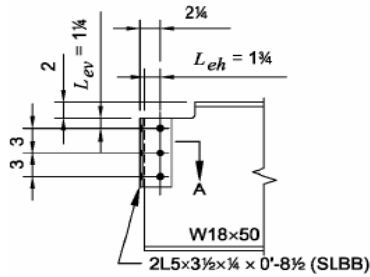
Example II.A-3   All-Welded Double-Angle Connection

For welded connection (AISC Table 10-3)
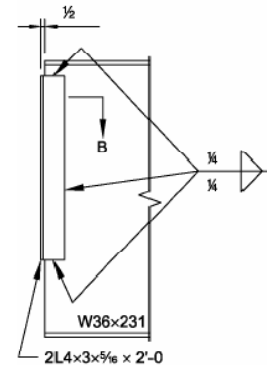
1a   Design the weld between the beam-web and the angle leg (welds A)

2a   Design the welds between support and the angle leg (welds B)

3a   Check minimum angle thickness

W36×231

2L4×3×⁵⁄₁₆ × 2'-0

Double-Angle Connection (coped)

Example II.A-4   All-Bolted Double-Angle Connection

2¼
L_{eh} = 1¾
L_{ev} = 1¼
2
3, 3

A

W18×50

2L5×3½×¼ × 0'-8½ (SLBB)

1 *Check bolt shear. Check angles for bolt bearing, shear yielding, shear rupture and block shear rupture*

2 *Check beam web for bolt bearing, block shear rupture, shear yielding and shear rupture*

3 *Check supporting member flange for bolt bearing*

4 *Check block shear rupture*
$U_{bs} = 1.0$

$$\phi R_n = \phi F_u A_{nt} U_{bs} + \min\left(\phi 0.6 F_y A_{gv}, \ \phi F_u A_{nv}\right)$$

5 *Check flexural rupture on the coped section*
Check local web buckling at the coped section
Check shear yielding on beam web

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Double-Angle Connection (coped)

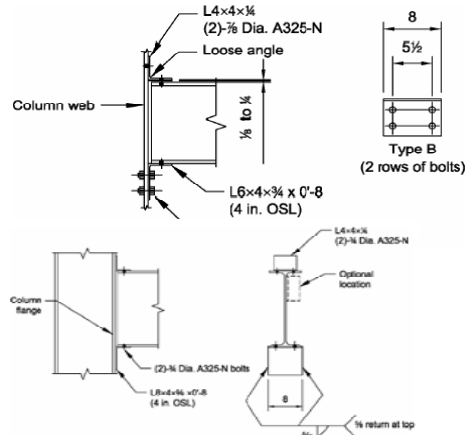Example II.A-5   Bolted/Welded Double-Angle Connection (beam-to-girder web)
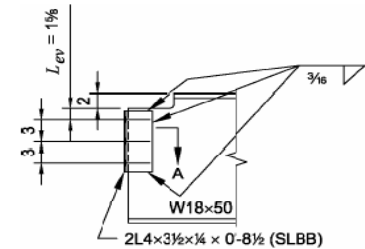
L_{ev} = 1⅝
2
3, 3
3/16

A

W18×50

2L4×3½×¼ × 0'-8½ (SLBB)

1a *Design the weld between the beam-web and the angle leg (welds A)*

2a *Check minimum angle thickness*

Check shear rupture on beam web

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Unstiffened Seated Connection

Example II.A-12   All-Bolted Unstiffened Seated Connection (beam-to-column web).

L4×4×¼
(2)-⅞ Dia. A325-N
Loose angle
Column web
⅜ to ¼
L6×4×¾ x 0'-8
(4 in. OSL)

8
5½
Type B
(2 rows of bolts)

Column flange
L4×4×¼
(2)-¾ Dia. A325-N
Optional location
(2)-¾ Dia. A325-N bolts
L8×4×½ x0'-8
(4 in. OSL)
8
¼ return at top

1 *Check beam web*

For local web yielding;
For web crippling.

2 *Check shear yielding and flexural yielding of angle. Check local yielding and crippling of beam web*

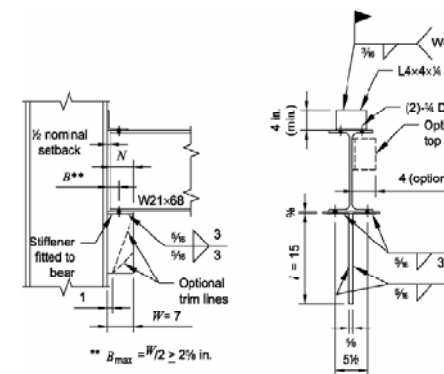3 *Check bolt bearing on the angle*

4 *Check supporting column*

1a *Check minimum angle thickness*

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Stiffened Seated Connection

Example II.A-14   Stiffened Seated Connection (beam-to-column flange)

½ nominal setback
B^{**}
N
Stiffener fitted to bear
W21×68
W= 7
** $B_{max} = W/2 \geq 2\frac{1}{2}$ in.

Weld toe only
5/16
L4×4×¼ shop attached to beam
(2)-¾ Dia. A325-N bolts
Optional location top angle
4 (optional)
4 in. (min.)
5/16 3
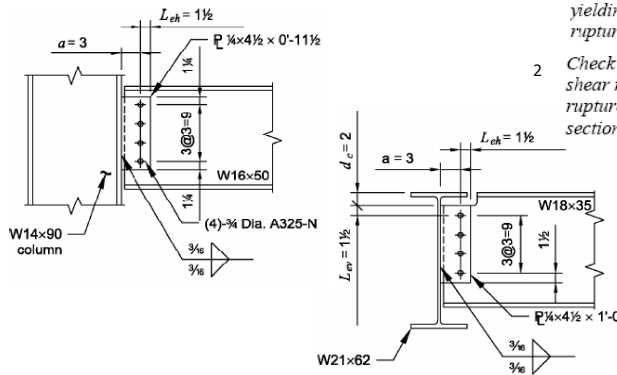5/16 3
⅜
L = 15
⅜
5/16 3
⅜
5½

1 *Determine stiffener width W required*
For web crippling;
For local web yielding

2 *Determine stiffener length L and stiffener to column flange weld size*

3 *Determine weld requirements for seat plate*

4 *Determine the seat plate dimensions*

5 *Check column web thickness*

6 *Select top angle, bolts, and welds*

Example II.A-15   Stiffened Seated Connection (beam-to-column web)

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Single-Plate Connection

Example II.A-17   Single-Plate Connection (conventional – beam-to-column flange)

$L_{eh} = 1\frac{1}{2}$
$a = 3$
ℙ ¼×4½ × 0'-11½

3@3=9
W16×50

W14×90 column

(4)-¾ Dia. A325-N

³⁄₁₆
³⁄₁₆

$L_{eh} = 1\frac{1}{2}$
$d_c = 2$
$a = 3$

W18×35

3@3=9

$L_{ev} = 1\frac{1}{2}$

ℙ¼×4½ × 1'-0

W21×62

³⁄₁₆
³⁄₁₆

Example II.A-18   Single-Plate Connection (beam-to-girder web)

For single-plate connection (AISC Table 10-9)

1   Check bolt shear. Check plate for shear yielding, shear rupture, and block shear rupture

2   Check beam web for bolt bearing. Block shear rupture, shear yielding and shear rupture will not control for an uncoped section.

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Single-Plate Connection

Example II.A-19   Extended Single-Plate Connection (beam-to-column web)

$L_{eh} = 1\frac{1}{4}$
W16×36
3@3
³⁄₁₆
³⁄₁₆
ℙ ½ thick
⅜ Ø A325
W14×90
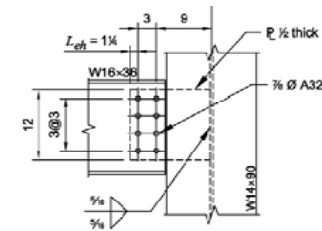
For extended single-plate connection

1   Determine the bearing strength of one bolt on the beam web

2   Determine the strength of the bolt group

3   Determine the maximum plate thickness
Check flexural strength of the plate
Check shear yielding of the plate

4   Determine critical flexural stress in presence of shear stress, f_v

5   Check shear rupture of the plate

6   Check block shear rupture of the plate

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Single-Plate Shear Splice

Example II.A-20   All-Bolted Single-Plate Shear Splice

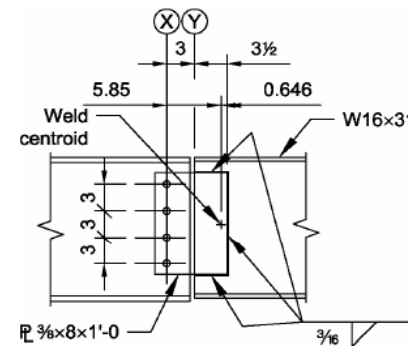

5
2¼   2¼
R
$M = \frac{R\,e}{2}$
3@3
R
ℙ⅜×8 × 1'-0"
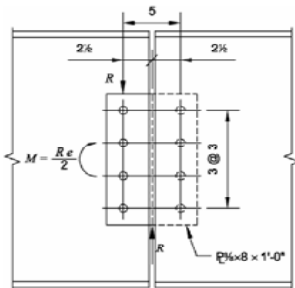
For all bolted shear splice

1   Design the bolt groups

2   Design splice plate

3   Check flexure of the plate

4   Check shear yielding of the plate

5   Check shear rupture of the plate

6   Check block shear rupture of the plate

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Single-Plate Shear Splice

Example II.A-21   Bolted/Welded Single-Plate Shear Splice

X Y
3   3½
5.85   0.646
Weld centroid
W16×31
3 3 3
ℙ ⅜×8×1'-0
³⁄₁₆

For welded shear splice

1a   Design the weld group

2a   Check shear rupture of beam web at the weld

3a   Design the bolt group

4a   Design splice plate

5a   Check flexure of the plate

6a   Check shear yielding of the plate

7a   Check shear rupture of the plate

8a   Check block shear rupture of the plate

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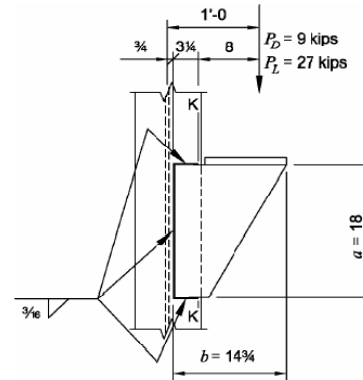# Bracket Plate Design

Example II.A-22   Bolted Bracket Plate Design

1'-0
2¾   9¼ P_D = 9 kips
P_L = 27 kips

K

5@3 = 1'-3

$a = 20$

K

2¼   5½ b = 15¼
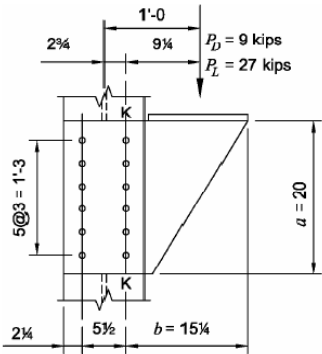
1   *Design the bolt groups*

2   *Check bolt bearing*

3   *Check flexure in the bracket plate*

4   *Check local buckling of the bracket plate*

5   *Check shear yielding of the bracket plate*

6   *Check shear rupture of the bracket plate*

7   *Check block shear rupture of the bracket plate*

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Bracket Plate Design

Example II.A-23   Welded Bracket Plate Design

1'-0
¾   3¼   8 P_D = 9 kips
P_L = 27 kips

K

$a = 18$

3⁄16

K

b = 14¾

1a   Try a C-shaped weld

2a   *Check flexure in the bracket plate*

3a   *Check local buckling of the bracket plate*

4a   *Check shear yielding of the bracket plate*

5a   *Check shear rupture of the bracket plate*

6a   *Check block shear rupture of the bracket plate*
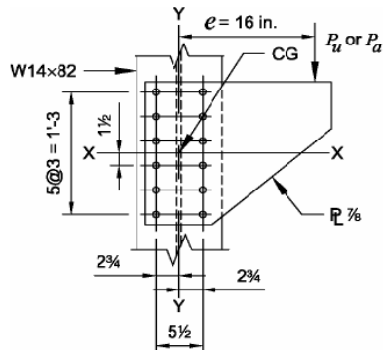
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Eccentrically-Loaded Group

Example II.A-24   Eccentrically-Loaded Bolt Group (IC method)

Example II.A-25   Eccentrically Loaded Bolt Group (elastic method)

Elastic Method

(AISC Tables 7-7~14 for IC Method)

Y
e = 16 in. P_u or P_a
W14×82   CG

5@3 = 1'-3   1½

X   X

PL ⅞

2¾   2¾

Y
5½

1   *Direct shear force per bolt*

2   *Additional shear force due to eccentricity*

3   *Resultant shear force*

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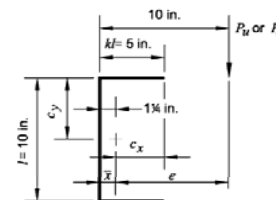---

Eccentrically-Loaded Group

Example II.A-26   Eccentrically-Loaded Weld Group (IC method)

Example II.A-27   Eccentrically-Loaded Weld Group (elastic method)

Elastic Method
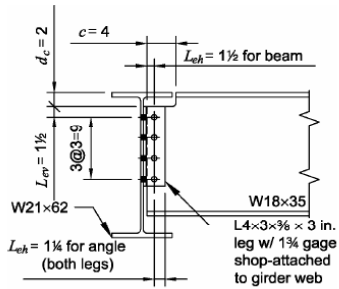
(AISC Tables 8-4~11 for IC Method)

10 in.
kl= 5 in. P_u or P_a
c_y
1¼ in.
l= 10 in.
c_x
$\bar{x}$ e

1a   *Direct shear force per inch of weld*

2a   *Additional shear force due to eccentricity*

3a   *Resultant shear force*

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Single-Angle Connection

Example II.A-28   All-Bolted Single-Angle Connection (beam-to-girder web)

1 Design the bolts and angle

2 Check shear yielding of the angle

3 Check shear rupture of the angle

4 Check block shear rupture of the angle

5 Check flexure of the support-leg of the angle

6 Check beam web for bolt bearing and block shear rupture.

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Single-Angle Connection

Example II.A-29   Bolted/Welded Single-Angle Connection (beam-to-column flange).

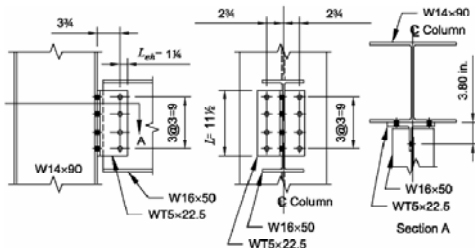*For bolted/welded single-angle connection (AISC Tables 10-10 or -11)*

1a Design single angle, bolts, and welds

2a Check supported beam web

3a Check support

18
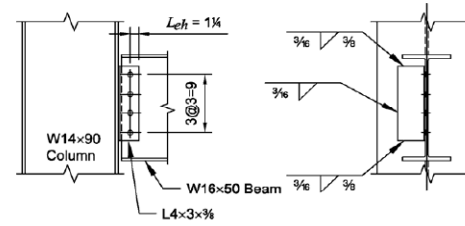
Tee Connection

Example II.A-30   All-Bolted Tee Connection (beam-to-column flange)
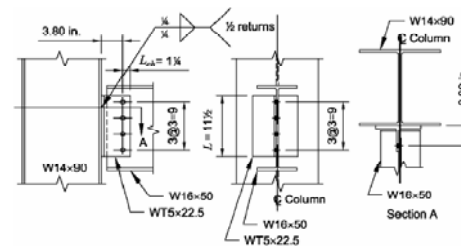
For all bolted tee connection

1 Check limitation on tee stem thickness

2 Check limitation on bolt diameter for bolts through tee flange

3 Check bolt group through beam web for shear and bearing

4 Check shear yielding of the tee stem

5 Check block shear rupture of the tee stem

6 Check bolt group through support for shear and bearing combined with tension due to eccentricity

7 Check design strength of bolts for tension-shear interaction

8 Check bearing strength at bolt holes

9 Check beam web for bolt bearing, block shear rupture, shear yielding and shear rupture

10 Check supporting member web or flange for bolt bearing

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Tee Connection

For bolted/welded tee connection

1a Check limitation on tee stem thickness

2a Design the welds connecting the tee flange to the column flange

3a Check the stem side of the connection

4a Check bolt group through beam web for shear and bearing

5a Check shear yielding of the tee stem

6a Check block shear rupture of the tee stem

7a Check bolt group through support for shear and bearing combined with tension due to eccentricity

8a Check design strength of bolts for tension-shear interaction

9a Check bearing strength at bolt holes

10a Check beam web for bolt bearing, block shear rupture, shear yielding and shear rupture

11a Check supporting member web or flange for bolt bearing

Example II.A-31   Bolted/Welded Tee Connection (beam-to-column flange)

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