# Solved problem For Shear Lag Factor

#4-2

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Structural steel Design

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McCormac

As a result of the preceding information, the AISC Specification (D2) states that the nominal strength of a tension member, $P_n$, is to be the smaller of the values obtained by substituting into the following two expressions:

For the limit state of yielding in the gross section (which is intended to prevent excessive elongation of the member),

$$P_n = F_y A_g \qquad \text{Limit State of yielding} \qquad \text{(AISC Equation D2-1)}$$

$$\phi_t P_n = \phi_t F_y A_g = \text{design tensile strength by LRFD } (\phi_t = 0.9)$$

$$\frac{P_n}{\Omega_t} = \frac{F_y A_g}{\Omega_t} = \text{allowable tensile strength for ASD } (\Omega_t = 1.67)$$

For tensile rupture in the net section, as where bolt or rivet holes are present,

$$P_n = F_u A_e \qquad \text{(AISC Equation D2-2)}$$

$$\phi_t P_n = \phi_t F_u A_e = \text{design tensile rupture strength for LRFD } (\phi_t = 0.75)$$

$$\frac{P_n}{\Omega_t} = \frac{F_u A_e}{\Omega_t} \text{ allowable tensile rupture strength for ASD } (\Omega_t = 2.00)$$

**TABLE 1-1** Tensile Stress and Ultimate Tensile Strength of Commonly Used Structural Steel

| Steel type | ASTM Specification of structural steel | $F_y$ (ksi) | $F_u$ (ksi) |
|---|---|---|---|
| Carbon steel | A36 | 36 | 58–80 |
| | A53 Grade B | 35 | 60 |
| | A500 Grade B | 42 or 46 | 58 |
| | A500 Grade C | 46 or 50 | 62 |
| | A529 | 50 | 65-100 |
| | | 55 | 70-100 |
| High-strength, low-alloy | A913 | 50 | 6 |
| | | 60 | 75 |
| | | 65 | 80 |
| | | 70 | 90 |
| | A992 | 50 | 65 |
| | A572 | 50 | 65 |
| Corrosion-resistant, high-strength, low-alloy | A242 | 50 | 70 |
| | A588 | 50 | 70 |

Adapted from AISCM Table 2-4

where

$F_u$ = Ultimate tensile strength, ksi, and

$F_y$ = Yield stress, ksi.

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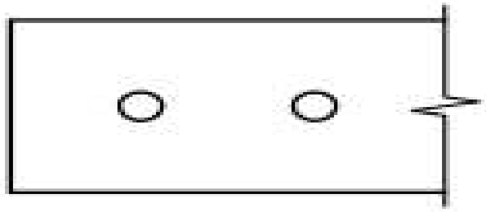
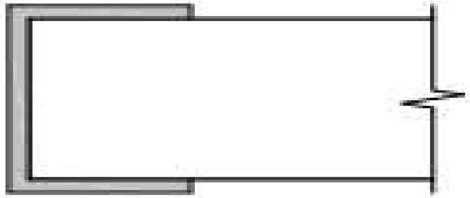
TABLE 4-1 Shear Lag Factor for Common Tension Member Connections

| Tension member type | Description | Shear lag factor, $U$ | Example |
|---|---|---|---|
| 1a. All tension members where the axial tension load is transmitted directly to all of its component elements | All bolted* | $U = 1.0$ |  |
| 1b. All tension members where the axial tension load is transmitted directly to all of its component elements | All welded | $U = 1.0$ |  |
| *2. All tension members with axial tension load transmitted to some but not all of the elements connected by bolts or a combination of long and transverse welds | Bolts or longitudinal plus transverse welds | $U = 1 - \frac{\bar{x}}{\ell}$ see Figure 4-5 for the definition of $\bar{x}$ and $\ell$ | |

Case No.1 specification

Case 2

$U = 1$ → Longtudinal & Transvers weld

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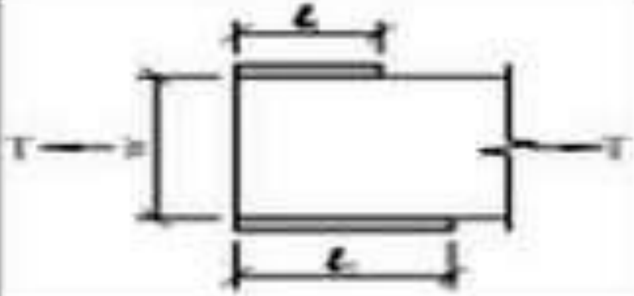
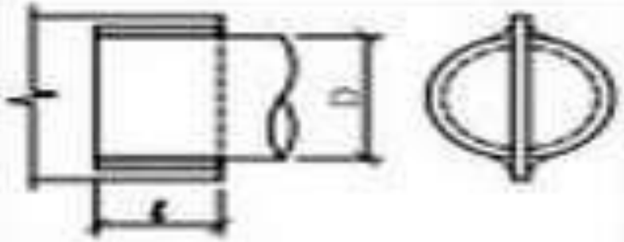
Cases 3-4-5 for U D3.1

| Tension member type | Description | Shear lag factor, $U$ | Example |
| --- | --- | --- | --- |
| 3. All tension members connected to some but not all the elements of the member | Transverse welds only | $U = 1.0$<br>$A_n$ = area of directly connected element |  |
| 4. Plates, angles, channels with welds at heels, tees, and W-shapes | Longitudinal welds only | $\frac{3l^2}{3l^2+w^2}\left(1-\frac{\bar{x}}{l}\right)$<br>where<br>$l = \frac{l_1+l_2}{2}$ |  |
| 5. Round HSS | Single concentric gusset plate | $l \geq 1.3D$, $U = 1.0$<br>$D \leq l < 1.3D$, $U = 1 - \frac{\bar{x}}{l}$<br>$\bar{x} = \frac{D}{\pi}$ |  |

Case 3 specificat

PL + L + [

Longtudinal weld

plates-angles and channels U -

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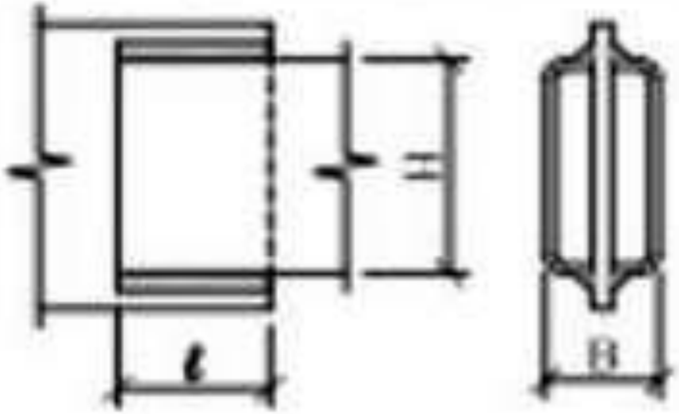
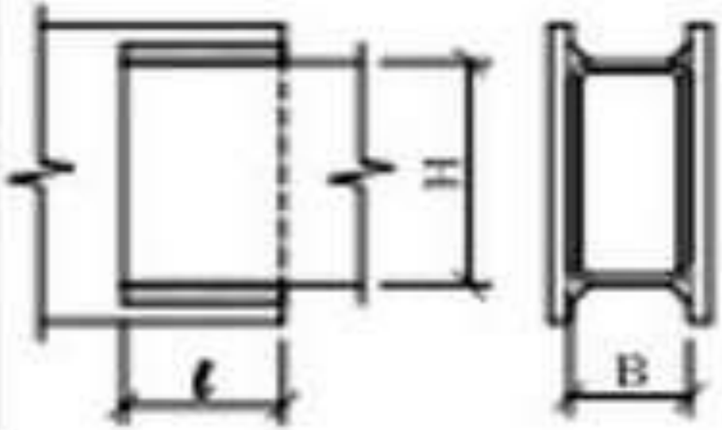
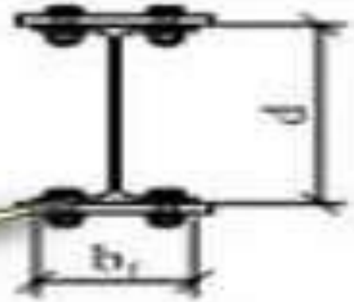
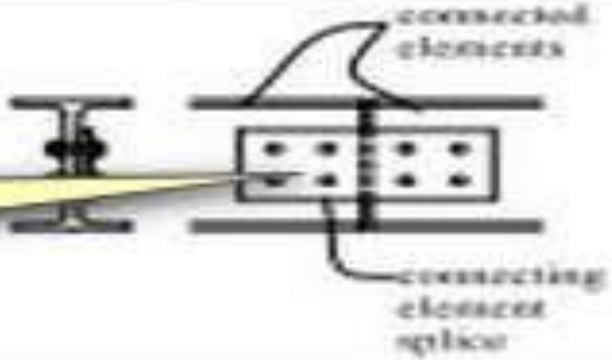
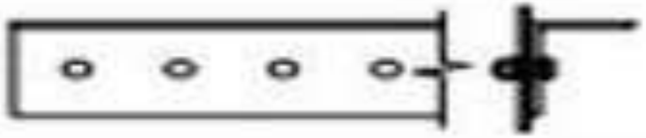
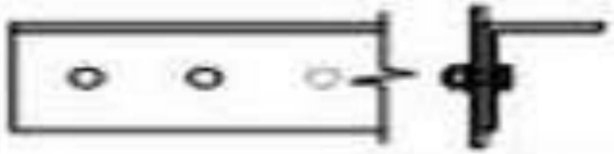
| | | | |
|---|---|---|---|
| 6a. Rectangular HSS | Single concentric gusset plate | $l \ge H,\ U = 1 - \frac{\bar{x}}{l}$ <br> $\bar{x} = \frac{B^2 + 2BH}{4(B+H)}$ |  |
| 6b. Rectangular HSS | Two-sided gusset plates | $l \ge H,\ U = 1 - \frac{\bar{x}}{l}$ <br> $\bar{x} = \frac{B^2}{4(B+H)}$ |  |

Cases 6a-6b-D3.1

| Tension member type | Description | Shear lag factor, $U$ | Example |
|---|---|---|---|
| 7. $W$, $M$, $S$, or HP, or Tees Cut from these shapes | Flange connected with three or more fasteners per line in the direction of the load | $b_f \geq \frac{2}{3}d$, $U = 0.90$<br>$b_f < \frac{2}{3}d$, $U = 0.85$ |   |
| | Web connected with four or more fasteners per line in the direction of the load | |   |
| 8. Single and double angles | Four or more fasteners per line in the direction of the load | $U = 0.80$ |  |
| | Two or three fasteners per line in the direction of the load | $U = 0.60$ |  |



* $U \geq$ Area of connected element/$A_g$ (See AISC Specification Section D3)

Cases 7 and - 8 for W and angles for U value

Flange case

Web case

# Longtudinal and Transverse Weld

SEGUi

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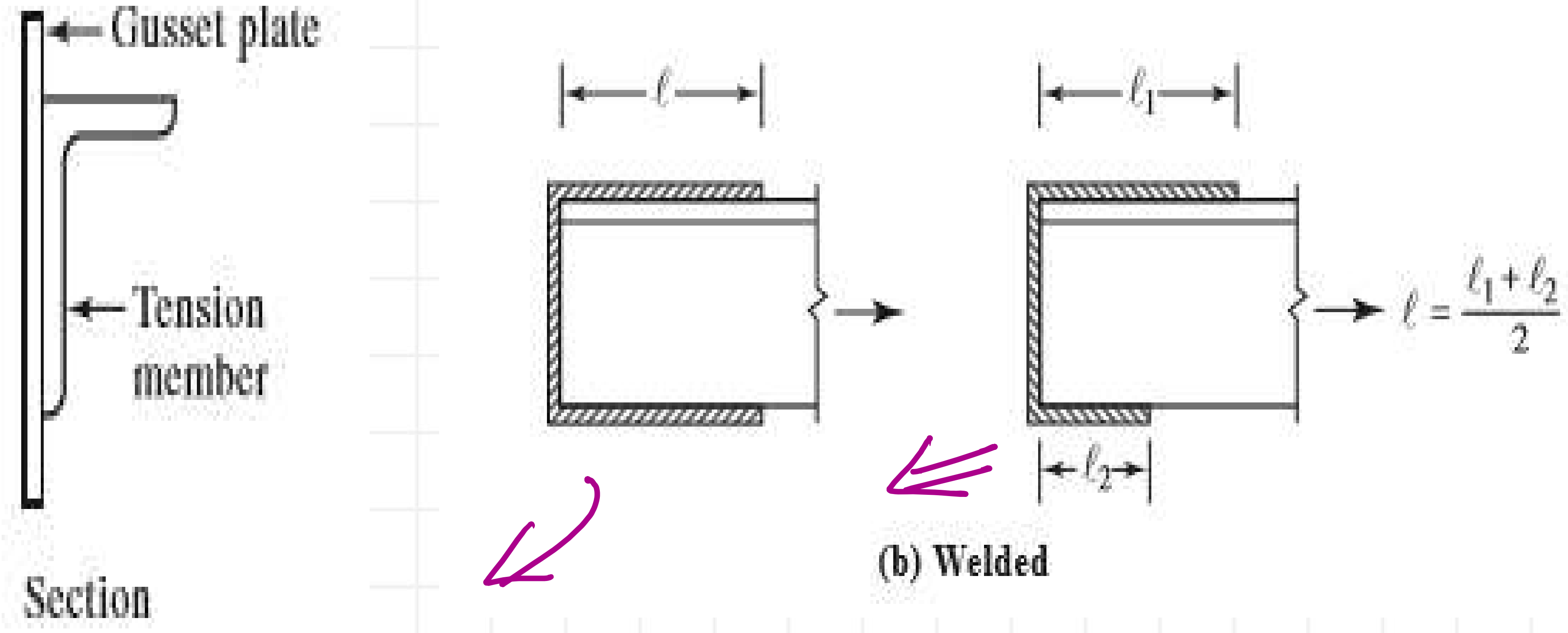


(b) Welded

Final Length of Connection

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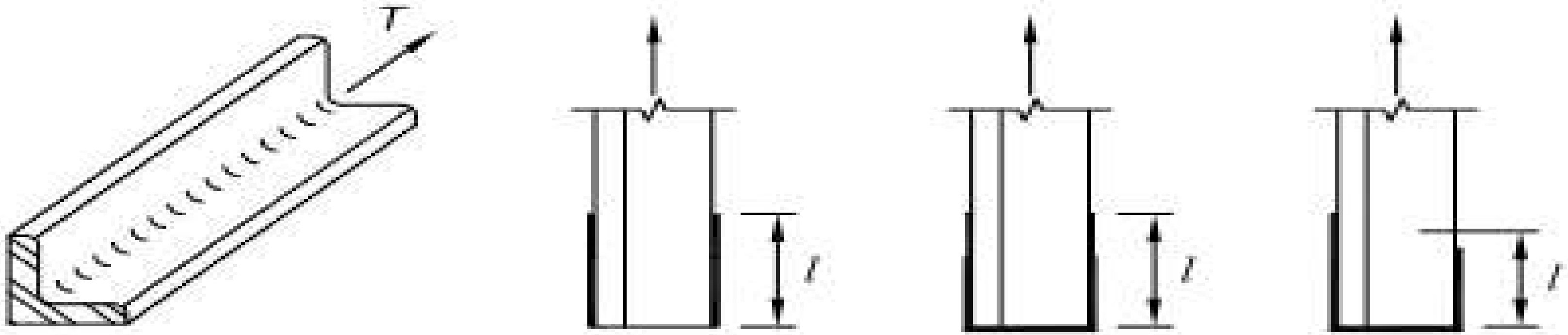
Commentary AISC-360-2016 → 316 page

For welded connections, $l$ is the length of the weld parallel to the line of force as shown in Figure C-D3.4 for longitudinal and longitudinal plus transverse welds. For welds with unequal lengths, use the average length.

End connections for HSS in tension are commonly made by welding around the perimeter of the HSS; in this case, there is no shear lag or reduction in the gross area. Alternatively, an end connection with gusset plates can be used. Single gusset plates may be welded in longitudinal slots that are located at the centerline of the cross section. Welding around the end of the gusset plate may be omitted for statically loaded connections to prevent possible undercutting of the gusset and having to bridge the gap at the end of the slot. In such cases, the net area at the end of the slot is the critical area as illustrated in Figure C-D3.5. Alternatively, a pair of gusset plates can be welded to opposite sides of a rectangular HSS with flare bevel groove welds with no reduction in the gross area.



EXAMPLE 4-2

## U-Value for a Welded Connection

For the welded tension member shown in Figure 4-7, determine the shear lag factor, $U$; the net area, $A_n$; and the effective area, $A_e$.

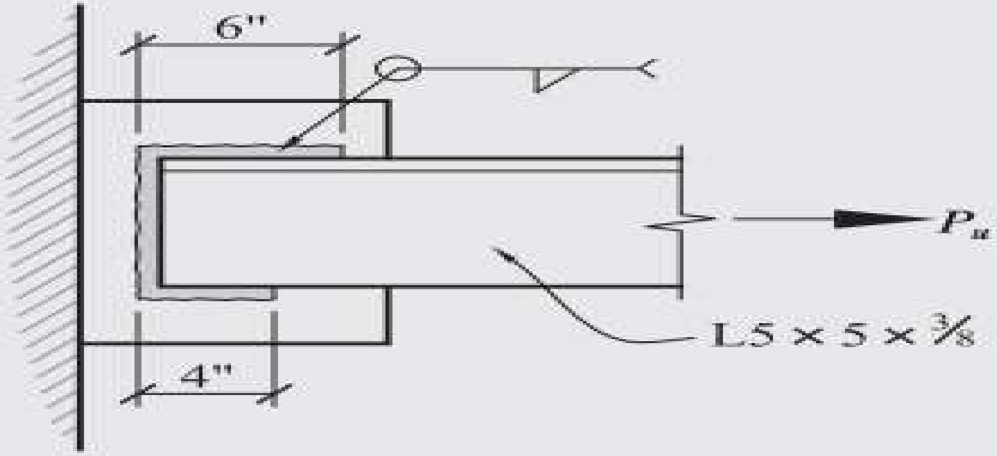



**Figure 4-7** Detail for Example 4-2.

*(continued)*

Solution

① Determine $\bar{x}$, area For L5X5X3/8

From Table 1-7

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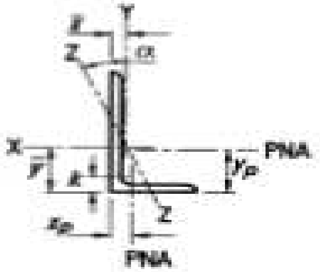
$L\ 5'' \times 5'' \times 3/8''$




## Table 1-7 (continued)
# Angles
## Properties

| Shape | k | Wt. | Area, A | Axis X-X I | S | r | $\bar{y}$ | Z | $y_p$ | Flexural-Torsional Properties J | $C_w$ | $\bar{r}_o$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | in. | lb/ft | in.$^2$ | in.$^4$ | in.$^3$ | in. | in. | in.$^3$ | in. | in.$^4$ | in.$^6$ | in. |
| L5×5×7/8 | 1 3/8 | 27.2 | 8.00 | 17.8 | 5.16 | 1.49 | 1.56 | 9.31 | 0.800 | 2.07 | 3.53 | 2.64 |
| ×3/4 | 1 1/4 | 23.6 | 6.98 | 15.7 | 4.52 | 1.50 | 1.52 | 8.14 | 0.698 | 1.33 | 2.32 | 2.67 |
| ×5/8 | 1 1/8 | 20.0 | 5.90 | 13.6 | 3.85 | 1.52 | 1.47 | 6.93 | 0.590 | 0.792 | 1.40 | 2.70 |
| ×1/2 | 1 | 16.2 | 4.79 | 11.3 | 3.15 | 1.53 | 1.42 | 5.66 | 0.479 | 0.417 | 0.744 | 2.73 |
| ×7/16 | 15/16 | 14.3 | 4.22 | 10.0 | 2.78 | 1.54 | 1.40 | 5.00 | 0.422 | 0.284 | 0.508 | 2.74 |
| ×3/8 | 7/8 | 12.3 | 3.65 | 8.76 | 2.41 | 1.55 | 1.37 | 4.33 | 0.365 | 0.183 | 0.327 | 2.76 |
| ×5/16 | 13/16 | 10.3 | 3.07 | 7.44 | 2.04 | 1.56 | 1.35 | 3.65 | 0.307 | 0.108 | 0.193 | 2.77 |

① $A_g = 3.65\ inch^2$

$\bar{x} = \bar{y}$

From Table 1-7 $= 1.37''$

② $L_{average} = \frac{4+6}{2} = 5''$

$L_{Least} = 4''$

$U = \left(1 - \frac{\bar{x}}{L}\right) = \left(1 - \frac{1.37}{5}\right) = 0.726$ → SEGUI

$A_{eff} = U \cdot A_g = 0.726(3.65) = 2.65\ inch^2$

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