Design of Steel Tension Members

What is the maximum P?

$$\sum \gamma_i Q_i \leq \phi R_n$$

LRFD Equation

Design of Steel Tension Members

Equations for strength of tension members:

a) For yielding in the gross section:

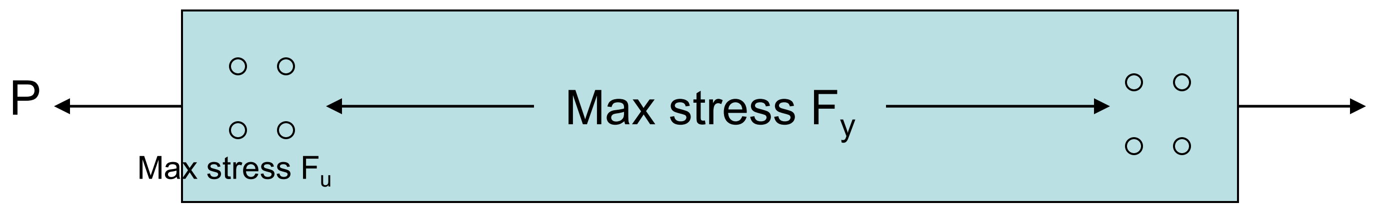
$$\phi_t P_n = \phi_t F_y A_g$$

b) For fracture in the net section:

$$\phi_t P_n = \phi_t F_u A_e$$

Design of Steel Tension Members

- Yielding in the gross section:



Variable Definitions

- Resistance factor, ϕ_t :

  = 0.90 for yielding (p. 2-12 LRFD)

  = 0.75 for fracture

- F_y = Yield Strength (p. 2-24 LRFD)
- F_u = Tensile or Ultimate strength (p. 2-24 LRFD)

Areas defined in Chapter B, Design Requirements

Design Requirements

- A_g – Gross cross-sectional area
- A_e – Effective net area

If tension load is transmitted directly to each of the cross-sectional elements by fasteners or welds:

- $A_e = A_n$
- A_n = Net cross-sectional area

  (gross-section minus bolt holes)

Design Requirements

If tension load transmitted through some but not all of the cross-sectional elements:

by fasteners,

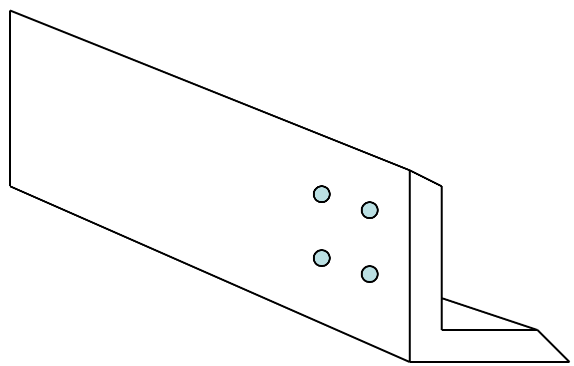
$$A_e = A_n U$$

by welds,

$$A_e = A_g U \qquad \text{or} \qquad A_e = AU$$

Example of tension transmitted by some but not all of cross-section

L –shape with bolts in one leg only

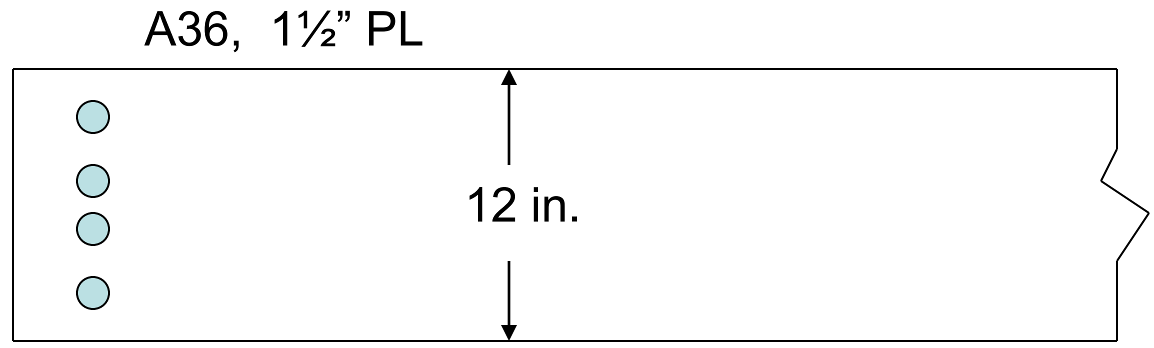


Reduction coefficient, $U = 1 - \left(\frac{\bar{x}}{l} \right) \leq 0.9$

Where $\bar{x}$ is the connection eccentricity (p. 16.1-177)

Tension Analysis Example

Determine the factored strength of a 12" x 1.5", A36 steel plate connected with one row of 4 – ¾" diameter bolts positioned transversely in a single line.

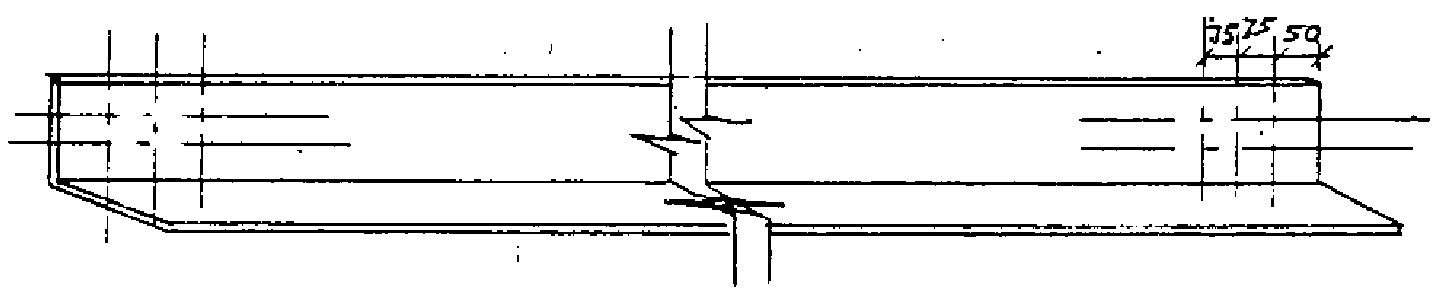


Design Example (top p. 9 notes)

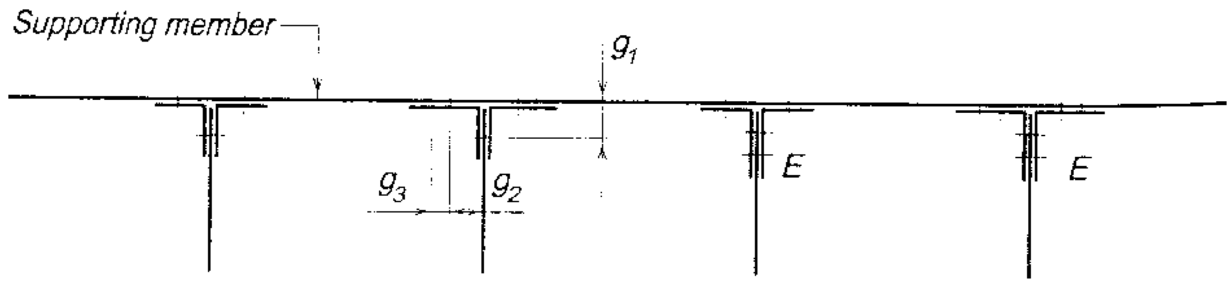
Design a 1000 mm long splice plate to carry a tensile live load of 130 kN and dead load due to a mass of 4500 kg. The bolts will be ¾" in diameter and there will be at least three of them in a row parallel to the direction of force at each end. Space constraints require you to keep the width of the plate ≤ 100 mm. Use A36 steel in conformance with the rest of the building.

Design Example (bottom p. 9 notes)

Design a tension member for a live load of 67.4 kips and a dead load of 22.0 kips. It is part of a web system of a truss and will be 14.8 ft long between connections. The end connections will require two rows of ¾” diameter bolts, with three bolts per row. As a truss web member, an angle section seems most appropriate. Use A36 steel to conform to the rest of the truss.



LRFD p. 10-10



E indicates that eccentricity must be considered in this leg.
Gages g_1 g_2 g_3 are workable gages as shown below

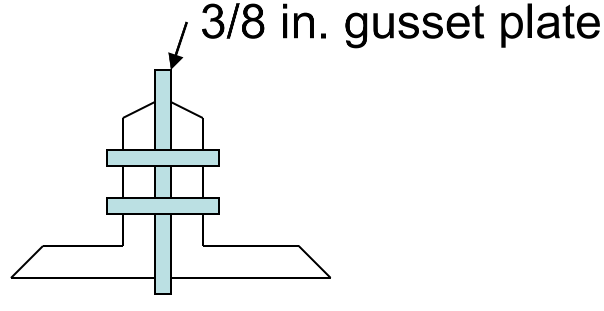
Workable gages* in angle legs, in.														
Leg	**8**	**7**	**6**	**5**	**4**	**3½**	**3**	**2½**	**2**	**1¾**	**1½**	**1⅜**	**1¼**	**1**
g_1	4½	4	3½	3	2½	2	1¾	1⅜	1⅛	1	⅞	⅞	¾	⅝
g_2	3	2½	2¼	2										
g_3	3	3	2½	1¾										

*Other gages are permitted to suit specific requirements subject to clearances and edge distance limitations.

Fig. 10-6. Eccentricity in double-angle connections.

Design Example (p. 10 notes)

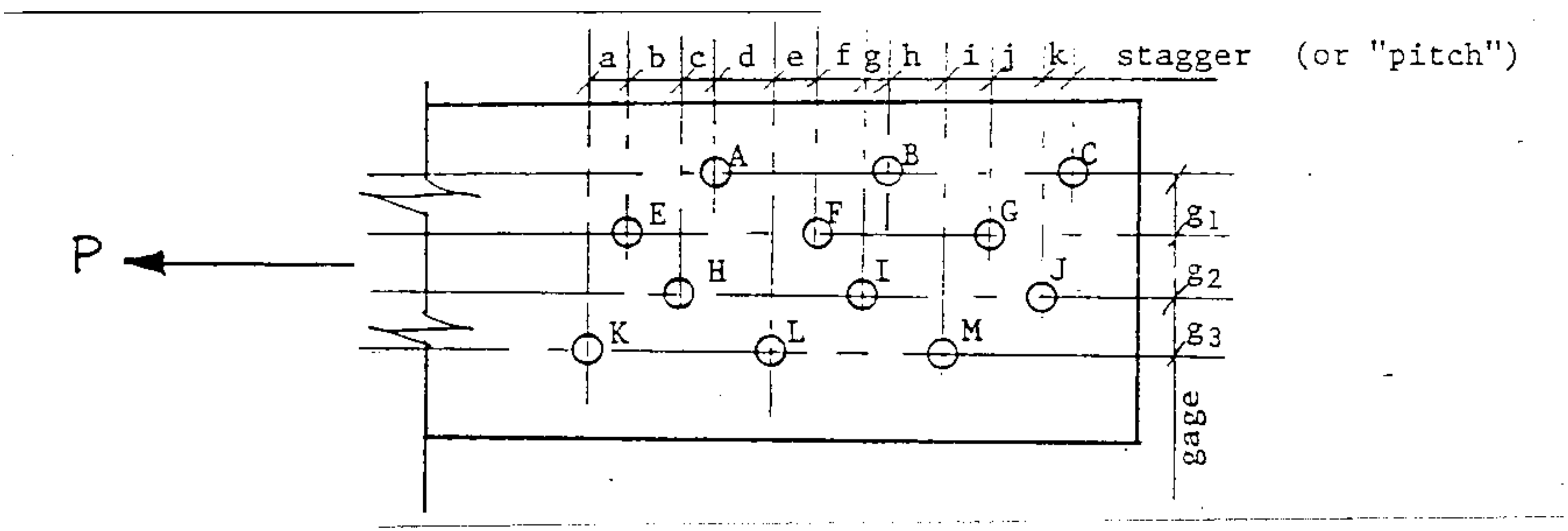
Same as previous example but with double angles back to back. Assume that they will be bolted to 3/8 in. thick gusset plates, straddling them at each end.



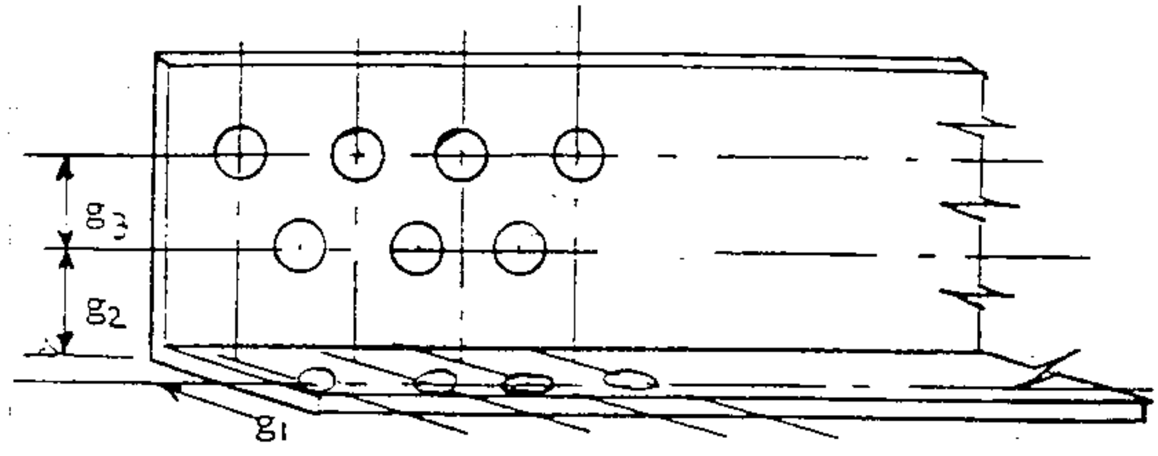
Net Section for Staggered Bolt Holes

Recall definition of Net Area, LRFD p. 16.1-10

$$A_n = A_g - \sum Dt + \sum \frac{s^2}{4g} t$$

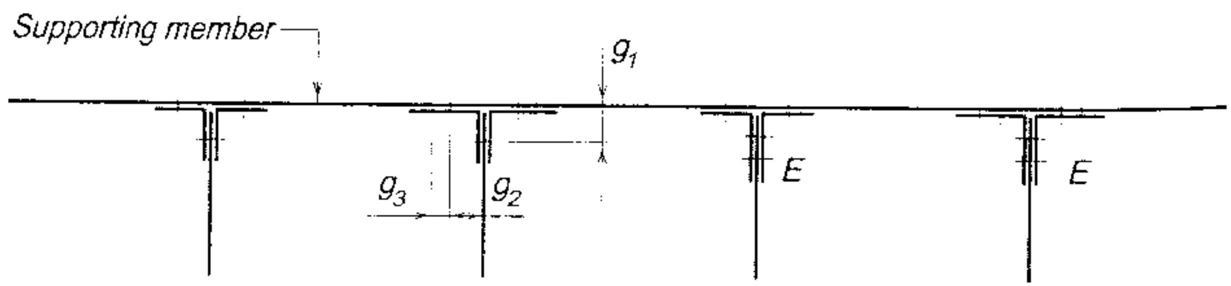


Staggered Bolt Hole Example (p. 12 notes)



Consider the 7 x 4 x ½ angle shown. The holes are 7/8" diameter, on normal gage lines. The holes are the U.S. standard 3" c.c. in each row, but the holes in the interior row in the 7" leg are offset by 1 ½ " from the other holes, which line up with each other. Find A_n for both a two hole and a three hold tear line.

LRFD p. 10-10



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g_1	4½	4	3½	3	2½	2	1¾	1⅜	1⅛	1	⅞	⅞	¾	⅝
g_2	3	2½	2¼	2										
g_3	3	3	2½	1¾										

*Other gages are permitted to suit specific requirements subject to clearances and edge distance limitations.

Fig. 10-6. Eccentricity in double-angle connections.