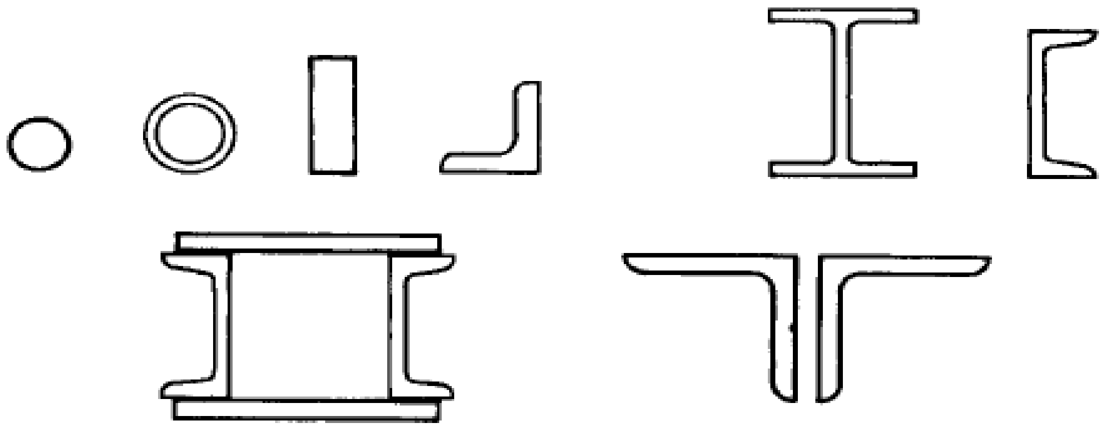

LRFD-Steel
SAVIN

Tension Members

- Tension members : structure element subjected to axial tensile force.
- Using of tension member is too wide as in
  - Cable in suspended roof
  - Cable in suspension
  - Cable in stayed bridge.
  - The only determinant of the strength of a tension member is the cross sectional area ,Therefore any cross sectional configuration may be used as (circular rod, rolled shapes, plates).



Tension Members

- The stress in an axially loaded tension member is given by:

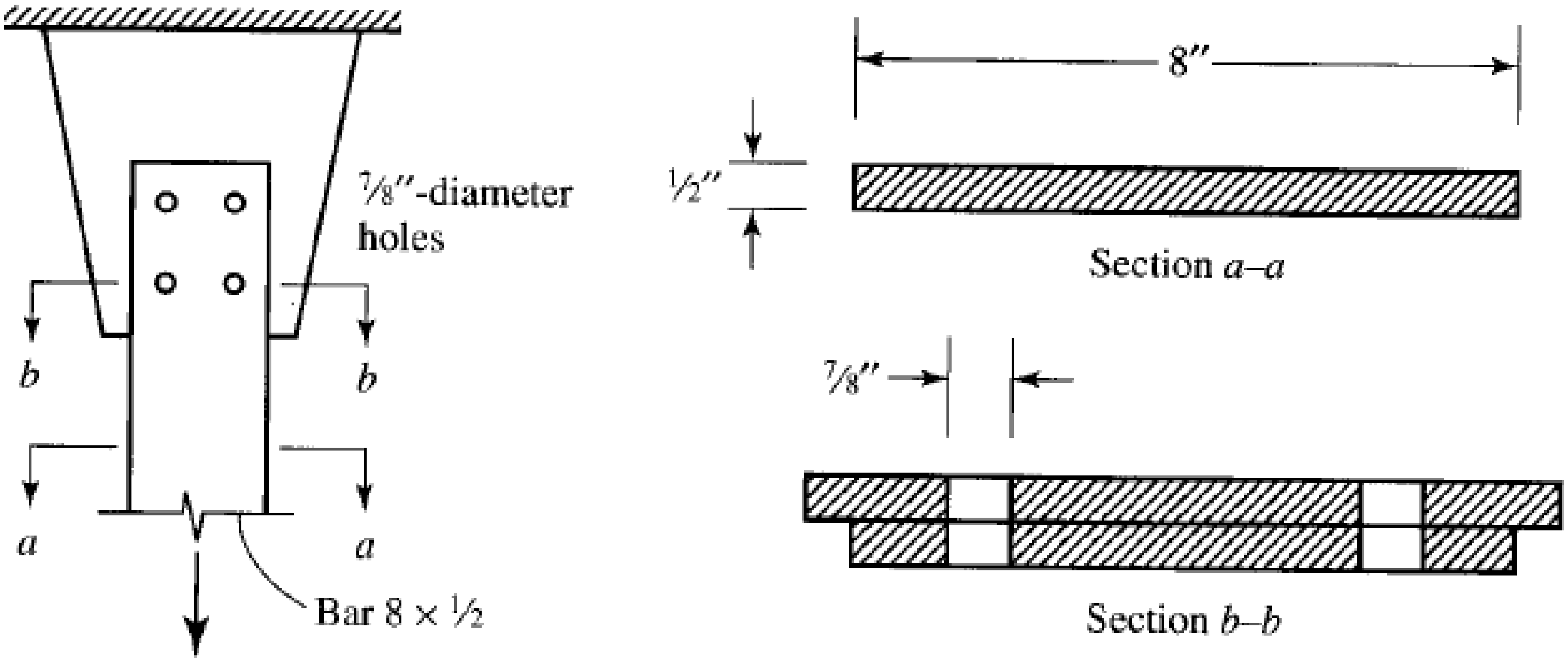
  P : magnitude of load

  A :cross sectional area

  [redacted]

  - If the cross sectional area of a tension member varies along its length the stress is a function of the particular section under consideration .
  - The presence of holes in any member will influence the stress at a cross section through the holes.
  - When the cross section area be reduced the stress on the net area (the remaining area after remove bolt's area) will be increases we should check the design of rod at connections.

Tension members are frequently connected at there ends with bolts as shown



Design Strength

- A tension member can fail by reach two limit states:
  - Excessive deformation
  - Fracture.
- To prevent excessive deformation the load on the gross section must be small enough that the stress on the gross section is less than the yield stress Fy
- To prevent fracture the stress on the net section must be less than the tensile strength Fu.

- The nominal strength in yielding is:
- the resistance factor Ø = Ø$_t$ for yielding = 0.90

[redacted]

- The nominal strength in fracture is:
- the resistance factor for fracture = 0.75

[redacted]

  where Ae is the effective net area

Design Strength

- **The presence of holes in any member will influence the stress at a cross section through the holes**
- **Because there are two limit state , both of the following condition must be satisfied:**

[redacted] [redacted]

- **for any bolts we must to add [redacted] inch to its diameter fastener in order to account the area net**
- **but for slotted holes we added [redacted] inch only.**

(See chapter J ,connection , joints , fasteners)

Design Strength

- Example 3.1 :

A ½ × 5 plate of A36 steel is used as a tension member. It is connected to a gusset plate with four 5/8-inch-diameter bolts, as shown. Assume that the effective net area A_e equals the actual net area A_n and compute the design strength.

Solution:

For yielding of the gross section,

$$A_g = 5\left(\frac{1}{2}\right) = 2.5 \text{ in.}^2$$

The *nominal* strength is

$$P_n = F_y A_g = 36(2.5) = 90 \text{ kips}$$

and the *design* strength is

$$\phi_t P_n = 0.90(90) = 81 \text{ kips}$$

For fracture of the net section,

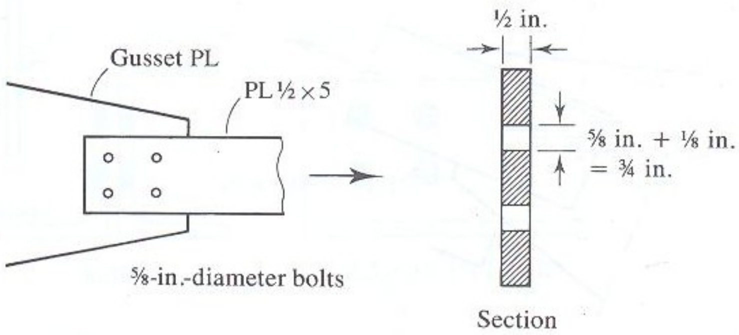
$$A_n = A_g - A_{\text{holes}}$$

$$= 2.5 - \left(\frac{1}{2}\right)\left(\frac{3}{4}\right) \times 2 \text{ holes}$$

$$= 2.5 - 0.75 = 1.75 \text{ in.}^2$$

$$A_e = A_n = 1.75 \text{ in.}^2$$

(This is true for this example, but A_e does not always equal A_n)



Design Strength

The *nominal* strength is

$$P_n = F_u A_e = 58(1.75) = 101.5 \text{ kips}$$

and the *design* strength is

$$\phi_t P_n = 0.75(101.5) = 76.1 \text{ kips}$$

The smaller value controls.

Answer Design strength = 76.1 kips.

Design Strength

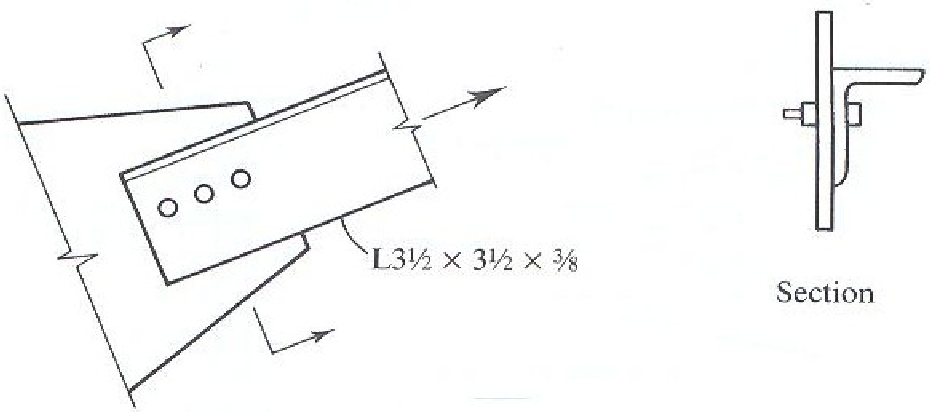
Example 3.2

A single-angle tension member, an L3 ½ × 3 ½ × ⅜, is connected to a gusset plate with ⅞-inch-diameter bolts as shown. A36 steel is used. The service loads are 35 Kips dead load and 15 Kips live load. Investigate this member for compliance with the AISC Specification. Assume that the effective net area is 85% of the computed net area.

Solution:

Combination 1: $1.4D = 1.4(35) = 49$ kips

Combination 2: $1.2D + 1.6L = 1.2(35) + 1.6(15) = 66$ kips



Design Strength

The second combination controls; $P_u = 66$ kips.

The design strengths are

Gross section: $A_g = 2.50 \text{ in.}^2$ (from Part 1 of the *Manual*)

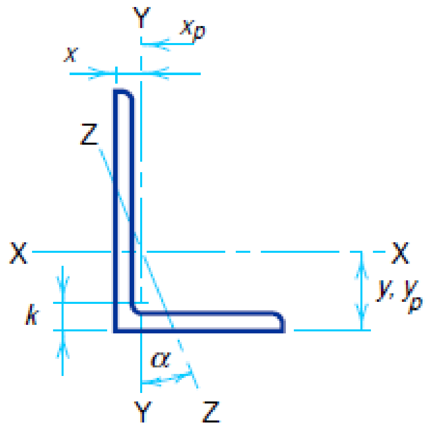
$$\phi_t P_n = \phi_t F_y A_g = 0.90(36)(2.50) = 81 \text{ kips}$$

Net section: $$A_n = 2.50 - \left(\frac{3}{8}\right)\left(\frac{7}{8} + \frac{1}{8}\right) = 2.125 \text{ in.}^2$$

$$A_e = 0.85A_n = 0.85(2.125) = 1.806 \text{ in.}^2$$ (in *this* example)

$$\phi_t P_n = \phi_t F_u A_e = 0.75(58)(1.806) = 78.6 \text{ kips}$$ (controls)

Since $P_u < \phi_t P_n$ (66 kips < 78.6 kips), the member is satisfactory.



ANGLES

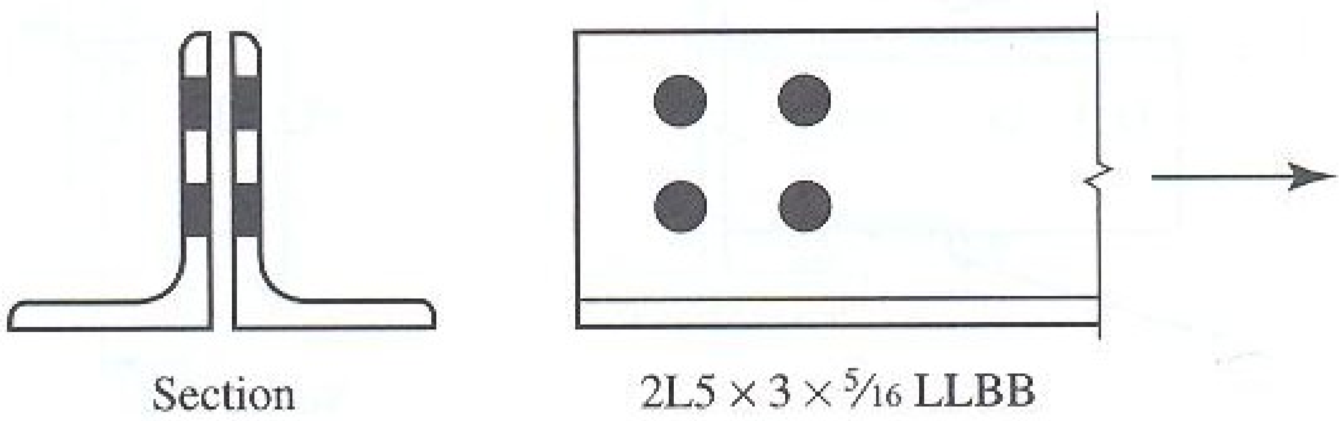
Equal legs and unequal legs
Properties for designing

Size and Thickness	k	Weight per ft	Area	Axis X-X					
				I	S	r	y	Z	y_p
in.	in.	lb	in.	in.^{2}	in.^{4}	in.^{3}	in.	in.^{3}	in.
L4×3×5/8	1 1/16	13.6	3.98	6.03	2.30	1.23	1.37	4.12	0.813
1/2	15/16	11.1	3.25	5.05	1.89	1.25	1.33	3.41	0.750
7/16	7/8	9.80	2.87	4.52	1.68	1.25	1.30	3.03	0.719
3/8	13/16	8.50	2.48	3.96	1.46	1.26	1.28	2.64	0.688
5/16	3/4	7.20	2.09	3.38	1.23	1.27	1.26	2.23	0.656
1/4	11/16	5.80	1.69	2.77	1.00	1.28	1.24	1.82	0.625
L3 1/2×3 1/2×1/2	7/8	11.1	3.25	3.64	1.49	1.06	1.06	2.68	0.464
7/16	13/16	9.80	2.87	3.26	1.32	1.07	1.04	2.38	0.410
3/8	3/4	8.50	2.48	2.87	1.15	1.07	1.01	2.08	0.355
5/16	11/16	7.20	2.09	2.45	0.976	1.08	0.990	1.76	0.299
1/4	5/8	5.80	1.69	2.01	0.794	1.09	0.968	1.43	0.241

Design Strength

- **Example 3.3**

Determine the tensile design strength of the double-angle shape shown. A36 steel is used, the holes are for 1/2-inch-diameter bolts. Assume that the effective net area is 75% of the computed net area.



Solution:

Figure 3.5 illustrates the notation for unequal-leg double-angle shapes. The notation LLBB means "long-legs back-to-back," and SLBB indicates "short-legs back-to-back."

When a double-shape section is used, two approaches are possible: (1) Consider a single shape and double everything, or (2) consider two shapes from the outset. (Properties of the double-angle shape are given in Part 1 of the *Manual*.) In this example, we consider one angle and double the result. For one angle, the design strength based on the gross area is

L5×3 1/2×3/4	1 3/16	19.8	5.81	13.9	4.26	1.55	1.74	7.60	1.12	1.09	1.52	2.36
×5/8	1 1/16	16.8	4.92	12.0	3.63	1.56	1.69	6.50	1.06	0.651	0.918	2.39
×1/2	15/16	13.6	4.00	9.96	2.97	1.58	1.65	5.33	0.997	0.343	0.491	2.42
×3/8	13/16	10.4	3.05	7.75	2.28	1.59	1.60	4.09	0.933	0.150	0.217	2.45
×5/16	3/4	8.70	2.56	6.58	1.92	1.60	1.57	3.45	0.901	0.0883	0.128	2.47
×1/4	11/16	7.00	2.06	5.36	1.55	1.61	1.55	2.78	0.868	0.0464	0.0670	2.48
L5×3×1/2	15/16	12.8	3.75	9.43	2.89	1.58	1.74	5.12	1.25	0.322	0.444	2.38
×7/16	7/8	11.3	3.31	8.41	2.56	1.59	1.72	4.53	1.21	0.220	0.304	2.39
×3/8	13/16	9.80	2.86	7.35	2.22	1.60	1.69	3.93	1.18	0.141	0.196	2.41
×5/16	3/4	8.20		6.24	1.87	1.61	1.67	3.32	1.15	0.0832	0.116	2.42
×1/4	11/16	6.60	1.94	5.09	1.51	1.62	1.64	2.68	1.12	0.0438	0.0606	2.43
L4×4×3/4	1 1/8	18.5	5.44	7.62	2.79	1.18	1.27	5.02	0.679	1.02	1.12	2.10
×5/8	1	15.7	4.61	6.62	2.38	1.20	1.22	4.28	0.576	0.610	0.680	2.13
×1/2	7/8	12.8	3.75	5.52	1.96	1.21	1.18	3.50	0.468	0.322	0.366	2.16
×7/16	13/16	11.3	3.31	4.93	1.73	1.22	1.15	3.10	0.413	0.220	0.252	2.18
×3/8	3/4	9.80	2.86	4.32	1.50	1.23	1.13	2.69	0.357	0.141	0.162	2.19
×5/16	11/16	8.20	2.40	3.67	1.27	1.24	1.11	2.26	0.300	0.0832	0.0963	2.21
×1/4	5/8	6.60	1.94	3.00	1.03	1.25	1.08	1.82	0.242	0.0438	0.0505	2.22

Design Strength

$$\phi_t P_n = \phi_t F_y A_g = 0.90(36)(2.41) = 78.08 \text{ kips}$$

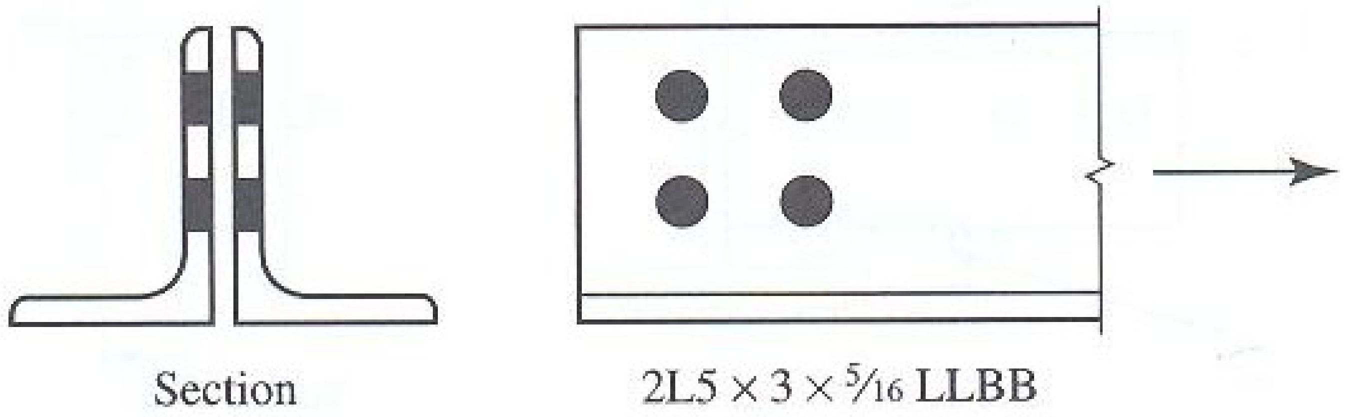
There are two holes in each angle, so the net area of one angle is

$$A_n = 2.41 - \left(\frac{5}{16}\right)\left(\frac{1}{2} + \frac{1}{8}\right) \times 2 = 2.019 \text{ in.}^2$$

The effective net area is

$$A_e = 0.75(2.019) = 1.514 \text{ in.}^2$$

Design Strength



- **The design strength based on the net area is**
- **Because 65.86 kips <78.08kips ,fracture of the net section controls , and the design strength for the two angles is 2 × 65.86 =132 Kips.**

$$\phi_t P_n = \phi_t F_u A_e = 0.75(58)(1.514) = 65.86 \text{ kips}$$