Solved problem 3-1-SEGUI- Find the LRFD and ASD design strength and allowable strength for a given plate 5x1/2 inches of A36 steel with two lines of bolts

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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),

$$P_n = F_y A_g \quad \text{(AISC Equation D2-1)}$$

Limit state of Yielding

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

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

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

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

Limit state of Rupture

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

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

Grade	Yield Point	Tensile Point
A36	36 ksi	58-80 ksi
A572	42-65 ksi*	0.5-0.7%
A514	100 ksi	110-130 ksi

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CM#15 A36 → up to 8" and over From 0.75" → 8" Check availabilty

2-50

Table 2-5
Applicable ASTM Specifications for Plates and Bars

Steel Type	ASTM Designation		F_y Yield Stress[a] (ksi)	F_u Tensile Stress[a] (ksi)	Plates and Bars, in.									
					to 0.75 incl.	over 0.75 to 1.25 incl.	over 1.25 to 1.5 incl.	over 1.5 to 2 incl.	over 2 to 2.5 incl.	over 2.5 to 4 incl.	over 4 to 5 incl.	over 5 to 6 incl.	over 6 to 8 incl.	over 8
Carbon	A36		32	58–80										
			36	58–80										
	A283[e]	Gr. C	30	55–75					d					
		Gr. D	33	60–80					d					
	A529	Gr. 50	50	65–100		b	b	b	b	b				
		Gr. 55	55	70–100		c	c	c	c	c				
	A709	Gr. 36	36	58–80										

New item

Two Grades added

[a] Minimum, unless a range is shown.
[b] Applicable for plates to 1 in. thickness and bars to 3½ in. thickness.
[c] Applicable for plates to 1 in. thickness and bars to 3 in. thickness.
[d] Thickness is not limited to 2 in. in ASTM A283 and thicker plates may be obtained but availability should be confirmed.
[e] This specification is not a prequalified base metal per AWS D1.1/D1.1M:2015.
[f] Applicable for plates to 3 in. thickness.
[g] Applicable for plates to 1 in. thickness.

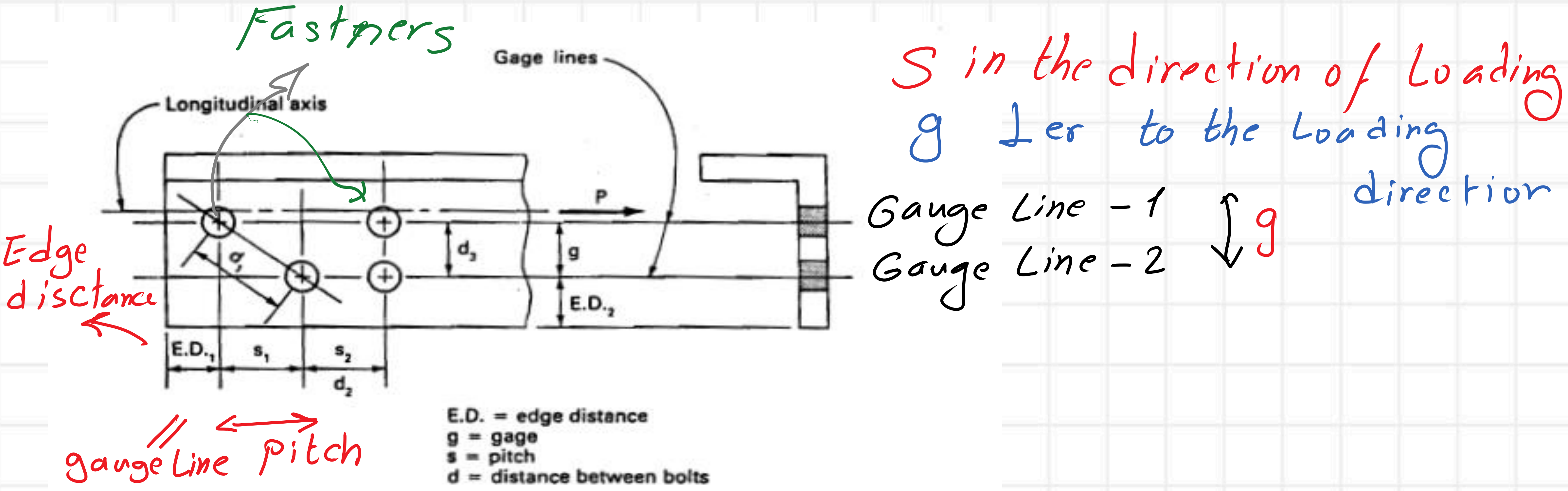

Figure 2-3 shows a tension member composed of a single steel angle with a 4-bolt connection. The tensile load P is assumed to be applied parallel to and coincident with the longitudinal axis of the member. The bolt holes are located on *gage lines* that are also parallel to the longitudinal axis. The dimension g between the gage lines is called the *gage*. The dimension s parallel to the gage line and taken between centers of bolt holes is called the *pitch* (or the *bolt spacing*). The *distance between bolts* is a straight line distance between any two bolts. The *edge distance* is the perpendicular distance from the *center of a hole* to the nearest edge.

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EXAMPLE 3.1

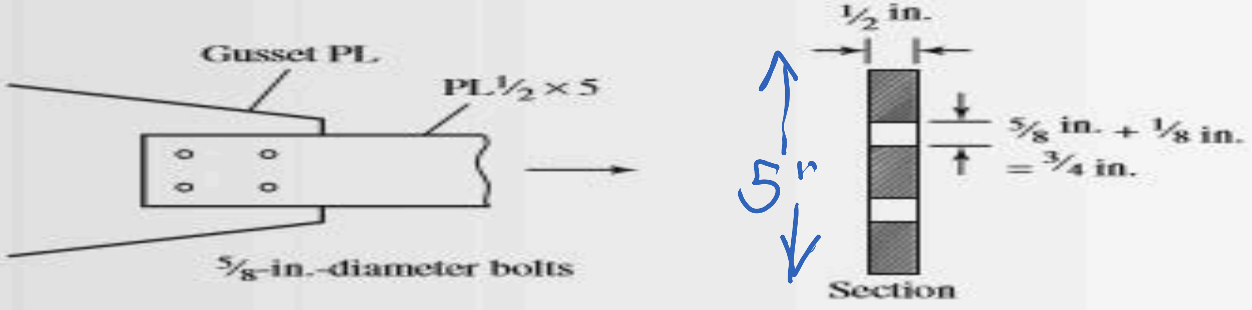
A ½ × 5 plate of A36 steel is used as a tension member. It is connected to a gusset plate with four ⅝-inch-diameter bolts as shown in Figure 3.3. Assume that the effective net area A_e equals the actual net area A_n (we cover computation of effective net area in Section 3.3).

a. What is the design strength for LRFD?

b. What is the allowable strength for ASD?

Limit State of Yielding

FIGURE 3.3



Fy

A 36 (36 ksi)

Fu = 58 ksi

Solution

$A_g = 5\left(\frac{1}{2}\right) = 2.50 \text{ inch}^2$

$\phi : \frac{5}{8} + \frac{1}{8} = \frac{6}{8}$

No = 2

$A_{net} = 2.50 - 2\left(\frac{6}{8}\right)\left(\frac{1}{2}\right) = 2.5 - \frac{6}{8} = 1.75 \text{ inch}^2$

LRFD: $P_n = A_g F_y$

$P_n = 2.50(36) = 90$ kips

$\phi_t P_n = 0.90(90) = 81$ kips

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A ½ × 5 plate of A36 steel is used as a tension member. It is connected to a gusset plate with four ⅝-inch-diameter bolts as shown in Figure 3.3. Assume that the effective net area A_e equals the actual net area A_n (we cover computation of effective net area in Section 3.3).

a. What is the design strength for LRFD?

b. What is the allowable strength for ASD?

dh=db+1/8"

dh=5/8+1/8=6/8 inches

FIGURE 3.3

Tensile rupture=Anet*Fu

A36-FU=58 ksi

Fy

A 36 (36 ksi)

FU = 58 ks

Solution

$A_g = 5\left(\frac{1}{2}\right) = 2.50 \text{ inch}^2$

$\phi = \frac{5}{8} + \frac{1}{8} = \frac{6}{8}$

No = 2

$A_{net} = 2.50 - 2\left(\frac{6}{8}\right)\left(\frac{1}{2}\right) = 2.5 - \frac{6}{8} = 1.75 \text{ inch}^2$

LRFD: $P = A_{net} F_U = 1.75(58) =$

$\phi = 0.75$

tensile rupture

$\phi P_n = 0.75(1.75)(58) = 76.1$ kips

$\phi P_n = \min(90, 76.1) \Rightarrow 76.1$ kips Final LRFD tensile strength

ADS limit state of yielding

$\Omega = \frac{1.50}{0.90} = 1.67$

$\frac{P_n}{\Omega_y} = \frac{1}{1.67}(2.50)(36) = 54$ kips

Limit state of Tension Fracture.

$\Omega = \frac{1.50}{\left(\frac{3}{4}\right)} = 2$, $A_{net} = 1.75 \text{ inch}^2$

$\frac{P_n}{\Omega_F} = \frac{1.75(58)}{2} = 50.8$ kips

Select $\frac{P_n}{\Omega_F} = 50.8$ Kips Final ASD allowable strength.