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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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 ($\phi_t = 0.9$)

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

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

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

Limit state of Rupture

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

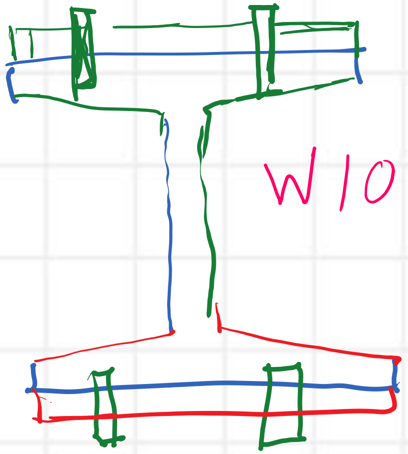
$$\frac{P_n}{\Omega_t} = \frac{F_u A_e}{\Omega_t} \text{ allowable tensile rupture strength for ASD } (\Omega_t = 2.00)$$

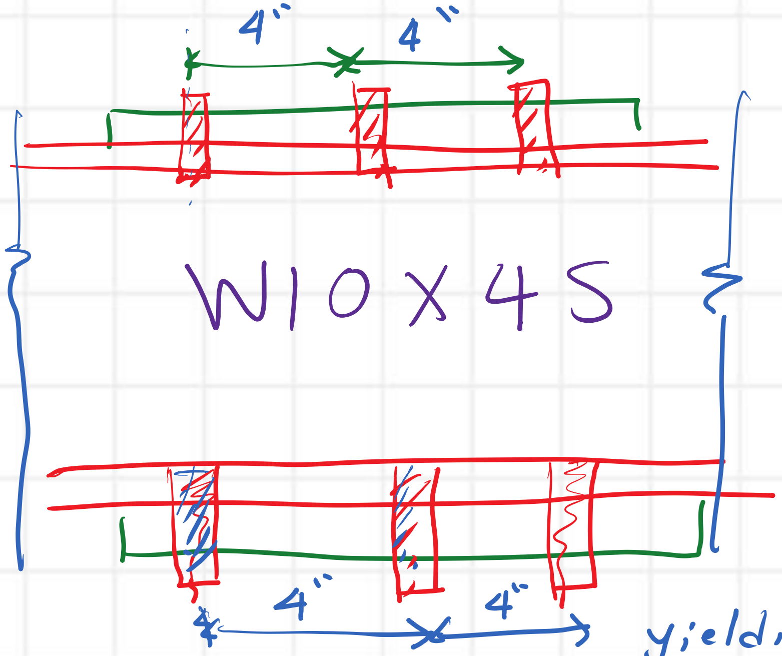
Mccormac.

Example 3-6

Determine the LRFD design tensile strength and the ASD allowable design tensile strength for a W10 × 45 with two lines of $\frac{3}{4}$-in diameter bolts in each flange using A572 Grade 50 steel, with $F_y = 50$ ksi and $F_u = 65$ ksi, and the AISC Specification. There are assumed to be at least three bolts in each line 4 in on center, and the bolts are not staggered with respect to each other.

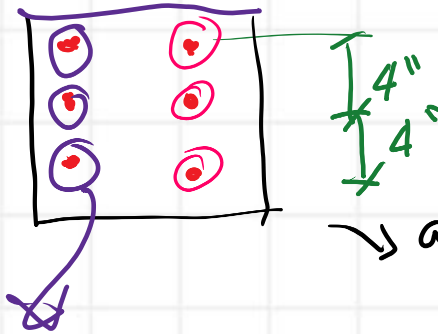
Solution





$$d_b = \frac{3}{4}" \rightarrow d_h = \frac{3}{4} + \frac{1}{8} = 7/8$$

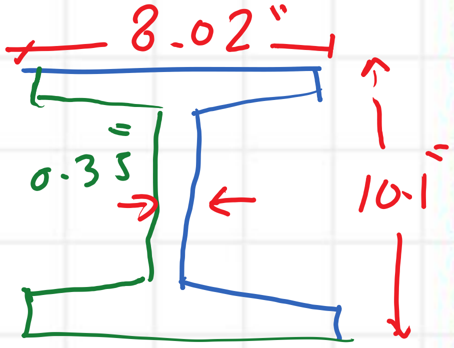
Shape	Area, A	Depth, d		Web Thickness, t_w		$\frac{t_w}{2}$	Flange Width, b_f		Flange Thickness, t_f		Distance k k_{des}	k k_{det}	k_1	T	Workable Gage
	in.^{2}	in.		in.		in.	in.		in.		in.	in.	in.	in.	in.
W10×45	13.3	10.1	10 1/8	0.350	3/8	3/16	8.02	8	0.620	5/8	1.12	1 5/16	13/16	7 1/2	5 1/2
×39	11.5	9.92	9 7/8	0.315	5/16	3/16	7.99	8	0.530	1/2	1.03	1 3/16	13/16	↓	↓
×33	9.71	9.73	9 3/4	0.290	5/16	3/16	7.96	8	0.435	7/16	0.935	1 1/8	3/4		



yielding → A_g

Fracture → $A_e = U A_{net}$

LRFD, ASD



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LRFD | ASD

Tensile yielding → A_g

$\phi = 0.90$ →

$A_g = 13.30\ inch^2$

$F_y = 50\ ksi$

$P_n = A_g F_y = 13.30(50) = 665$ kips

↓ Nomial Tension

$\phi P_n = 0.90(665) = 598.5 \approx 599$ kips

ultimate

bigger of $\begin{bmatrix} 1.4D \\ 1.2D + 1.6L \end{bmatrix}$

ASD

Tensile yielding

$\Omega_t = 1.67$

$A_g = 13.30\ inch^2$

$F_y = 50\ ksi$

$P_n = 665$ kips

$\frac{P_n}{\Omega} = \frac{665}{1.67} = 399$ kips

$[D + L]$

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Tensile rupture

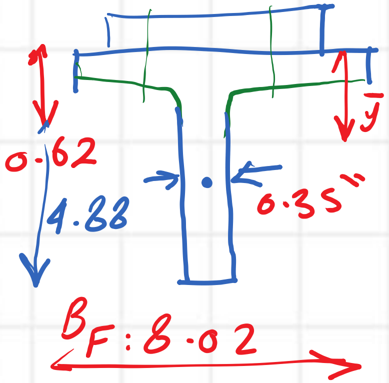
$A_e = U \cdot A_{net} = A_{net}\left(1 - \frac{\bar{x}}{L}\right)$ How

Consider WT 5X22.5

W10 X 45 → parent

Convert

$\bar{y} = 0.907$



$d = 5.5''$

$\bar{y} = 0.907$

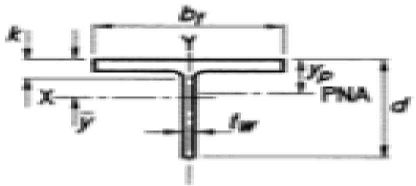
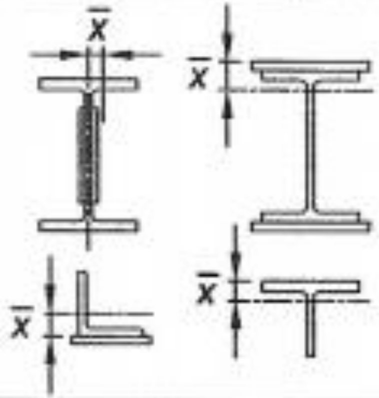


Table 1-8 (continued)
WT-Shapes
Dimensions

Shape	Area, A	Depth, d		Stem Thickness, t_w		Stem $\frac{t_w}{2}$	Stem Area	Flange Width, b_f		Flange Thickness, t_f		Distance k k_{des}	Distance k k_{det}	Workable Gage
	in.²	in.		in.		in.	in.²	in.		in.		in.	in.	in.
WT5×22.5	6.63	5.05	5	0.350	3/8	3/16	1.77	8.02	8	0.620	5/8	1.12	1 5/16	
×19.5	5.73	4.96	5	0.315	5/16	3/16	1.56	7.99	8	0.530	1/2	1.03	1 3/16	
×16.5	4.85	4.87	4 7/8	0.290	5/16	3/16	1.41	7.96	8	0.435	7/16	0.935	1 1/8	

Nominal Wt.	Compact Section Criteria $\frac{b_f}{2t_f}$	Compact Section Criteria $\frac{d}{t_w}$	Axis X-X I	Axis X-X S	Axis X-X r	Axis X-X $\bar{y}$	Axis X-X Z	Axis X-X y_p	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r	Axis Y-Y Z	Q_s $F_y = 50$ ksi	Torsional Properties J	Torsional Properties C_w
lb/ft			in.⁴	in.³	in.	in.	in.³	in.	in.⁴	in.³	in.	in.³		in.⁴	in.⁶
22.5	6.47	14.4	10.2	2.47	1.24	0.907	4.65	0.413	26.7	6.65	2.01	10.1	1.00	0.753	0.981
19.5	7.53	15.7	8.84	2.16	1.24	0.876	3.99	0.359	22.5	5.64	1.98	8.57	1.00	0.487	0.616
16.5	9.15	16.8	7.71	1.93	1.26	0.869	3.48	0.305	18.3	4.60	1.94	7.00	1.00	0.291	0.356

General Case

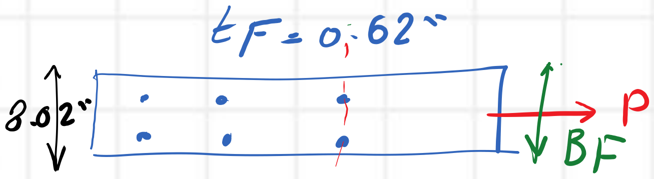
2	All tension members, except HSS, where the tension load is transmitted to some but not all of the cross-sectional elements by fasteners or by longitudinal welds in combination with transverse welds. Alternatively, Case 7 is permitted for W, M, S and HP shapes. (For angles, Case 8 is permitted to be used.)	$U = 1 - \frac{\bar{x}}{l}$	

Case 7

Flange Connection

7	W-, M-, S- or HP-shapes, or tees cut from these shapes. (If U is calculated per Case 2, the larger value is permitted to be used.)	with flange connected with three or more fasteners per line in the direction of loading	$b_f \geq \frac{2}{3}d,\ U = 0.90$ $b_f < \frac{2}{3}d,\ U = 0.85$	–
		with web connected with four or more fasteners per line in the direction of loading	$U = 0.70$	–

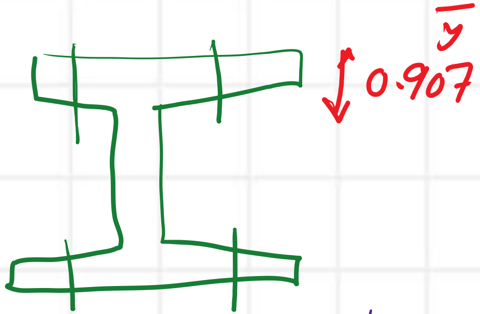
web-connection



Top and bottom

$A_{net} = A_{gross} - \phi \cdot t_F = 13.30 - (\frac{7}{8})\, 4(0.62) = 11.13$ inch²

For $U = (1 - \frac{\bar{X}}{L}) \rightarrow U = (1 - \frac{0.907}{2(4)}) = 0.8867 = 0.89$



U From Table

Case - 2

Fastner 3 or more

7	W-, M-, S- or HP-shapes, or tees cut from these shapes. (If U is calculated per Case 2, the larger value is permitted to be used.)	with flange connected with three or more fasteners per line in the direction of loading	$b_f \geq \frac{2}{3}d$, $U = 0.90$ $b_f < \frac{2}{3}d$, $U = 0.85$	–
		with web connected with four or more fasteners per line in the direction of loading	$U = 0.70$	–

Check bf/d

$b_f = 8.02"$

$d = 10.10"$

$\frac{b_f}{d} = \frac{8.02}{10.10"} = 0.794 > \frac{2}{3}$

$U = 0.90 \rightarrow$ Larger than 0.89

LRFD

$F_u : 65$ ksi

$\phi : 0.75$

inch²

$A_{eff} = 0.90(11.13) = 10.02$

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LRFD Tensile yielding

$\phi_T A_g F_y = 599$ kips

Min value $= 488.30$ kips

LRFD Tensile rupture

$\phi_T A_e \cdot F_u = 0.75(10.02)(65) = 488.30$ kips

ASD $\frac{1}{\Omega}(A_g)(F_y)$ 399 k → yielding

$\Omega = 1.67$

ASD rupture

$\frac{1}{\Omega} A_e F_u \Rightarrow \Omega = 2$

$\frac{1}{2}(10.02)(65)$

$= 325.6$ kips

$\frac{P_n}{\Omega}$ rupture $\Rightarrow 325.60$ kip min

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