CE 415
DESIGN OF STEEL STRUCTURES

LECTURE 3
TENSION MEMBER

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LRFD Design

$\phi_t T_n \geq T_u$

Where,
ϕ_t = resistance factor relating to tension member strength
T_n = nominal strength of a tension member (see AISC-Chapter D)
$\phi_t T_n$ = design strength of a tension member
T_u = factored load on a tension member

Tension Members have THREE limit states:

1. Yielding on gross section
2. Fracture on effective section
3. *Block Shear*

Yielding on gross section

$\phi_t T_n = \phi_t F_y A_g = 0.9\ F_y A_g$

Fracture on effective net section

$\phi_t T_n = \phi_t F_u A_e = 0.75\ F_u A_e$

Note that the resistance factor ϕ_t is 0.90 for the yielding limit state and 0.75 for the fracture limit state.

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ASD Design

Yielding on gross section

Nominal Strength: $T_n = F_y A_g$

Allowable Strength: $$\frac{T_n}{\Omega} = \frac{F_y A_g}{\Omega} = \frac{F_y A_g}{1.67}$$

Safety factor Ω = 1.67 for yielding on gross section

Fracture on effective net section

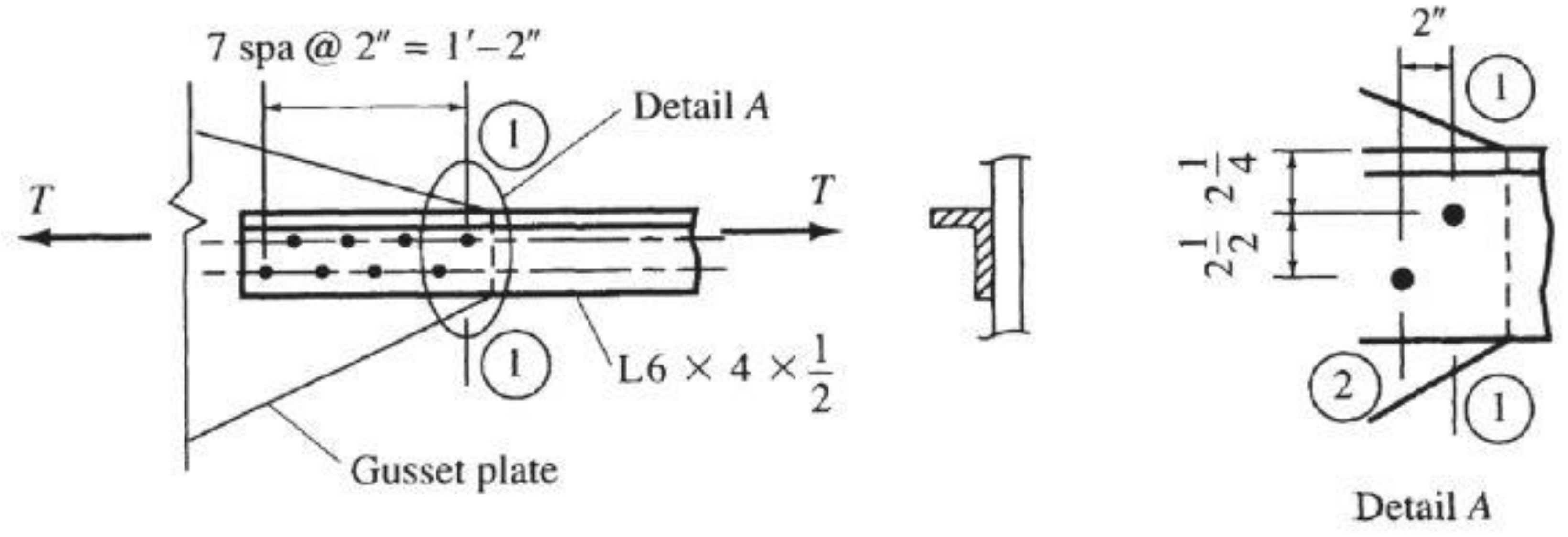
Nominal Strength: $T_n = F_u A_e$

Allowable Strength: $$\frac{T_n}{\Omega} = \frac{F_u A_e}{\Omega} = \frac{F_u A_e}{2.00}$$

Safety factor Ω = 2.00 for fracture on net section

ASD Load Capacity

Determine the service load capacity in tension for an L6 x 4 x $^1/_2$ A572 Grade 50 steel connected with $^7/_8$ –in.-diam. bolts in standard holes as shown. Assume live load to be three times the dead load. Neglect block shear failure.



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Designation						A	I_x	r_x	y	I_y	r_y	x
L 9x4x1	9	x	4	x	1	12.0	97.0	2.84	3.50	12.0	1.00	1.00
L 7x4x0.625	7	x	4	x	5/8	6.48	32.4	2.24	2.46	7.84	1.10	0.963
L 6x4x0.75	6	x	4	x	3/4	6.94	24.5	1.88	2.08	8.68	1.12	1.08
L 6x4x0.625	6	x	4	x	5/8	5.86	21.1	1.90	2.03	7.52	1.13	1.03
L 6x4x0.5625	6	x	4	x	9/16	5.31	19.3	1.90	2.01	6.91	1.14	1.01
L 6x4x0.5	6	x	4	x	1/2	4.75	17.4	1.91	1.99	6.27	1.15	0.987
L 6x4x0.4375	6	x	4	x	7/16	4.18	15.5	1.92	1.96	5.60	1.16	0.964
L 6x4x0.375	6	x	4	x	3/8	3.61	13.5	1.93	1.94	4.90	1.17	0.941
L 4x3.5x0.437	4	x	3 1/2	x	7/16	3.09	4.76	1.24	1.23	3.40	1.05	0.978
L 4x3.5x0.375	4	x	3 1/2	x	3/8	2.67	4.18	1.25	1.21	2.95	1.06	0.955
L 4x3.5x0.312	4	x	3 1/2	x	5/16	2.25	3.56	1.26	1.18	2.55	1.07	0.932
L 4x3.5x0.25	4	x	3 1/2	x	1/4	1.81	2.91	1.27	1.16	2.09	1.07	0.909
L 4x3x0.625	4	x	3	x	5/8	3.98	6.03	1.23	1.37	2.87	0.849	0.871
L 4x3x0.5	4	x	3	x	1/2	3.25	5.05	1.25	1.33	2.42	0.864	0.827
L 4x3x0.4375	4	x	3	x	7/16	2.87	4.52	1.25	1.30	2.18	0.871	0.804
L 4x3x0.375	4	x	3	x	3/8	2.48	3.96	1.26	1.28	1.92	0.879	0.782
L 3.5x2.5x0.25	3 1/2	x	2 1/2	x	1/4	1.44	1.8	1.12	1.11	0.777	0.735	0.614
L 3x2.5x0.5	3	x	2 1/2	x	1/2	2.50	2.08	0.913	1.00	1.30	0.722	0.750
L 3x2.5x0.437	3	x	2 1/2	x	7/16	2.21	1.88	0.920	0.978	1.18	0.729	0.728
L 3x2.5x0.375	3	x	2 1/2	x	3/8	1.92	1.66	0.928	0.956	1.04	0.736	0.706
L 3x2.5x0.312	3	x	2 1/2	x	5/16	1.62	1.42	0.937	0.933	0.898	0.744	0.683
L 3x2.5x0.25	3	x	2 1/2	x	1/4	1.31	1.17	0.945	0.911	0.743	0.753	0.661
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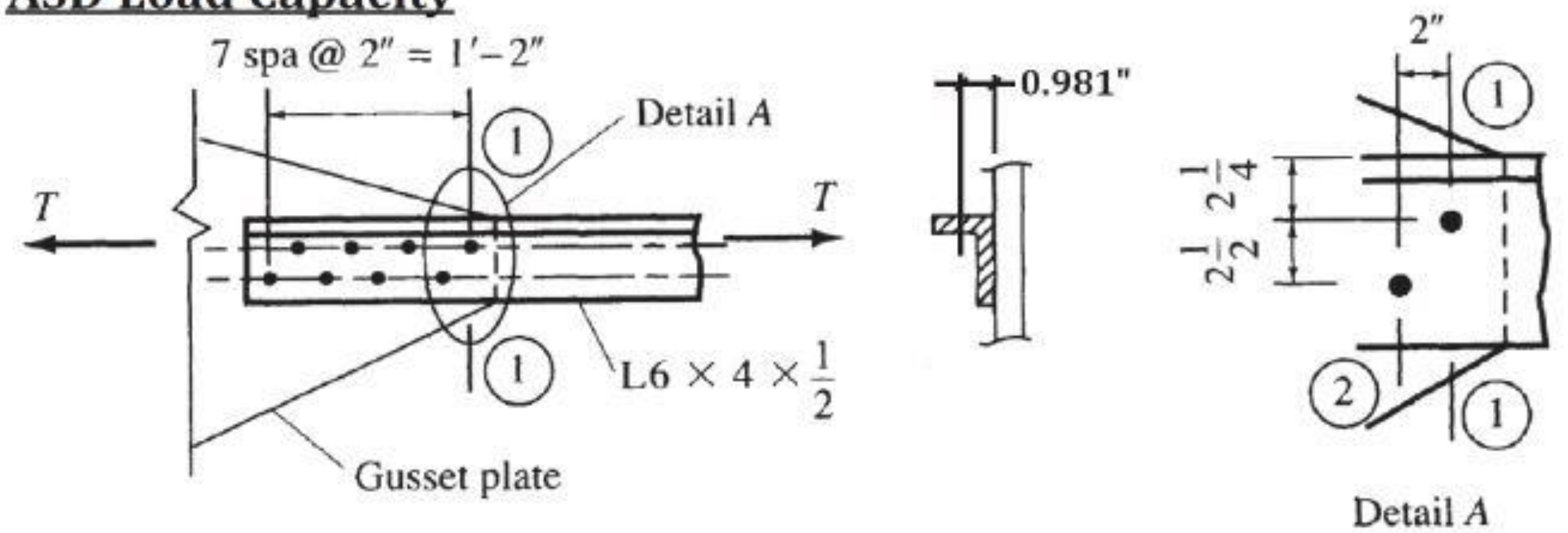
ASD Load Capacity



Consider net section along 1-1 and along 1-2, because at these two sections, full force is transferred.

From AISC Manual: $A_g = 4.75\ \text{in}^2$ **and** $\bar{x} = 0.981$

Along 1-1: $A_n = A_g - (\text{1-hole}) = 4.75 - (7/8 + 1/8)\times(1/2) = 4.25\ \text{in}^2$

Along 1-2: $A_n = A_g - (\text{2-hole}) + s^2/4g$

$= 4.75 - 2(7/8 + 1/8)\times(1/2) + 2^2/(4\times 2.5)(1/2)$

$= 3.95\ \text{in}^2$

$U = 1 - \bar{x}/L = 1 - 0.981/14 = 0.93$

$A_e = UA_n = 0.93 \times 3.95 = 3.67\ \text{in}^2.$

ASD Load Capacity

A572 Grade 50 steel: F_y = 50 ksi, F_u=65 ksi.

Yielding on gross area:

Allowable tension = $T_n/\Omega = F_yA_g/\Omega = 50(4.75)/1.67 = 142$ kips

Fracture on effective area:

Allowable tension = $T_n/\Omega = F_uA_e/\Omega = 65(3.67)/2.00 = 119$ kips $\rightarrow$ Governs

Now, $D + L = 119$

$\Rightarrow D + 3D = 119$

$\Rightarrow D = 29.75$ kips

$\therefore L = 3D = 89.25$ kips

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