CE 415
DESIGN OF STEEL STRUCTURES

LECTURE 11
MIDTERM REVIEW

SEMESTER: SUMMER 2020

COURSE TEACHER: SAURAV BARUA

CONTACT NO: +8801715334075

EMAIL: saurav.ce@diu.edu.bd

OUTLINE

- MIDTERM SYLLABUS

LECTURE 1 (16.5.20) – LECTURE 7 (13.6.20)

MARKS 25 MARKS

  - 2 questions with a (Math), b and c (theory type) segments
  - Time 2hr
  - No alternatives options

LRFD & ASD

Load and Resistance Factor Design (LRFD)

Resistance or strength:	R_n
Resistance factor:	$\phi < 1.0$
Load effect:	Q_i [i = 1,2,3.... for dead load, live load etc.]
Load factor:	γ_i [i = 1,2,3.... for dead load, live load etc.]
R_u:	Factored load effect

LRFD safety requirement

$$\phi R_n \geq R_u \; (= \Sigma \gamma_i Q_i)$$

Allowable Strength Design (ASD)

Resistance or strength:	R_n
Safety factor:	$\Omega > 1.0$
Load effect:	Q_i [i = 1,2,3.... for dead load, live load etc.]
Load factor:	$\gamma_i = 1.0$ [i = 1,2,3.... for dead load, live load etc.]
R_a:	Required strength / allowable strength

- **The two distinct procedures employed by designers are,**
  - **Allowable Strength Design (ASD) &**
  - **Load & Resistance Factor Design (LRFD).**

Effective hole diameter $= \text{Actual hole diameter} + {}^{1}/_{16}''$

$= \text{Bolt diameter} + {}^{1}/_{8}''$

Effective Net Area $A_e = UA_n$
where U is Shear Lag Factor (a reduction co-efficient).

$U = 1.0 - \bar{x}/L$ [except plates and HSS sections, AISC Table D3.1]

$\bar{x}$ = distance between loading line (c.g. of tension member section) and connection plane.

L = Length of connection

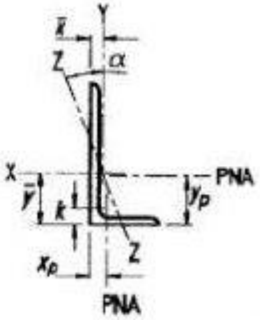


Table 1–7
Angles
Properties

Shape	k	Wt.	Area, A	Axis X-X						Flexural-Torsional Properties		
				I	S	r	$\bar{y}$	Z	y_p	J	C_w	$\bar{r}_o$
	in.	lb/ft	in.^{2}	in.^{4}	in.^{3}	in.	in.	in.^{3}	in.	in.^{4}	in.^{6}	in.
L6×6×1	1 1/2	37.4	11.0	35.4	8.55	1.79	1.86	15.4	0.918	3.68	9.24	3.18
×7/8	1 3/8	33.1	9.75	31.9	7.61	1.81	1.81	13.7	0.813	2.51	6.41	3.21
×3/4	1 1/4	28.7	8.46	28.1	6.64	1.82	1.77	11.9	0.705	1.61	4.17	3.24
×5/8	1 1/8	24.2	7.13	24.1	5.64	1.84	1.72	10.1	0.594	0.955	2.50	3.28
×9/16	1 1/16	21.9	6.45	22.0	5.12	1.85	1.70	9.18	0.538	0.704	1.85	3.29
×1/2	1	19.6	5.77	19.9	4.59	1.86	1.67	8.22	0.481	0.501	1.32	3.31
×7/16	15/16	17.2	5.08	17.6	4.06	1.86	1.65	7.25	0.423	0.340	0.899	3.32
×3/8	7/8	14.9	4.38	15.4	3.51	1.87	1.62	6.27	0.365	0.218	0.575	3.34
×5/16	13/16	12.4	3.67	13.0	2.95	1.88	1.60	5.26	0.306	0.129	0.338	3.35

Weight calculations

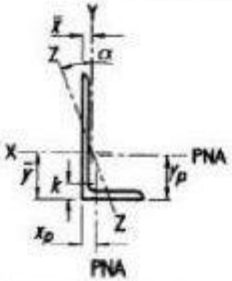
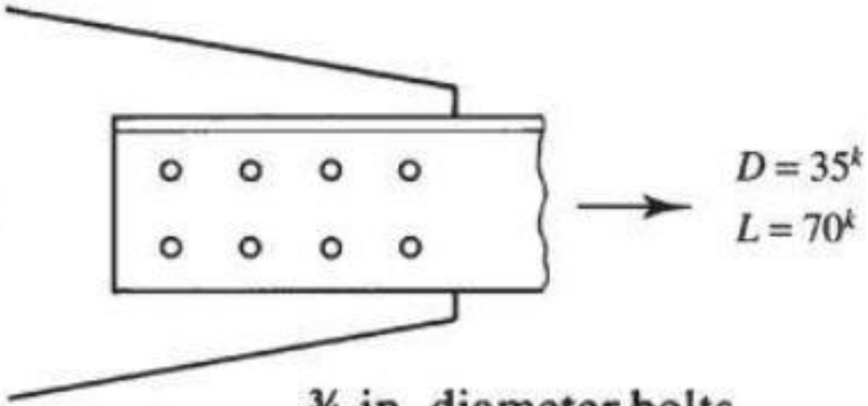


Table 1–7 (continued)
Angles
Properties

Shape	k	Wt.	Area, A	Axis X-X						Flexural-Torsional Properties		
				I	S	r	ȳ	Z	y_p	J	C_w	$\bar{r}_o$
	in.	lb/ft	in.²	in.⁴	in.³	in.	in.	in.³	in.	in.⁴	in.⁶	in.
L4×3½×½	⅞	11.9	3.50	5.30	1.92	1.23	1.24	3.46	0.497	0.301	0.302	2.03
×⅜	¾	9.10	2.67	4.15	1.48	1.25	1.20	2.66	0.433	0.132	0.134	2.06
×5/16	11/16	7.70	2.25	3.53	1.25	1.25	1.17	2.24	0.401	0.0782	0.0798	2.08
×¼	⅝	6.20	1.81	2.89	1.01	1.26	1.14	1.81	0.368	0.0412	0.0419	2.09
L4×3×⅝	1	13.6	3.89	6.01	2.28	1.23	1.37	4.08	0.810	0.529	0.472	1.91
×½	⅞	11.1	3.25	5.02	1.87	1.24	1.32	3.36	0.747	0.281	0.255	1.94
×⅜	¾	8.50	2.48	3.94	1.44	1.26	1.27	2.60	0.683	0.123	0.114	1.97
×5/16	11/16	7.20	2.09	3.36	1.22	1.27	1.25	2.19	0.651	0.0731	0.0676	1.98
×¼	⅝	5.80	1.69	2.75	0.988	1.27	1.22	1.77	0.618	0.0386	0.0356	1.99
L3½×3½×½	⅞	11.1	3.25	3.63	1.48	1.05	1.05	2.66	0.466	0.281	0.238	1.87
×7/16	13/16	9.80	2.87	3.25	1.32	1.06	1.03	2.36	0.412	0.192	0.164	1.89
×⅜	¾	8.50	2.48	2.86	1.15	1.07	1.00	2.06	0.357	0.123	0.106	1.90
×5/16	11/16	7.20	2.09	2.44	0.969	1.08	0.979	1.74	0.301	0.0731	0.0634	1.92
×¼	⅝	5.80	1.69	2.00	0.787	1.09	0.954	1.41	0.243	0.0386	0.0334	1.93

Tension member design problem:

Select an unequal-leg angle tension member 15 ft long to resist a service dead load of 35 kips and a service live load of 70 kips. Use A36 steel (F_y = 36 ksi, F_u=58 ksi). The connection is shown in figure below. It shall be connected to a gusset plate using 8 nos. ¾-in dia. bolts in two rows as shown. Neglect block shear failure mode and follow LRFD principle.



Solution:

The factored load is

$P_u = 1.2D + 1.6L = 1.2(35) + 1.6(70)$
$= 154$ kips

On gross area: $P_u \le \phi P_n = \phi F_y A_g$

$\therefore\ A_g = P_u/(\phi F_y) = 154/(0.9\times 36)$
$= 4.75\ in^2.$

On net area: $P_u \le \phi P_n = \phi F_u A_e$

$\therefore\ A_e = P_u/(\phi F_u) = 154/(0.75\times 58)$
$= 3.54\ in^2.$

To find the net area A_n, we need U. However, at this stage, the section is unknown. We can assume $U = 0.8$ (Case 7, AISC Table D3.1, four bolts in a row).

Thus, $A_n = A_e/U = 3.54/.8 = 4.425$ in^2.

$\therefore$ Gross area $A_g = A_n$ + bolt holes = $4.425 + 2(3/4 + 1/8)t$

Where t is the thickness of the angle which is unknown.

Conservatively, we choose t = ¾ in

$\therefore A_g = 4.425 + 2(3/4 + 1/8)(3/4) = 5.74$ in^2 (governs)

Now we choose a section from AISC Manual with $A_g \geq 5.74$ in^2 and $t \leq$ ¾ in. We choose L6 x 4 x $^5/_8$

$A_g = 5.86$ in^2, $t = {^5/_8}$ in. $\therefore A_n = 5.86 - 2(3/4+1/8){^5/_8} = 4.77$ in^2.

$A_e = U A_n = 0.8(4.77) = 3.82$ in^2.

$\therefore$ Yield on gross area, $\phi P_n = \phi F_y A_g = 0.9(36)5.86 = 189.9$ kip,
Fracture on effective area, $\phi P_n = \phi F_u A_e = 0.75(58)3.82 = 166.2$ kip
Thus, tension capacity $\phi P_n = 166.2 > P_u$ OK.

How it will be if 3 row bolts!!!

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 3.5x2.5x0.2	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