L-3/T-2/CE Date : 19/05/2014

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2011-2012

Sub : **CE 319** (Design of Steel Structure)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Briefly discuss on possible modes on failure in a tension member. **(9)**

(b) Determine allowable strength "T" for the angle L5 × 4 × $\frac{1}{4}$ with three $\frac{7}{8}$ inch dia bolts in standard holes. Use A36 steel. The member is shown in Fig. 1. **(26)**

2. (a) Write short notes on short column, intermediate column and long column and show their region in a column strength curve. **(9)**

(b) Using ASD method, calculate the strength of the column having cross section and support condition shown in Fig. 2. Use A992 steel. **(26)**

3. (a) How is residual stress introduced in steel members. Write down its effect. **(9)**

(b) Select lightest W12 section (From Annexure I) of A992 steel for a column to carry dead load 250^k and live load 150^k. The unbraced lengths are L_x = 20 ft and L_y = 10 ft. The column is pinned at both ends. **(26)**

4. (a) Define effective length factor. Determine effective length factors for column AD, DG and EH (Fig. 3) **(15)**

(b) An angle L6 × 4 × $\frac{3}{8}$ of A992 steel is to be connected to a gusset plate with fillet welds to carry service load of 100^k. Design the weld connection (transverse and longitudinal weld). Use E70XX electrode (Fig. 4) and $\frac{3}{16}$ inch weld leg size.. **(20)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

Symbols and notation bear their usual meanings.

5. (a) What are the advantages and disadvantages of steel as a structural building material? **(8)**

Contd P/2

(b) The tension member shown in Fig. 5 is PL $\frac{5}{8} \times 10$, and the steel is A36 ($F_y = 36\ ksi,\ F_u = 50\ ksi$). The bolts are $\frac{7}{8}$-inch in diameter. Following ASD principle, determine the allowable tension capacity considering limit states of plate only. Also, neglect the block shear failure mode. **(12)**

(c) Determine the parameter C_b for the beam shown in Fig. 6. Consider that the beam is laterally un-supported along its whole length except at ends. **(15)**

6. (a) Differentiate between steel and concrete structures from engineering point of view. **(8)**

(b) A $\frac{1}{2}$-inch-thick tension member is spliced with two $\frac{1}{4}$-inch-thick splice plates as shown in Fig. 7. The bolts are $\frac{7}{8}$-inch-diameter, A325 (F_y = 90 ksi, F_u = 120 ksi) and all plates are A36 steel (F_y = 36 ksi, F_u = 50 ksi). Compute the allowable strength of the splice based on bolt limit states. Follow ASD principle. **(12)**

(c) The tension member shown in Fig. 8 is a channel section C12 × 20.7 of A572 steel (F_y = 50 ksi, F_u = 65 ksi). Determine the maximum allowable tensile load capacity based on limits states of the channel section. Follow ASD principle. **(15)**

7. (a) What do you understand by residual stresses in rolled shapes? Briefly discuss with neat sketches. **(8)**

(b) Determine the shape factor for the T section shown in Fig. 9. **(12)**

(c) Determine the maximum allowable moment of a beam having W14×68 section of A242 steel (F_y = 50 ksi, F_u = 70 ksi) subject to (i) continuous lateral support, (ii) an un-braced length of 20 ft with C_b = 1.0 and (iii) an un-braced length of 30 ft with C_b = 1.0. Follow ASD method. **(15)**

8. (a) What do you understand by weldability of steel? Mention the preferred alloy composition of good weldable structural steel. **(8)**

(b) Determine the elastic shear stress distribution on a W14×120 beam subjected to a service load shear force of 65 kips acting for major axis bending. Also compute the portion of the shear carried by the flange and that carried by the web. **(12)**

(c) Tension member shown in Fig. 10 is an L6 × $3^1/_2$ × $^5/_{16}$. It is connected to a $^5/_{16}$-inch-thick gusset plate with $^3/_4$-inch-diameter A325 bearing type bolts (F_y = 90 ksi, F_u = 120 ksi). Both the tension member and the gusset plate are of A36 steel (F_y = 36 ksi, F_u = 50 ksi). What is the total service load that can be supported, based on bolt limit states? The bolt threads are in the plane of shear. Follow ASD method. **(15)**

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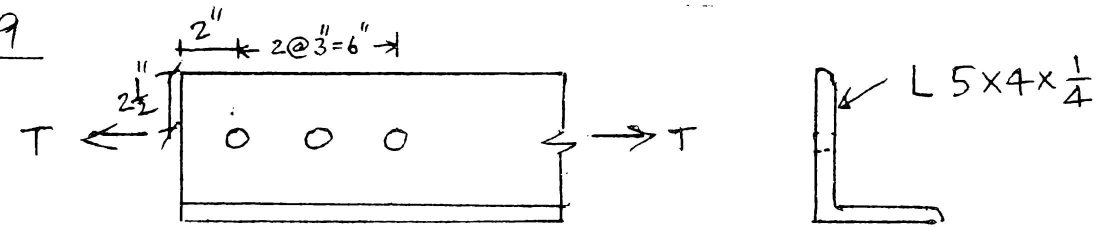

Fig-1

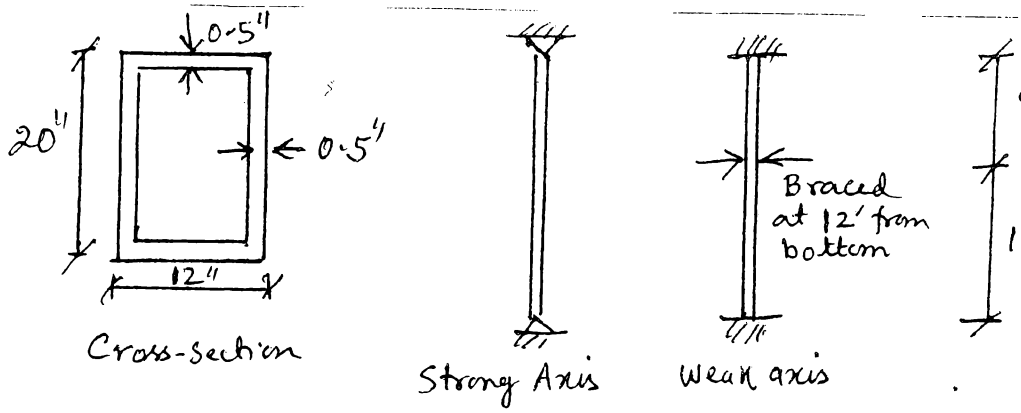

Fig. 2

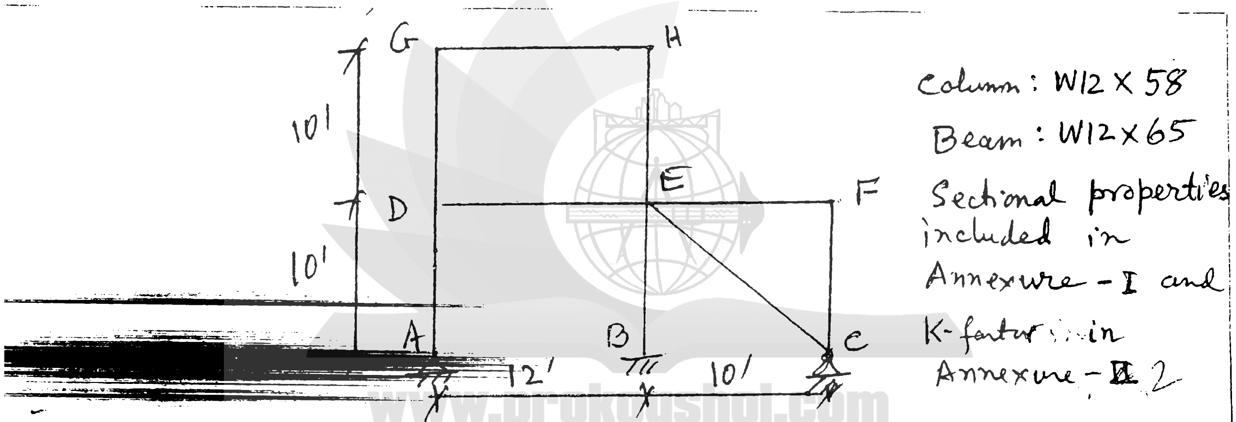

Fig. 3

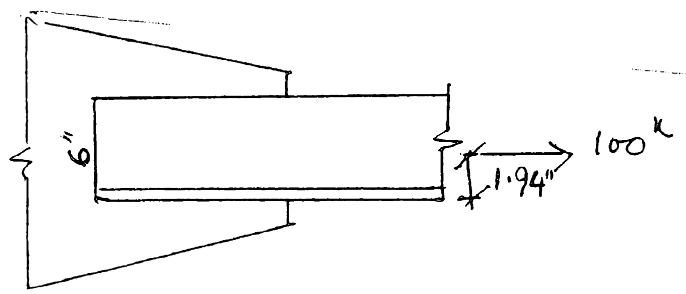

Fig. 4

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Fig. 5

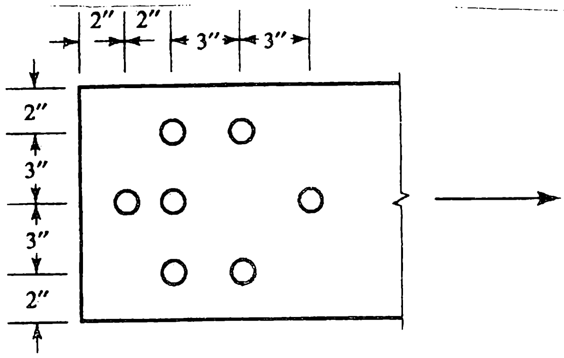


Fig. 6

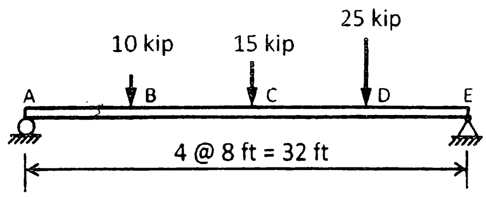


Fig. 7

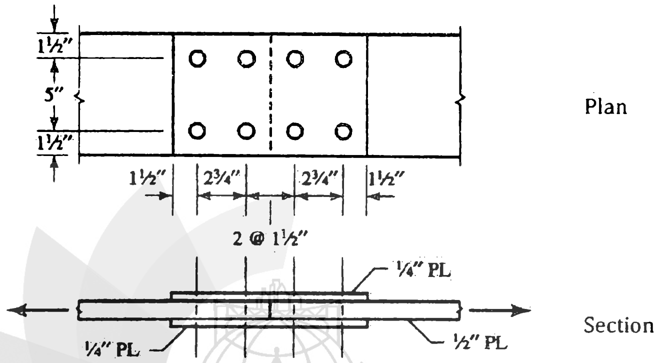


Fig. 8

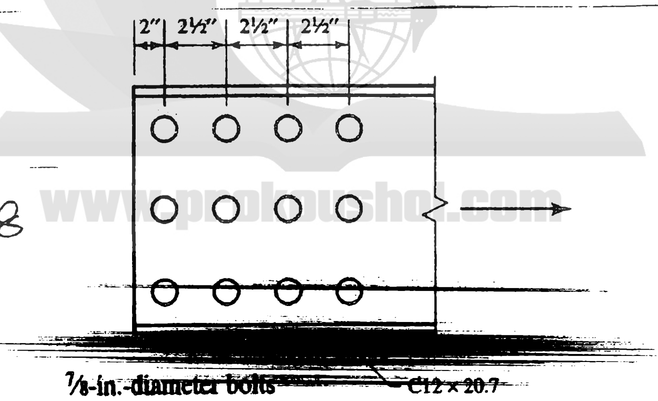


Fig. 9

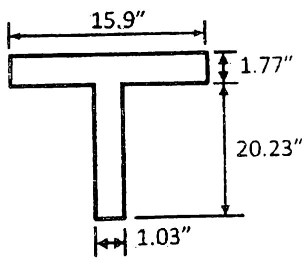
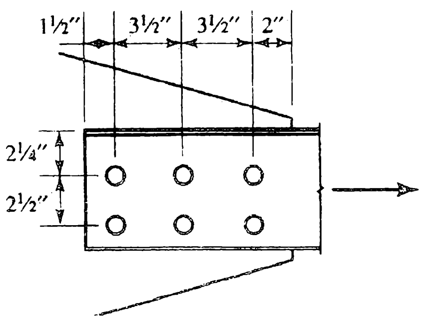


Fig. 10



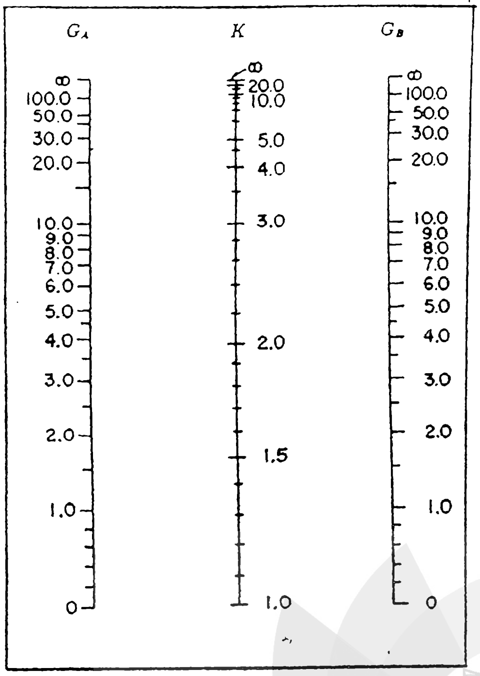
Annexure-1

Designation	Area A	Depth d		Web Thickness t_w		$\frac{t_w}{2}$	Flange Width b_f		Flange Thickness t_f		Distance T	Distance k	Distance k_1
	In.²	In.		In.		In.	In.		In.		In.	In.	In.
W 12×336*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13.385	13⅜	2.955	2 15/16	9½	3 11/16	1½
×305*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9½	3 7/16	1 7/16
×279*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9½	[illegible]	1⅜
×252*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9½	[illegible]	[illegible]
×230*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9½	[illegible]	[illegible]
×210*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9½	[illegible]	[illegible]
×190	55.8	14.38	14⅜	1.060	1 1/16	9/16	12.670	12⅝	1.735	1¾	9½	2 7/16	1 3/16
×170	50.0	14.03	14	0.960	15/16	½	12.570	12⅝	1.560	1 9/16	9½	2¼	1⅛
×152	44.7	13.71	13¾	0.870	⅞	7/16	12.480	12½	1.400	1⅜	9½	2⅛	1 1/16
×136	39.9	13.41	13⅜	0.790	13/16	7/16	12.400	12⅜	1.250	1¼	9½	1 15/16	1
×120	35.3	13.12	13⅛	0.710	11/16	⅜	12.320	12⅜	1.105	1⅛	9½	1 13/16	1
×106	31.2	12.89	12⅞	0.610	⅝	5/16	12.220	12¼	0.990	1	9½	1 11/16	15/16
× 96	28.2	12.71	12¾	0.550	9/16	5/16	12.160	12⅛	0.900	⅞	9½	1⅝	⅞
× 87	25.6	12.53	12½	0.515	½	¼	12.125	12⅛	0.810	13/16	9½	1½	⅞
× 79	23.2	12.38	12⅜	0.470	½	¼	12.080	12⅛	0.735	¾	9½	1 7/16	⅞
× 72	21.1	12.25	12¼	0.430	7/16	¼	12.040	12	0.670	11/16	9½	1⅜	⅞
× 65	19.1	12.12	12⅛	0.390	⅜	3/16	12.000	12	0.605	⅝	9½	1 5/16	13/16
W 12× 58	17.0	12.19	12¼	0.360	⅜	3/16	10.010	10	0.640	⅝	9½	1⅜	13/16
× 53	15.6	12.06	12	0.345	⅜	3/16	9.995	10	0.575	9/16	9½	1¼	13/16
W 12× 50	14.7	12.19	12¼	0.370	⅜	3/16	8.080	8⅛	0.640	⅝	9½	1⅜	13/16
× 45	13.2	12.06	12	0.335	5/16	3/16	8.045	8	0.575	9/16	9½	1¼	13/16
× 40	11.8	11.94	12	0.295	5/16	3/16	8.005	8	0.515	½	9½	1¼	¾
W 12× 35	10.3	12.50	12½	0.300	5/16	3/16	6.560	6½	0.520	½	10½	1	9/16
× 30	8.79	12.34	12⅜	0.260	¼	⅛	6.520	6½	0.440	7/16	10½	15/16	½
× 26	7.65	12.22	12¼	0.230	¼	⅛	6.490	6½	0.380	⅜	10½	⅞	½
W 12× 22	6.48	12.31	12¼	0.260	¼	⅛	4.030	4	0.425	7/16	10½	⅞	½
× 19	5.57	12.16	12⅛	0.235	¼	⅛	4.005	4	0.350	⅜	10½	13/16	½
× 16	4.71	11.99	12	0.220	¼	⅛	3.990	4	0.265	¼	10½	¾	½
× 14	4.16	11.91	11⅞	0.200	3/16	⅛	3.970	4	0.225	¼	10½	11/16	½

*For application refer to Notes in Table 2.
Shapes in shaded rows are not available from domestic producers.

Nominal Wt. per Ft	$\frac{b_f}{2t_f}$	F_y'	$\frac{d}{t_w}$	F_y'''	r_T	$\frac{d}{A_f}$	X-X I	X-X S	X-X r	Y-Y I	Y-Y S	Y-Y r	Z_x	Z_y
Lb.		Ksi		Ksi	In.		In.⁴	In.³	In.	In.⁴	In.³	In.	In.³	In.³
336	2.3	—	9.5	—	3.71	0.43	4060	483	6.41	1190	177	3.47	603	274
305	2.4	—	10.0	—	3.67	0.46	3550	435	6.29	1050	159	3.42	537	244
279	2.7	—	10.4	—	3.64	0.49	3110	393	6.16	937	143	3.38	481	220
252	2.9	—	11.0	—	3.59	0.53	2720	353	6.06	828	127	3.34	428	196
230	3.1	—	11.7	—	3.56	0.56	2420	321	5.97	742	115	3.31	386	177
210	3.4	—	12.5	—	3.53	0.61	2140	292	5.89	664	104	3.28	348	159
190	3.7	—	13.6	—	3.50	0.65	1890	263	5.82	589	93.0	3.25	311	143
170	4.0	—	14.6	—	3.47	0.72	1650	235	5.74	517	82.3	3.22	275	126
152	4.5	—	15.8	—	3.44	0.79	1430	209	5.66	454	72.8	3.19	243	111
136	5.0	—	17.0	—	3.41	0.87	1240	186	5.58	398	64.2	3.16	214	98.0
120	5.6	—	18.5	—	3.38	0.96	1070	163	5.51	345	56.0	3.13	186	85.4
106	6.2	—	21.1	—	3.36	1.07	933	145	5.47	301	49.3	3.11	164	75.1
96	6.8	—	23.1	—	3.34	1.16	833	131	5.44	270	44.4	3.09	147	67.5
87	7.5	—	24.3	—	3.32	1.28	740	118	5.38	241	39.7	3.07	132	60.4
79	8.2	62.6	26.3	—	3.31	1.39	662	107	5.34	216	35.8	3.05	119	54.3
72	9.0	52.3	28.5	—	3.29	1.52	597	97.4	5.31	195	32.4	3.04	108	49.2
65	9.9	43.0	31.1	—	3.28	1.67	533	87.9	5.28	174	29.1	3.02	96.8	44.1
58	7.8	—	33.9	57.6	2.72	1.90	475	78.0	5.28	107	21.4	2.51	86.4	32.5
53	8.7	55.9	35.0	54.1	2.71	2.10	425	70.6	5.23	95.8	19.2	2.48	77.9	29.1
50	6.3	—	32.9	60.9	2.17	2.36	394	64.7	5.18	56.3	13.9	1.96	72.4	21.4
45	7.0	—	36.0	51.0	2.15	2.61	350	58.1	5.15	50.0	12.4	1.94	64.7	19.0
40	7.8	—	40.5	40.3	2.14	2.90	310	51.9	5.13	44.1	11.0	1.93	57.5	16.8
35	6.3	—	41.7	38.0	1.74	3.66	285	45.6	5.25	24.5	7.47	1.54	51.2	11.5
30	7.4	—	47.5	29.3	1.73	4.30	238	38.6	5.21	20.3	6.24	1.52	43.1	9.56
26	8.5	57.9	53.1	23.4	1.72	4.95	204	33.4	5.17	17.3	5.34	1.51	37.2	8.17
22	4.7	—	47.3	29.5	1.02	7.19	156	25.4	4.91	4.66	2.31	0.847	29.3	3.66
19	5.7	—	51.7	24.7	1.00	8.67	130	21.3	4.82	3.76	1.88	0.822	24.7	2.98
16	7.5	—	54.5	22.2	0.96	11.3	103	17.1	4.67	2.82	1.41	0.773	20.1	2.26
14	8.8	54.3	59.6	18.6	0.95	13.3	88.6	14.9	4.62	2.36	1.19	0.753	17.4	1.90

Annexure-2



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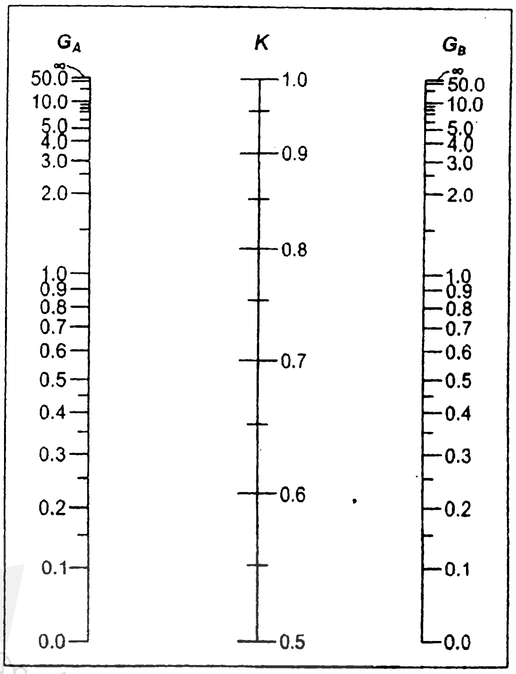

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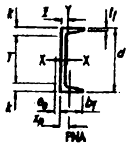
Annexure 3

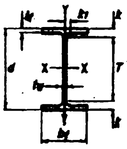


C Shapes
Dimensions

C Shapes
Properties

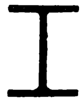
C SHAPES

Shape	Area, A	Depth, d		Web Thickness, t_w		$\frac{t_w}{2}$	Flange Width, b_f		Flange Thickness, t_f		Distance k	Distance T	Workable Gage	$\bar{r}_{ts}$	h_o	Shear Ctr, e_o	X-X I	X-X S	X-X r	X-X Z	Y-Y I	Y-Y S	Y-Y r	Y-Y $\bar{x}$	Y-Y Z	Y-Y x_p	J	C_w	$\bar{r}_o$	H
	in.²	in.		in.		in.	in.		in.		in.	in.	in.	in.	in.	in.	in.⁴	in.³	in.	in.³	in.⁴	in.³	in.	in.	in.³	in.	in.⁴	in.⁶	in.	
C15×50	14.7	15.0	15	0.716	11/16	3/8	3.72	3 3/4	0.650	5/8	1 7/16	12 1/8	2 1/4	1.17	14.4	0.583	404	53.8	5.24	68.5	11.0	3.77	0.865	0.799	8.14	0.490	2.65	492	5.49	0.937
×40	11.8	15.0	15	0.520	1/2	1/4	3.52	3 1/2	0.650	5/8	1 7/16	12 1/8	2	1.15	14.4	0.767	348	46.5	5.45	57.5	9.17	3.34	0.883	0.778	6.84	0.392	1.45	410	5.73	0.927
×33.9	10.0	15.0	15	0.400	3/8	3/16	3.40	3 3/8	0.650	5/8	1 7/16	12 1/8	2	1.13	14.4	0.896	315	42.0	5.62	50.8	8.07	3.09	0.901	0.788	6.19	0.332	1.01	358	5.94	0.920
C12×30	8.81	12.0	12	0.510	1/2	1/4	3.17	3 1/8	0.501	1/2	1 1/8	9 3/4	1 3/4g	1.01	11.5	0.618	162	27.0	4.29	33.8	5.12	2.05	0.762	0.674	4.32	0.367	0.861	151	4.54	0.919
×25	7.34	12.0	12	0.387	3/8	3/16	3.05	3	0.501	1/2	1 1/8	9 3/4	1 3/4g	1.00	11.5	0.746	144	24.0	4.43	29.4	4.45	1.87	0.779	0.674	3.82	0.306	0.538	130	4.72	0.909
×20.7	6.08	12.0	12	0.282	5/16	3/16	2.94	3	0.501	1/2	1 1/8	9 3/4	1 3/4g	0.983	11.5	0.870	129	21.5	4.61	25.6	3.86	1.72	0.797	0.698	3.47	0.253	0.369	112	4.93	0.899



W Shapes
Dimensions

W Shapes
Properties



W14 – W12

Shape	Area, A	Depth, d		Web Thickness, t_w		$\frac{t_w}{2}$	Flange Width, b_f		Flange Thickness, t_f		k_{des}	k_{det}	k_1	T	Workable Gage	$\frac{b_f}{2t_f}$	$\frac{h}{t_w}$	X-X I	X-X S	X-X r	X-X Z	Y-Y I	Y-Y S	Y-Y r	Y-Y Z	r_{ts}	h_o	J	C_w
	in.²	in.		in.		in.	in.		in.		in.	in.	in.	in.	in.			in.⁴	in.³	in.	in.³	in.⁴	in.³	in.	in.³	in.	in.	in.⁴	in.⁶
W14×132	38.8	14.7	14 5/8	0.645	5/8	5/16	14.7	14 3/4	1.03	1	1.63	2 5/16	1 9/16	10	5 1/2	7.15	17.7	1530	209	6.28	234	548	74.5	3.76	113	4.23	13.6	12.3	25500
×120	35.3	14.5	14 1/2	0.590	9/16	5/16	14.7	14 5/8	0.940	15/16	1.54	2 1/4	1 1/2	↓	↓	7.80	19.3	1380	190	6.24	212	495	67.5	3.74	102	4.20	13.5	9.37	22700
×109	32.0	14.3	14 3/8	0.525	1/2	1/4	14.6	14 5/8	0.860	7/8	1.46	2 3/16	1 1/2	↓	↓	8.49	21.7	1240	173	6.22	192	447	61.2	3.73	92.7	4.17	13.5	7.12	20200
×99f	29.1	14.2	14 1/8	0.485	1/2	1/4	14.6	14 5/8	0.780	3/4	1.38	2 1/16	1 7/16	↓	↓	9.34	23.5	1110	157	6.17	173	402	55.2	3.71	83.6	4.14	13.4	5.37	18000
×90f	26.5	14.0	14	0.440	7/16	1/4	14.5	14 1/2	0.710	11/16	1.31	2	1 7/16	↓	↓	10.2	25.9	999	143	6.14	157	362	49.9	3.70	75.6	4.11	13.3	4.06	16000
W14×82	24.0	14.3	14 1/4	0.510	1/2	1/4	10.1	10 1/8	0.855	7/8	1.45	1 11/16	1 1/16	10 7/8	5 1/2	5.92	22.4	881	123	6.05	139	148	29.3	2.48	44.8	2.85	13.5	5.07	6710
×74	21.8	14.2	14 1/8	0.450	7/16	1/4	10.1	10 1/8	0.785	13/16	1.38	1 5/8	1 1/16	↓	↓	6.41	25.4	795	112	6.04	126	134	26.6	2.48	40.5	2.82	13.4	3.87	5990
×68	20.0	14.0	14	0.415	7/16	1/4	10.0	10	0.720	3/4	1.31	1 9/16	1 1/16	↓	↓	6.97	27.5	722	103	6.01	115	121	24.2	2.46	36.9	2.80	13.3	3.01	5380
×61	17.9	13.9	13 7/8	0.375	3/8	3/16	10.0	10	0.645	5/8	1.24	1 1/2	1	↓	↓	7.75	30.4	640	92.1	5.98	102	107	21.5	2.45	32.8	2.78	13.2	2.19	4710

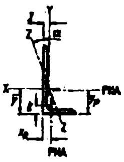


Table 1-7 (continued)
Angles
Properties

Table 1-7 (continued)
Angles
Properties

L6-L4

Shape	k	Wt.	Area, A	X-X I	X-X S	X-X r	X-X $\bar{y}$	X-X Z	X-X y_p	J	C_w	$\bar{r}_o$	Y-Y I	Y-Y S	Y-Y r	Y-Y $\bar{x}$	Y-Y Z	Y-Y x_p	Z-Z I	Z-Z S	Z-Z r	Tan α	Q_s, F_y=36 ksi
	in.	lb/ft	in.²	in.⁴	in.³	in.	in.	in.³	in.	in.⁴	in.⁶	in.	in.⁴	in.³	in.	in.	in.³	in.	in.⁴	in.³	in.		
L6×4×7/8	1 3/8	27.2	7.98	27.7	7.13	1.86	2.12	12.7	1.44	2.03	4.04	2.82	9.70	3.37	1.10	1.12	6.26	0.665	5.82	1.90	0.854	0.421	1.00
×3/4	1 1/4	23.6	6.94	24.5	6.23	1.88	2.07	11.1	1.38	1.31	2.64	2.85	8.63	2.95	1.12	1.07	5.42	0.578	5.08	1.66	0.856	0.428	1.00
×5/8	1 1/8	20.0	5.86	21.0	5.29	1.89	2.03	9.44	1.31	0.775	1.59	2.88	7.48	2.52	1.13	1.03	4.56	0.488	4.32	1.42	0.859	0.435	1.00
×9/16	1 1/16	18.1	5.31	19.2	4.81	1.90	2.00	8.59	1.28	0.572	1.18	2.90	6.86	2.29	1.14	1.00	4.13	0.442	3.94	1.30	0.861	0.438	1.00
×1/2	1	16.2	4.75	17.3	4.31	1.91	1.98	7.71	1.25	0.407	0.843	2.91	6.22	2.06	1.14	0.981	3.69	0.396	3.55	1.17	0.864	0.440	1.00
×7/16	15/16	14.3	4.18	15.4	3.81	1.92	1.95	6.81	1.22	0.276	0.575	2.93	5.56	1.83	1.15	0.957	3.24	0.349	3.14	1.04	0.867	0.443	0.973
×3/8	7/8	12.3	3.61	13.4	3.30	1.93	1.93	5.89	1.19	0.177	0.369	2.94	4.86	1.58	1.16	0.933	2.79	0.301	2.73	0.908	0.870	0.446	0.912
×5/16	13/16	10.3	3.03	11.4	2.77	1.94	1.90	4.96	1.16	0.104	0.217	2.96	4.13	1.34	1.17	0.908	2.33	0.252	2.31	0.769	0.874	0.449	0.826
L6×3 1/2×1/2	1	15.3	4.50	16.6	4.23	1.92	2.07	7.49	1.48	0.386	0.779	2.88	4.24	1.59	0.968	0.829	2.88	0.376	2.58	0.914	0.756	0.343	1.00
×3/8	7/8	11.7	3.42	12.9	3.23	1.93	2.02	5.74	1.41	0.168	0.341	2.90	3.33	1.22	0.984	0.781	2.18	0.287	2.00	0.714	0.763	0.349	0.912
×5/16	13/16	9.80	2.87	10.9	2.72	1.94	2.00	4.84	1.38	0.0990	0.201	2.92	2.84	1.03	0.991	0.756	1.82	0.241	1.70	0.609	0.767	0.352	0.826

Beam formulas:

$$\frac{L_p}{r_y} = 1.76\sqrt{\frac{E}{F_y}} = \frac{300}{\sqrt{F_y,\ \text{ksi}}}, \quad L_r = 1.95 r_{ts}\frac{E}{0.7F_y}\sqrt{\frac{Jc}{S_x h_o}}\sqrt{1 + \sqrt{1 + 6.76\left(\frac{0.7F_y}{E}\frac{S_x h_o}{Jc}\right)^2}}$$

$$F_{cr} = \frac{C_b \pi^2 E}{\left(\frac{L_b}{r_{ts}}\right)^2}\sqrt{1 + 0.078\frac{Jc}{S_x h_o}\left(\frac{L_b}{r_{ts}}\right)^2}$$