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2707/302
STRUCTURES III
June/July 2016
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN CIVIL ENGINEERING

MODULE III

STRUCTURES III

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Scientific calculator.
*Answer any **FIVE** of the following **EIGHT** questions.*
All questions carry equal marks.
Maximum marks for each part of a question are as shown.
Candidates should answer the questions in English.

This paper consists of 10 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

Turn over

1. Using the three moments theorem, analyse the beam shown in figure 1 and plot the bending moment diagram indicating the critical values. (20 marks)

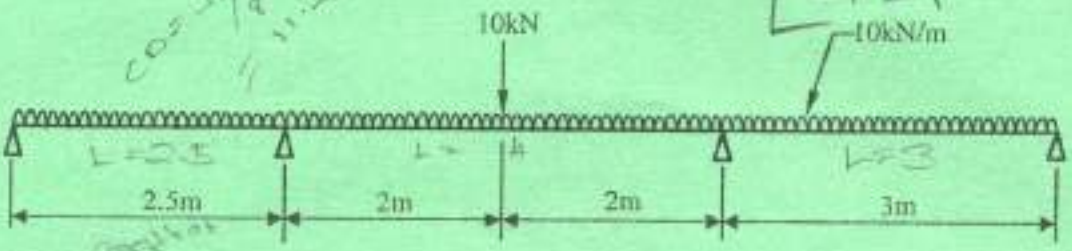


Fig. 1

2. (a) Define the following terms as applied to columns:

(i) short column;
(ii) long column;
(iii) slenderness ration;
(iv) buckling load;
(v) crushing load. (5 marks)

(b) State **four** assumptions made in Euler's theory. (4 marks)

(c) Calculate the crippling load of a steel rod 4 m long and 50 mm diameter when used as a column with one end fixed and the other end free.

Take E = 210 kN/mm². (4 marks)

(d) Figure 2 shows an I - section of size 100 x 150 mm strengthened with 120 x 12 mm plates. Calculate the safe load the column can carry if its 3 m long with one end fixed and the other end hinged. Assume a factor of safety of 3.0 and use the following information: (7 marks)

I - section:
Area = 21.67 cm²
I_{xx} = 839.1cm⁴
I_{yy} = 94.8 cm⁴
Fc = 315 N/mm²
Rankines constant = 1/7500

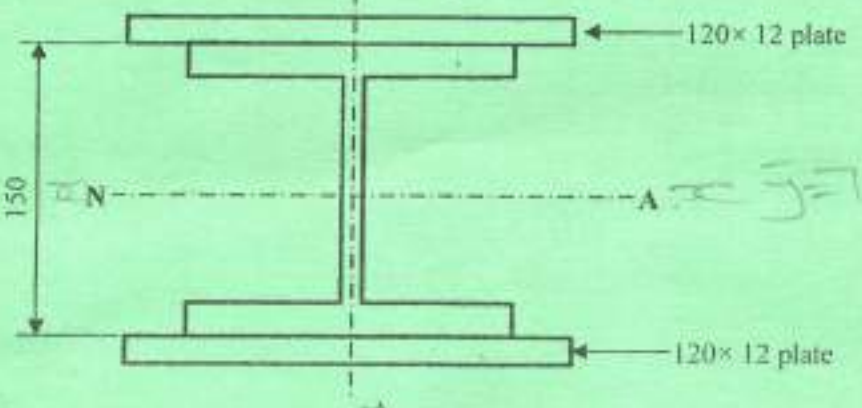


Fig. 2

3. Using the method of moment distribution, analyse the frame shown in figure 3 and plot the bending moment diagram indicating the critical values. (20 marks)

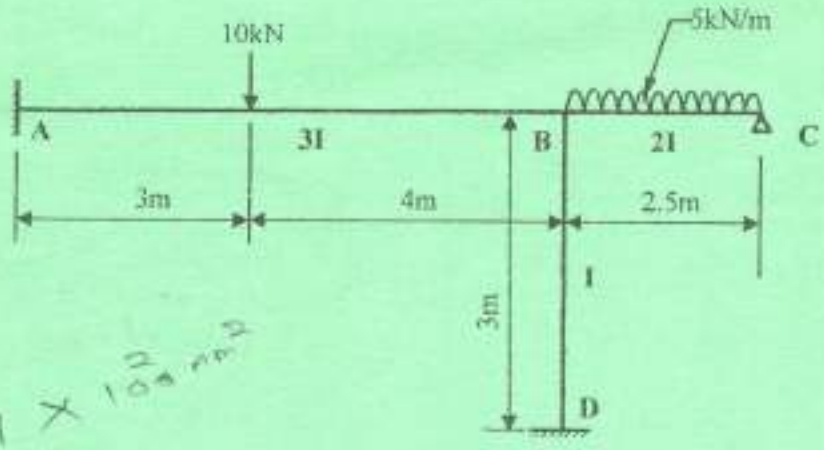


Fig. 3

4. (a) Define the following terms in structural timber:

(i) visual stress grading;
(ii) machine stress grading;
(iii) strength class;
(iv) modification factor. (6 marks)

(b) Design timber floor joists for a suspended floor given the following information:

- Joists are spaced at 500 mm c/c
- Effective span of joists = 3.5 m
- Dead load = 0.45 kN/m^2
- Imposed load = 1.8 kN/m^2
- Bending stress parallel to grain = 5.3 N/mm^2
- Shear parallel to grain = 0.67 N/mm^2
- Compression parallel to grain = 2.2 N/mm^2
- Long term loading factor = 1.0
- Load sharing factor = 1.1
- Allowable deflection = 0.003 span
- E = 8800 N/mm^2.

(14 marks)

5. (a) Figure 4 shows the plan of a loaded column of actual length 4.5 m and is fixed in position and direction at both ends. Check the adequacy of a 203 x 203 x 86 kg/m UC in grade 43 steel. (10 marks)
Take P_{bc} = 165 N/mm^2.

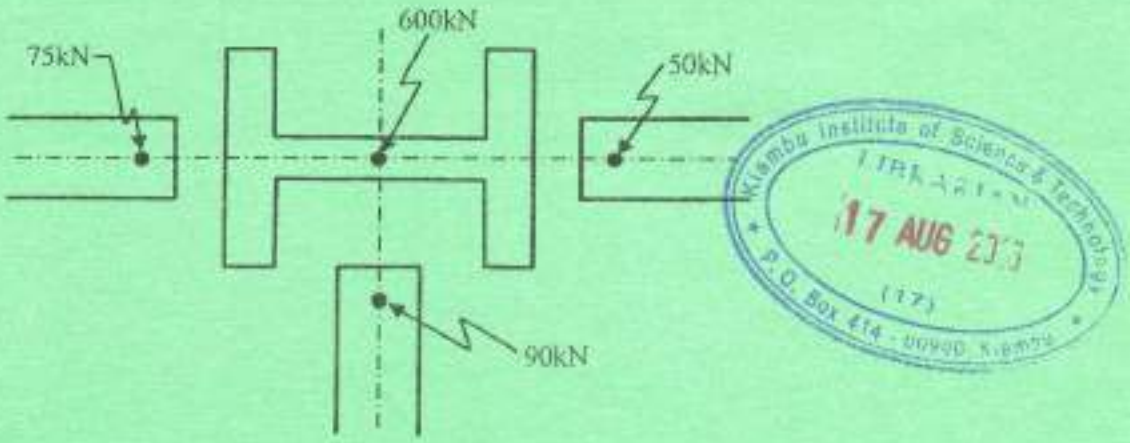


Fig. 4

(b) Check the adequacy of a 203 x 203 x 60 kg/m UC of actual length 4.2 m in grade 43 steel which is cased in accordance with requirements of BS 449. The column is loaded axially and is restrained in position at both ends.

(10 marks)

6. (a) (i) State **two** advantages of riveted connections.
(ii) State **two** assumptions made in the design of riveted connections. (4 marks)

(b) Figure 5 shows a welded connection subjected to a load of 100 kN. Determine the size of fillet welds given that stresses in both fillets are the same.
Take fs = 100 N/mm².

(6 marks)

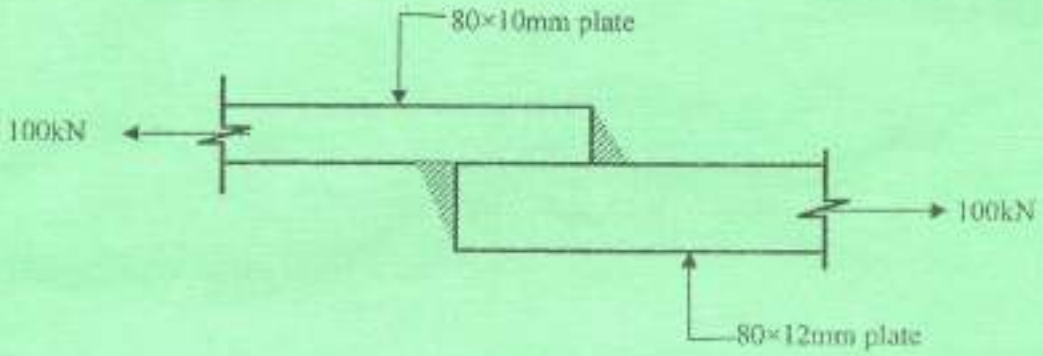


Fig. 5

(c) A uniformly distributed load of 5 kN/m of 6 m length crosses a bridge of span 40 m from left to right as shown in figure 6. Using influence lines, calculate the shear force and bending moment at a point 12 m from the left support when the head of the load is 16 m from the left support. (10 marks)

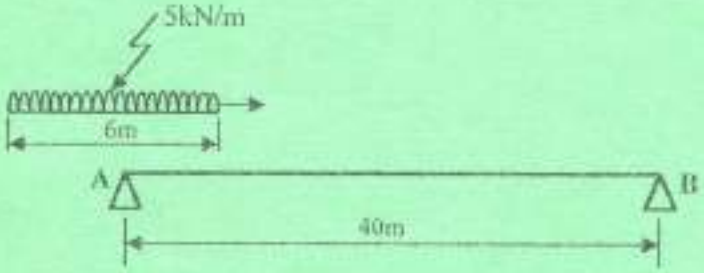


Fig. 6

7. (a) State **four** advantages of steel as a construction material. (4 marks)

(b) Select a suitable UB section in grade 43 steel for the simply supported beam shown in figure 7. Check the beam for flexure, shear, web buckling and deflection. (16 marks)

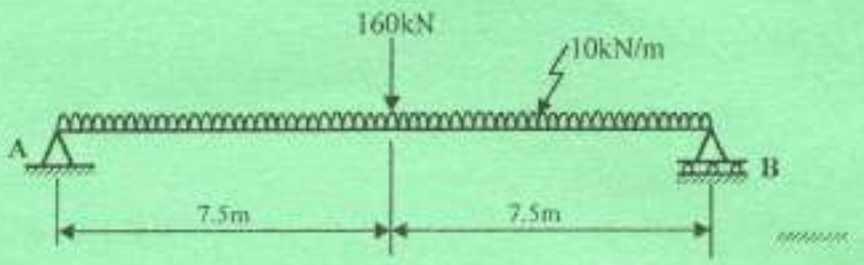


Fig. 7

Pbc = 165 N/mm²
E = 210 kN/mm²
Permisible shear stress = 70 N/mm²
Ignore beam's self weight

8. Figure 8 shows a universal beam section strengthened by the addition of a steel plate at the bottom. Determine the actual stresses at points A, B, C and D if a force of 600 kN acts on the section as shown. (20 marks)

$$\frac{P}{A} \pm \frac{Pe\bar{x} \text{ or } \bar{y}}{I_{xx} \text{ or } I_{yy}}$$

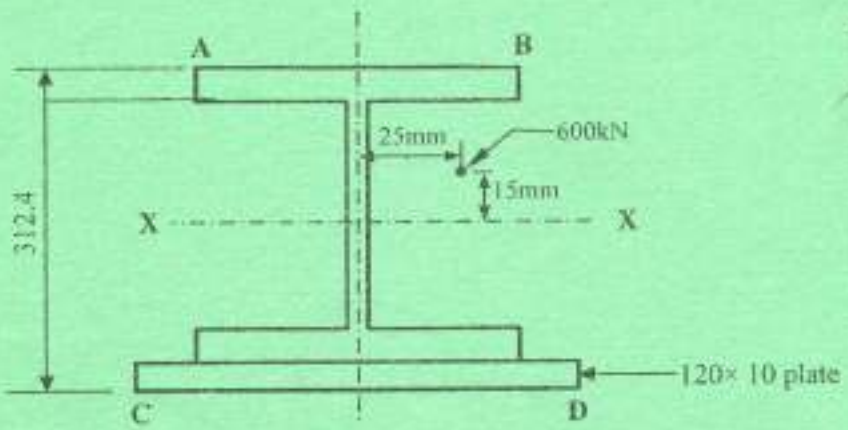


Fig. 8

Properties of the universal beam:

Area	=	41.80 cm²
I_{xx}	=	6482 cm⁴
I_{yy}	=	189 cm⁴
B	=	102.4 mm

Table : Geometrical properties of sawn softwoods

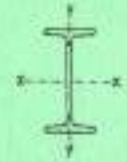
Basic Size mm	Area (10^3 mm^2)	Section modulus (10^3 mm^3)		Second moment of area (10^6 mm^4)		Radius of gyration (mm)	
		About x-x	About y-y	About x-x	About y-y	About x-x	About y-y
36×75	2.70	33.8	16.2	1.27	0.292	21.7	10.4
36×100	3.60	60.0	21.6	3.00	0.389	28.9	10.4
36×125	4.50	93.8	27.0	5.86	0.486	36.1	10.4
36×150	5.40	135	32.4	10.1	0.583	43.3	10.4
38×75	2.85	35.6	18.1	1.34	0.343	21.7	11.0
38×100	3.80	63.3	24.1	3.17	0.457	28.9	11.0
38×125	4.75	99.0	30.1	6.18	0.572	36.1	11.0
38×150	5.70	143	36.1	10.7	0.686	43.3	11.0
38×175	6.54	194	42.1	17.0	0.800	50.5	11.0
38×200	7.60	253	48.1	25.3	0.915	57.7	11.0
44×75	8.55	321	54.2	36.1	1.03	65.0	11.0
44×100	3.30	41.3	24.2	1.55	0.532	21.7	12.7
44×125	4.40	73.3	32.3	3.67	0.71	28.9	12.7
44×150	5.40	115	40.3	7.16	0.887	36.1	12.7
44×175	6.60	165	48.4	12.4	1.06	43.3	12.7
44×200	7.70	225	56.5	19.7	1.24	50.5	12.7
44×225	8.80	293	64.5	29.3	1.42	57.7	12.7
44×250	9.90	371	72.6	41.8	1.60	65.0	12.7
44×275	11.0	458	80.7	57.3	1.77	72.2	12.7
44×300	13.2	660	96.8	99.0	2.13	86.6	12.7
47×75	3.53	44.1	27.6	1.65	0.649	21.7	13.6
47×100	4.70	78.3	36.8	3.92	0.865	28.9	13.6
47×125	5.88	122	46.0	7.65	1.08	36.1	13.6
47×150	7.05	176	55.2	13.2	1.30	43.3	13.6
47×175	8.23	240	64.4	21.0	1.51	50.5	13.6
47×200	9.40	313	73.6	31.3	1.73	57.7	13.6
47×225	10.6	397	82.8	44.6	1.95	65.0	13.6
47×250	11.8	490	92.0	61.2	2.16	72.2	13.6
47×300	14.1	705	116	106	2.60	86.6	13.6
50×75	3.75	46.9	31.3	1.76	0.781	21.7	14.4
50×100	5.00	83.3	41.7	4.17	1.04	28.9	14.4
50×125	6.25	130	52.1	8.14	1.30	36.1	14.4
50×150	7.50	188	62.5	14.1	1.56	43.3	14.4
50×175	8.75	255	72.9	22.3	1.82	50.5	14.4
50×200	10.0	333	83.3	33.3	2.08	57.7	14.4
50×225	11.3	422	93.8	47.5	2.34	65.0	14.4
50×250	12.5	521	104	65.1	2.60	72.2	14.4
50×300	15.0	750	125	113	3.13	86.6	14.4
63×100	6.30	105	66.2	5.25	2.08	28.9	18.2
63×125	7.88	164	82.7	10.3	2.60	36.1	18.2
63×150	9.45	236	99.2	17.7	3.13	43.3	18.2
63×175	11.0	322	116	28.1	3.65	50.5	18.2
63×200	12.6	420	132	42.0	4.17	57.7	18.2
63×225	14.2	532	149	59.8	4.69	65.0	18.2
75×100	7.50	125	93.8	6.25	3.52	28.9	21.7
75×125	9.38	195	117	12.2	4.39	36.1	21.7
75×150	11.3	281	141	21.1	5.27	43.3	21.7
75×175	13.1	383	164	33.5	6.15	50.5	21.7
75×200	15.0	500	188	50.0	7.03	57.7	21.7
75×225	16.9	633	211	71.2	7.91	65.0	21.7
75×250	18.8	781	234	97.7	8.79	72.2	21.7
75×300	22.5	1130	281	169	10.5	86.6	21.7
100×100	10.0	167	167	8.33	8.33	28.9	28.9
100×150	15.0	375	250	28.1	12.5	43.3	28.9
100×200	20.0	667	333	66.7	16.7	57.7	28.9
100×250	25.0	1040	417	130	20.8	72.2	28.9
100×300	30.0	1500	500	225	25.0	86.6	28.9
150×150	22.5	563	563	42.2	42.2	43.3	43.3
150×200	30.0	1000	750	100	56.3	57.7	43.3
150×300	45.5	2250	1130	338	84.4	86.6	43.3
200×200	40.0	1330	1330	133	133	57.7	57.7
250×250	62.5	2600	2600	326	326	72.2	72.2
300×300	90.0	4500	4500	675	675	86.6	86.6

UNIVERSAL BEAMS

DIMENSIONS AND PROPERTIES

UNIVERSAL BEAMS

DIMENSIONS AND PROPERTIES



Serial Size	Mass per metre	Depth of Section D	Width of Section B	Thickness: Web t	Thickness: Flange T	Root Radius r	Depth between Fillets d	Area of Section
mm	kg	mm	mm	mm	mm	mm	mm	cm²
457 × 152	82	465.1	153.5	10.7	18.9	10.2	404.6	104.4
	74	461.3	152.7	9.9	17.0	10.2	404.4	94.9
	67	457.2	151.9	9.1	16.0	10.2	404.4	86.3
	60	454.7	152.9	8.0	13.3	10.2	407.7	76.9
	52	449.8	152.4	7.6	10.9	10.2	407.7	66.5
406 × 178	74	412.8	179.7	9.7	16.0	10.2	357.4	94.9
	67	409.4	178.8	8.8	14.3	10.2	357.4	85.4
	60	406.4	177.8	7.8	12.8	10.2	357.4	76.1
	54	402.6	177.6	7.6	10.9	10.2	357.4	68.3
406 × 152	74	416.3	153.7	10.1	18.1	10.2	357.4	94.8
	67	412.2	152.9	9.3	16.0	10.2	357.4	85.3
	60	407.9	153.2	8.6	13.9	10.2	357.4	75.8
406 × 140	46	402.3	142.4	6.9	11.2	10.2	357.4	58.9
	39	397.3	141.8	6.3	8.6	10.2	357.4	49.3
381 × 152	67	388.6	154.3	8.7	16.3	10.2	333.2	85.4
	60	384.8	153.4	8.7	14.4	10.2	333.2	76.9
	52	381.0	152.4	7.6	12.4	10.2	333.2	66.6
356 × 171	67	364.0	173.2	9.1	15.7	10.2	309.1	85.3
	57	358.8	172.1	8.0	13.0	10.2	309.1	72.1
	51	355.8	171.5	7.3	11.5	10.2	309.1	64.5
	45	352.0	171.0	6.9	9.7	10.2	309.1	56.9
356 × 127	39	352.8	126.0	6.5	10.7	10.2	309.1	49.3
	33	348.5	125.4	5.9	8.5	10.2	309.1	41.7
305 × 165	54	310.9	166.8	7.7	13.7	8.9	262.8	68.3
	46	307.1	165.7	6.7	11.8	8.9	262.8	58.8
	40	303.8	165.1	6.1	10.2	8.9	262.8	51.4
305 × 127	48	310.4	125.2	8.9	14.0	8.9	262.8	60.8
	42	306.6	124.3	8.0	12.1	8.9	262.8	53.1
	37	303.8	123.5	7.2	10.7	8.9	262.8	47.4
305 × 102	33	312.7	102.4	6.6	10.8	7.6	275.3	41.8
	28	308.9	101.9	6.1	8.9	7.6	275.3	36.3
	25	304.8	101.6	5.8	6.8	7.6	275.3	31.4
254 × 146	43	259.6	147.3	7.3	12.7	7.6	216.2	55.0
	37	256.0	146.4	6.4	10.9	7.6	216.2	47.4
	31	251.5	146.1	6.1	8.6	7.6	216.2	39.9
254 × 102	28	260.4	102.1	6.4	10.0	7.6	224.5	36.2
	25	257.0	101.8	6.1	8.4	7.6	224.5	32.1
	22	254.0	101.6	5.8	6.8	7.6	224.5	28.4
203 × 133	30	209.8	133.9	6.3	9.6	7.6	169.9	38.0
	25	209.2	133.4	5.8	7.8	7.6	169.9	32.3

Serial Size	Moment of Inertia: Axis x–x Gross	Moment of Inertia: Axis x–x Net	Moment of Inertia: Axis y–y	Radius of Gyration: Axis x–x	Radius of Gyration: Axis y–y	Elastic Modulus: Axis x–x	Elastic Modulus: Axis y–y	Ratio D/T
mm	cm⁴	cm⁴	cm⁴	cm	cm	cm³	cm³	
457 × 152	36160	32058	1093	18.6	3.24	1555	142.5	24.6
	32360	28731	963	18.5	3.18	1404	126.1	27.1
	28522	25342	829	18.3	3.12	1248	105.1	30.5
	25484	22613	794	18.3	3.23	1120	104.0	34.2
	21345	19034	645	17.9	3.11	949.0	84.61	41.3
406 × 178	27279	23981	1448	17.0	3.91	1322	161.2	25.8
	24279	21367	1299	16.9	3.86	1186	141.9	28.8
	21520	18928	1108	16.8	3.82	1059	124.7	31.8
	18576	16349	972	16.6	3.87	922.8	103.5	36.9
406 × 152	26938	23811	1047	16.9	3.32	1294	136.2	23.0
	23798	21065	908	16.7	3.26	1155	118.6	25.8
	20619	18283	768	16.5	3.18	1011	100.9	29.3
406 × 140	15803	13698	500	16.3	2.82	775.6	70.26	35.9
	12406	10963	373	15.9	2.75	624.7	52.61	46.2
381 × 152	21278	18817	947	15.8	3.33	1095	122.7	23.8
	18832	16489	814	15.7	3.27	968.4	106.2	26.7
	16046	14228	686	15.5	3.21	842.3	89.96	30.7
356 × 171	19493	17003	1278	15.1	3.87	1071	147.6	23.2
	16038	14018	1026	14.9	3.77	894.3	119.2	27.6
	14118	12348	885	14.8	3.71	794.0	103.3	30.9
	12052	10578	730	14.6	3.68	684.7	85.38	36.3
356 × 127	10054	8668	333	14.3	2.60	570.0	52.87	33.0
	8167	7099	257	14.0	2.48	468.7	40.99	41.0
305 × 165	11888	10119	988	13.1	3.80	751.8	118.8	22.7
	9824	8596	825	13.0	3.74	646.4	99.54	26.0
	8500	7388	691	12.8	3.67	559.5	83.71	29.8
305 × 127	9488	8137	438	12.6	2.68	611.1	68.94	22.2
	8124	6978	367	12.4	2.63	530.0	58.99	25.3
	7142	6142	316	12.3	2.58	470.2	51.11	28.4
305 × 102	6482	5792	199	12.5	2.13	414.6	37.00	29.0
	5416	4856	153	12.2	2.05	350.7	30.01	34.7
	4381	3958	116	11.9	1.92	287.5	22.85	44.8
254 × 146	8546	6683	633	10.9	3.39	504.3	85.97	20.4
	5544	4814	528	10.8	3.34	433.1	72.11	23.5
	4427	3869	408	10.5	3.19	352.1	55.53	29.2
254 × 102	4004	3585	174	10.5	2.18	307.6	34.13	28.0
	3404	3041	144	10.3	2.11	264.9	28.33	30.6
	2883	2572	116	10.0	2.02	226.4	22.84	37.4
203 × 133	2880	2489	364	8.71	3.09	278.5	62.85	21.5
	2348	2020	280	8.53	2.94	231.1	41.92	26.1

UNIVERSAL BEAMS

DIMENSIONS AND PROPERTIES

Serial Size	Mass per metre	Depth of Section D	Width of Section B	Thickness: Web t	Thickness: Flange T	Root Radius r	Depth between Fillets d	Area of Section
mm	kg	mm	mm	mm	mm	mm	mm	cm²
914 x 419	388	920.5	420.5	21.5	36.6	24.1	791.5	493.9
	343	911.4	418.5	19.4	32.0	24.1	791.5	436.9
914 x 305	289	926.6	307.8	19.6	32.0	19.1	819.2	368.5
	253	918.5	305.5	17.3	27.9	19.1	819.2	322.9
	224	910.3	304.1	15.9	23.9	19.1	819.2	284.9
	201	903.0	303.4	15.2	20.2	19.1	819.2	256.1
838 x 292	226	850.9	293.8	16.1	26.8	17.8	756.4	288.4
	194	840.7	292.4	14.7	21.7	17.8	756.4	246.9
	176	834.9	291.8	14.0	19.8	17.8	756.4	223.8
762 x 267	197	769.8	268.0	15.6	25.4	16.5	681.2	250.5
	173	762.0	266.7	14.3	21.6	16.5	681.2	220.2
	147	753.9	265.3	12.9	17.5	16.5	681.2	187.6
686 x 254	170	692.9	255.8	14.5	23.7	15.2	610.6	216.3
	152	687.6	254.5	13.2	21.0	15.2	610.6	193.8
	140	683.5	253.7	12.4	19.0	15.2	610.6	178.4
	125	677.9	253.0	11.7	16.2	15.2	610.6	159.4
610 x 305	238	633.0	311.5	18.6	31.4	16.5	531.6	303.5
	179	617.5	307.0	14.1	23.6	16.5	531.6	227.7
	149	609.6	304.8	11.9	19.7	16.5	531.6	189.9
610 x 229	140	617.0	230.1	13.1	22.1	12.7	543.1	178.2
	125	611.9	229.0	11.9	19.6	12.7	543.1	159.4
	113	607.3	228.2	11.2	17.3	12.7	543.1	144.3
	101	602.2	227.6	10.6	14.8	12.7	543.1	129.0
610 x 178	91	602.6	178.4	10.6	15.0	12.7	547.1	116.9
	82	598.2	177.8	10.1	12.8	12.7	547.1	104.4
533 x 330	212	548.1	333.6	16.7	27.8	16.5	460.1	269.6
	188	538.8	331.7	14.9	25.0	16.5	460.1	241.3
	167	533.4	330.2	13.4	22.0	16.5	460.1	212.7
533 x 210	122	544.6	211.9	12.8	21.3	12.7	472.7	155.6
	109	539.6	210.7	11.6	18.8	12.7	472.7	138.4
	101	536.7	210.1	10.9	17.4	12.7	472.7	129.1
	92	533.1	209.3	10.2	15.6	12.7	472.7	117.6
	82	528.3	208.7	9.6	13.2	12.7	472.7	104.3
533 x 165	73	528.8	165.8	8.9	13.6	12.7	476.5	93.0
	66	524.8	165.1	8.8	11.6	12.7	476.5	83.8
457 x 191	98	467.4	192.8	11.4	19.6	10.2	404.4	125.2
	89	463.6	192.0	10.6	17.7	10.2	404.4	113.8
	82	460.2	191.3	9.9	16.0	10.2	404.4	104.4
	74	457.2	190.5	9.1	14.5	10.2	404.4	94.9
	67	453.6	189.9	8.5	12.7	10.2	404.4	85.4

PROPERTIES OF STEEL SECTIONS

UNIVERSAL BEAMS

DIMENSIONS AND PROPERTIES

Serial Size	Moment of Inertia: Axis x–x Gross	Moment of Inertia: Axis x–x Net	Moment of Inertia: Axis y–y	Radius of Gyration: Axis x–x	Radius of Gyration: Axis y–y	Elastic Modulus: Axis x–x	Elastic Modulus: Axis y–y	Ratio D/T
mm	cm⁴	cm⁴	cm⁴	cm	cm	cm³	cm³	
914 x 419	717325	639177	42481	38.1	9.27	15588	2021	25.2
	623866	555835	38251	37.8	9.11	13681	1733	28.5
914 x 305	503781	469903	14793	37.0	6.34	10874	961.3	28.0
	435708	406504	12512	36.8	6.23	9490	819.2	32.9
	375111	350206	10425	36.3	6.06	8241	686.6	38.1
	324715	303783	8932	35.9	5.81	7192	589.1	44.7
838 x 292	335130	315153	10661	34.3	8.06	7871	725.9	31.8
	278833	259825	8364	33.8	5.83	6633	573.6	38.7
	245412	228857	7111	33.1	5.64	5879	487.6	44.4
762 x 267	239404	221138	7689	30.9	5.54	6223	574.8	30.3
	204747	189341	6576	30.5	5.38	5374	478.1	38.3
	168535	156213	5002	30.0	5.16	4471	377.1	43.1
686 x 254	169843	155106	6225	28.0	5.36	4902	486.8	29.2
	140038	127985	5081	27.8	5.26	4364	423.7	32.7
	122972	112156	4283	27.6	5.18	3979	377.5	36.0
	111700	101580	3892	27.2	5.00	3472	316.5	41.8
610 x 305	207262	192203	14973	25.1	7.02	6549	961.3	20.2
	161312	140269	10871	25.8	6.81	4901	668.8	26.2
	134341	115233	8471	25.6	6.68	4076	556.9	30.9
610 x 229	111673	101889	4253	25.0	4.88	3820	369.6	27.9
	98408	89675	3676	24.8	4.80	3217	321.1	31.2
	87260	79645	3184	24.6	4.70	2874	278.1	35.1
	76549	69132	2658	24.2	4.54	2509	233.8	40.7
610 x 178	63970	57738	1427	23.5	3.51	2124	160.0	40.2
	55779	50076	1203	23.1	3.39	1865	135.3	46.7
533 x 330	141862	121777	18064	22.9	7.72	5189	963.2	19.8
	125618	107882	14093	22.8	7.64	4667	848.6	21.8
	109109	93647	12067	22.6	7.53	4091	730.3	24.2
533 x 210	76078	68719	3209	22.1	4.54	2794	302.8	25.6
	68610	60219	2755	21.8	4.48	2488	261.6	28.7
	61530	55871	2512	21.8	4.41	2283	239.2	30.8
	55225	50040	2212	21.7	4.34	2072	211.3	34.2
	47353	43062	1826	21.3	4.15	1793	175.0	40.0
533 x 165	40414	35752	1027	20.8	3.32	1528	124.1	38.2
	36063	31144	863	20.6	3.21	1337	104.9	45.6
457 x 191	45653	40489	2216	19.1	4.21	1954	229.9	22.8
	40956	36313	1960	19.0	4.15	1757	204.2	25.2
	37039	32889	1746	18.8	4.09	1610	182.5	28.8
	33324	29570	1547	18.7	4.04	1458	162.4	31.5
	29337	26072	1328	18.5	3.95	1293	139.9	35.7

Turn over

2707/302
June/July 2016

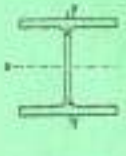
UNIVERSAL COLUMNS

Parallel Flanges

DIMENSIONS AND PROPERTIES

Serial Size	Mass per metre	Depth of Section D	Width of Section B	Thickness: Web t	Thickness: Flange T	Root Radius r	Depth between Fillets d	Area of Section
mm	kg	mm	mm	mm	mm	mm	mm	cm²
356 x 406	634	474.7	424.1	47.6	77.0	15.2	290.1	808.1
	551	455.7	418.5	42.0	67.5	15.2	290.1	701.9
	467	435.9	412.4	35.9	58.0	15.2	290.1	595.5
	393	416.1	407.0	30.6	49.2	15.2	290.1	500.9
	340	406.4	403.0	26.5	42.9	15.2	290.1	432.7
	287	393.7	399.0	22.6	36.5	15.2	290.1	365.0
	235	381.0	395.0	18.5	30.2	15.2	290.1	299.9
Column Core	477	427.0	424.4	48.0	53.2	15.2	290.1	607.2
356 x 368	202	374.7	374.4	16.8	27.0	15.2	290.1	257.9
	177	368.3	372.1	14.5	23.9	15.2	290.1	225.7
	153	362.0	370.2	12.6	20.7	15.2	290.1	195.2
	129	355.6	368.3	10.7	17.5	15.2	290.1	164.9
305 x 305	283	365.3	321.8	26.9	44.1	15.2	246.6	360.4
	240	362.6	317.9	23.0	37.7	15.2	246.6	306.6
	198	339.9	314.1	19.2	31.4	15.2	246.6	252.3
	158	327.2	310.6	15.7	25.0	15.2	246.6	201.2
	137	320.5	309.7	13.8	21.7	15.2	246.6	174.6
	118	314.5	306.8	11.9	18.7	15.2	246.6	149.8
	97	307.8	304.6	9.9	15.4	15.2	246.6	123.3
254 x 254	167	289.1	264.5	19.2	31.7	12.7	200.2	212.4
	132	276.4	261.0	15.5	25.1	12.7	200.2	167.7
	107	266.7	258.3	13.0	20.5	12.7	200.2	136.6
	89	260.4	255.9	10.5	17.3	12.7	200.2	114.0
	73	254.0	254.0	8.6	14.2	12.7	200.2	92.9
203 x 203	86	222.3	209.6	13.0	20.5	10.2	160.8	110.1
	71	215.9	206.2	10.3	17.3	10.2	160.8	91.1
	60	209.6	205.2	9.3	14.2	10.2	160.8	75.8
	52	206.2	203.9	8.0	12.5	10.2	160.8	66.4
	46	203.2	203.2	7.3	11.0	10.2	160.8	58.8
152 x 152	37	161.8	154.4	8.1	11.5	7.6	123.4	47.6
	30	157.5	152.9	6.6	9.4	7.6	123.4	38.2
	23	152.4	152.4	6.1	6.8	7.6	123.4	29.8

PROPERTIES OF STEEL SECTIONS



UNIVERSAL COLUMNS

Parallel Flanges

DIMENSIONS AND PROPERTIES

Serial Size	Moment of Inertia: Axis x–x Gross	Moment of Inertia: Axis x–x Net	Moment of Inertia: Axis y–y	Radius of Gyration: Axis x–x	Radius of Gyration: Axis y–y	Elastic Modulus: Axis x–x	Elastic Modulus: Axis y–y	Ratio D/T
mm	cm⁴	cm⁴	cm⁴	cm	cm	cm³	cm³	
356 x 406	275140	243076	98211	18.5	11.0	11592	4632	6.2
	227033	200312	82669	18.0	10.9	9964	3961	6.8
	182118	161351	67905	17.5	10.7	8386	3293	7.6
	146765	129159	55410	17.1	10.5	7004	2723	8.5
	122474	107897	46816	16.8	10.4	6027	2324	9.5
	98694	87843	38714	16.5	10.3	5080	1940	10.9
	79110	69424	31009	16.2	10.2	4155	1570	12.6
Column Core	173391	152836	68057	16.8	10.6	8075	3207	8.0
356 x 368	69307	57806	23632	16.0	9.97	3540	1261	13.9
	57153	46796	20470	15.9	9.82	3104	1100	15.5
	48526	42250	17470	15.8	9.46	2681	943.8	17.6
	40246	35040	14556	15.6	9.29	2264	790.4	20.3
305 x 305	38777	32827	24848	14.8	8.23	4314	1525	9.3
	34177	29295	20239	14.5	8.14	3841	1273	9.4
	28933	24935	16330	14.2	8.02	3361	1034	10.8
	23740	20766	12624	13.9	7.93	2868	806.3	13.1
	20838	18314	10672	13.7	7.82	2548	691.4	14.8
	17601	15473	9006	13.6	7.75	2195	587.0	16.8
	13302	11699	7288	13.4	7.68	1662	478.9	20.0
254 x 254	22214	17171	9786	11.9	6.79	2070	740.6	9.1
	18418	14350	7444	11.6	6.66	1822	570.4	11.0
	15510	11890	5901	11.2	6.67	1513	454.9	13.0
	12907	9875	4849	11.2	6.52	1266	378.9	15.1
	11260	10297	3973	11.1	6.46	894.8	305.0	17.9
203 x 203	9462	8574	3119	9.27	5.32	851.5	299.7	10.8
	7647	6758	2536	9.15	5.29	708.4	248.0	12.5
	6089	5283	2041	8.98	5.19	581.1	199.6	14.8
	5283	4553	1770	8.90	5.16	510.6	173.6	16.5
	4566	4005	1539	8.81	5.11	449.2	151.8	18.5
152 x 152	2218	1932	708	6.84	3.87	274.2	91.79	14.1
	1742	1515	556	6.73	3.82	221.2	73.08	16.8
	1263	1104	403	6.51	3.68	163.7	52.65	22.4