2705/302
2709/302
2710/302
STRUCTURES III
Oct./Nov. 2016
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN BUILDING TECHNOLOGY
DIPLOMA IN ARCHITECTURE

MODULE III

STRUCTURES III

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Scientific calculator.
*This paper consists of **EIGHT** questions.*
*Answer any **FIVE** 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. (a) Define the following terms with respect to timber design:

(i) applied stress;
(ii) basic stress;
(iii) modification factors;
(iv) strength class.

(4 marks)

(b) A suspended timber floor has joists of size 225 x 75 mm, effective length of 4.3 m and spaced at 450 mm c/c. If the total load due to self weight is 1 kN/m^2, determine the safe intensity of live load on the floor, considering bending only. Use the following data:

- Grade stress in bending parallel to grain = 5.3 N/mm^2
- Load duration K_3 medium term = 1.25
- Load sharing factor K_8 = 1.1
- Depth factor K_7 = 1.04

(16 marks)

2. Using three moment theorem analyse the beam shown in figure 1 and hence draw shear force and bending moment diagrams and indicate values at critical points.

(20 marks)

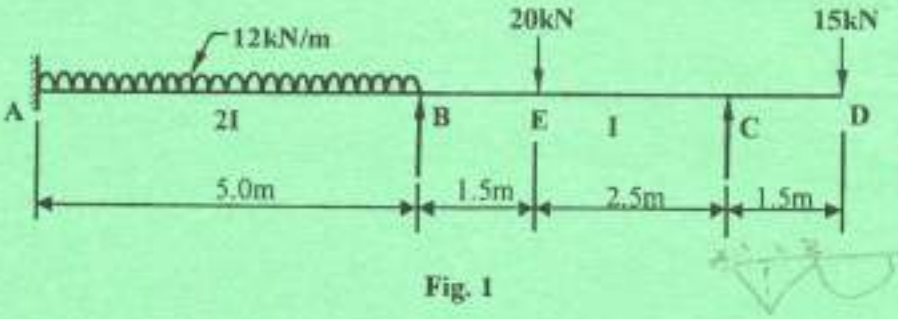


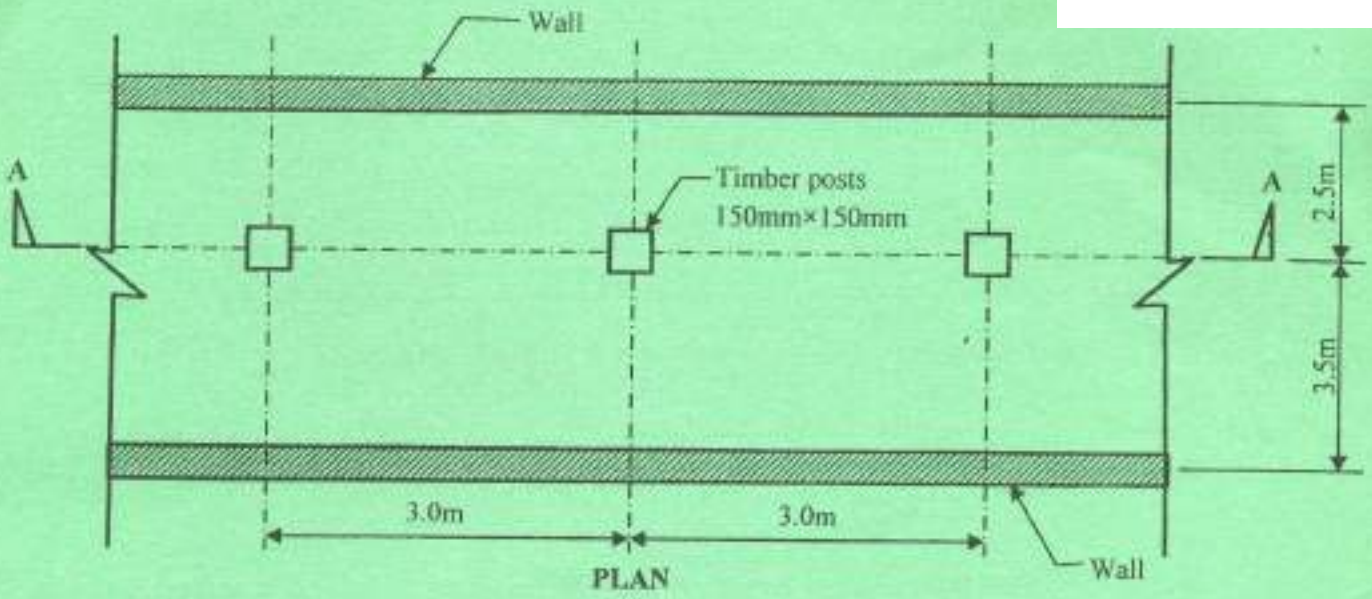
Fig. 1

3. (a) State **three** factors which determine the load capacity of a timber post. (3 marks)

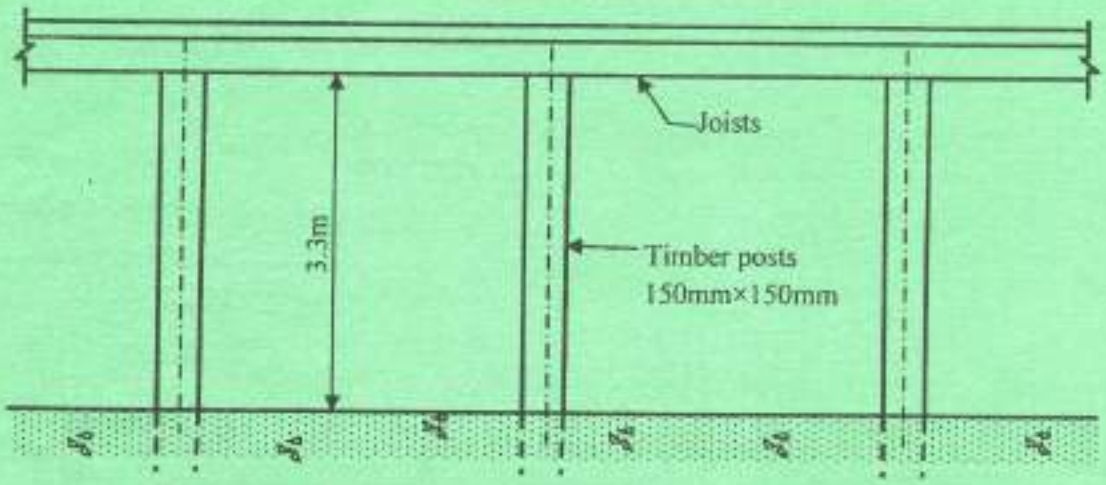
(b) Figure 2 shows layout plan and section of a loaded timber floor supported on timber column posts of size 150 mm x 150 mm. Check the adequacy of the posts under the following conditions:

- columns fixed at the bottom and pinned at the top.
- E_{mean} = 8800 N/mm^2
- Permissible stress in compression parallel to grain 7.33 n/mm^2
- Imposed loads on floor (long term) = 2.5 kN/m^2.

(17 marks)



PLAN



SECTION A-A

Fig. 2

4. Using moment distribution method analyse the loaded beam shown in figure 3 and hence draw the shear force and bending moment diagrams showing values at critical points.

(20 marks)

NB: Make four distributions only.

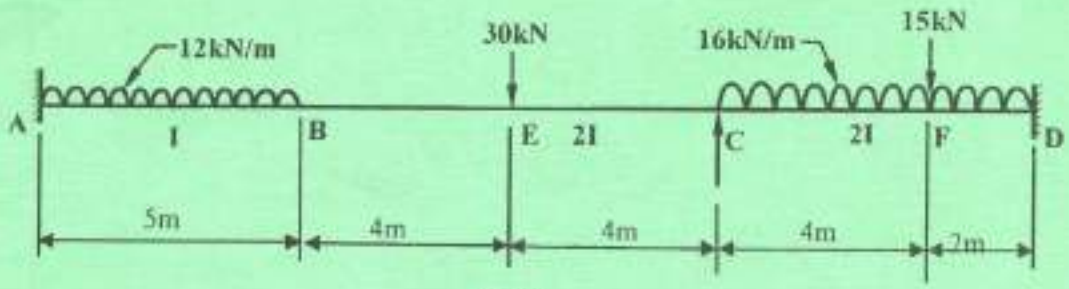


Fig. 3

5. A simply supported floor in a braced industrial frame supports grid flooring and a column as shown in figure 4. Using the design data given, check the suitability of the steel beam with respect to shear and bending.

(20 marks)

Data:

- uniformly distributed dead loads (including self weight) = 8 kN/m
- uniformly distributed imposed load = 10 kN/m
- dead load in column = 10 kN
- imposed load in column = 30 kN

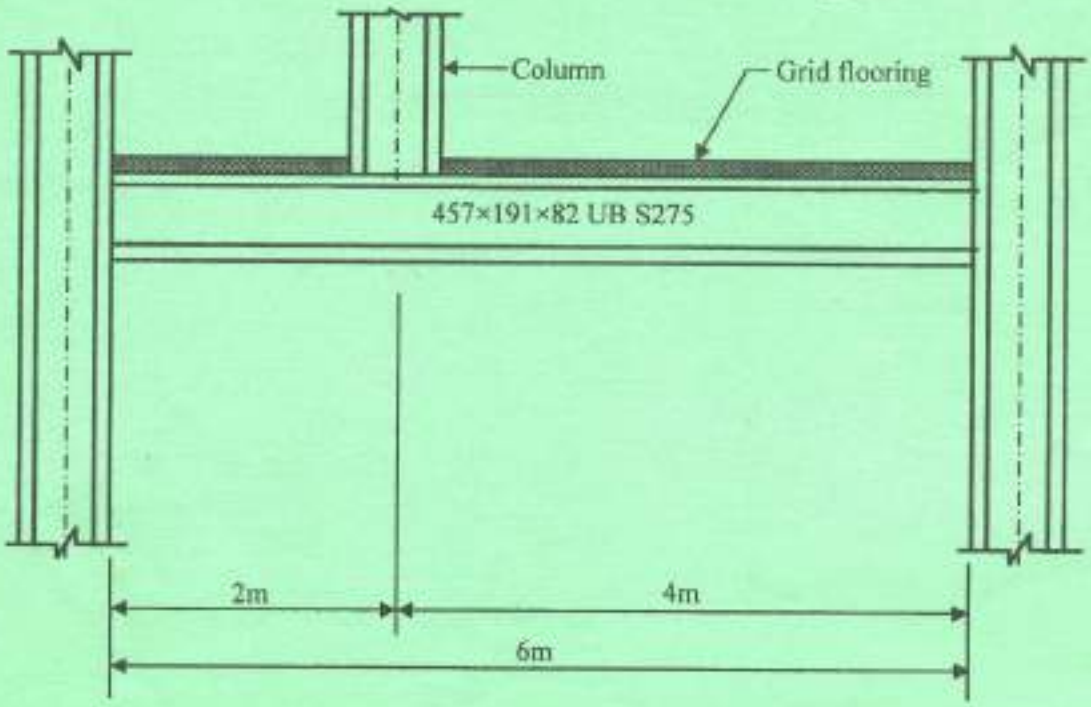


Fig. 4

6. (a) Sketch the influence line diagrams for the reactions at A and B, RA and RB for the beam shown in figure 5(a). (6 marks)

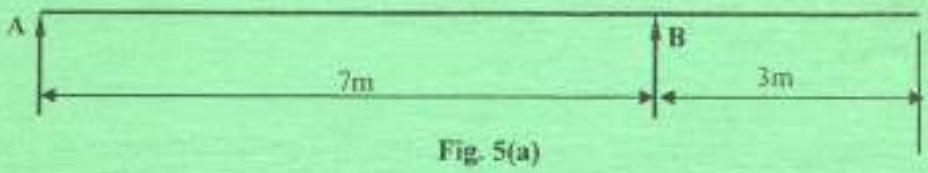


Fig. 5(a)

(b) Using the influence lines sketched in 6(a) above determine the reactions R_A and R_B when a train of loads as shown in figure 5(b) moves along the beam with the 20 kN load at 3 m from support A. (14 marks)

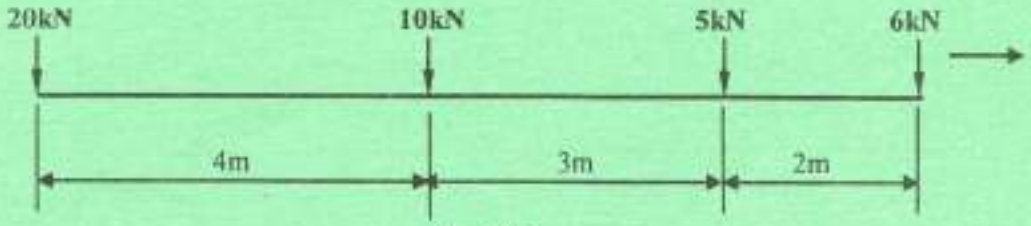


Fig. 5(b)

7. Using moment distribution method analyse the portal frame shown in figure 6 and hence draw the bending moment diagram to show values at critical points. (20 marks)

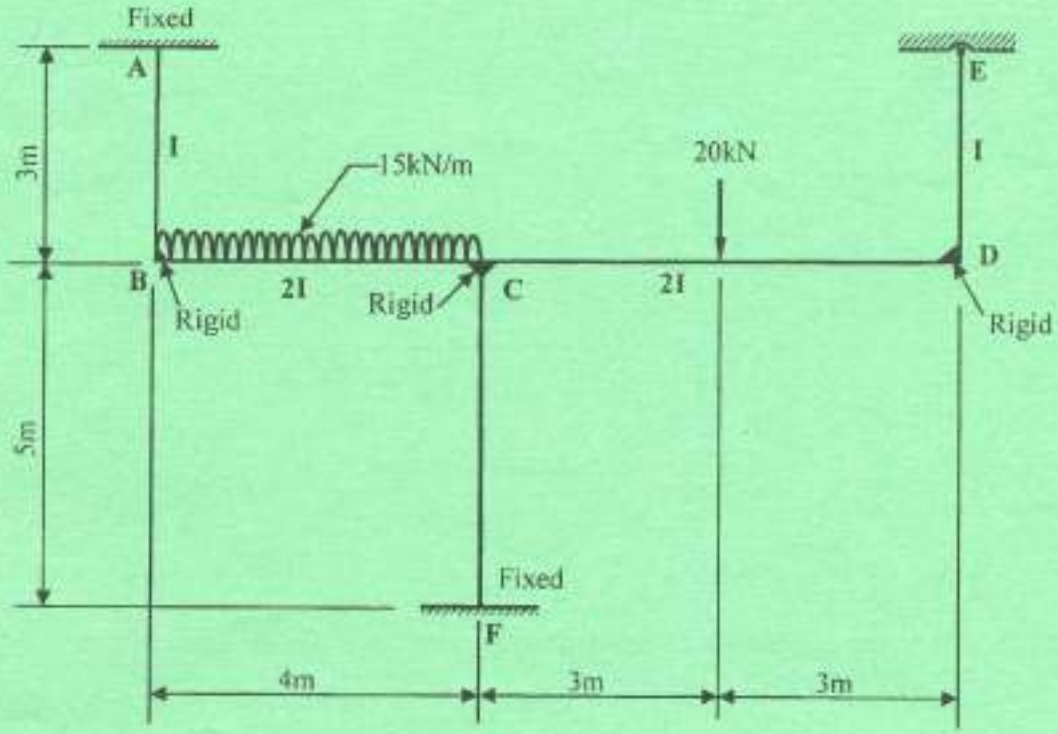


Fig. 6

8. (a) A 100 mm x 25 mm strap is spliced as shown in figure 7. The bolts are 25 mm in diameter. Check the load capacity of the connection with respect to:

(i) bolt shear;
(ii) bolt bearing;
(iii) plate bearing and
(iv) plate tension capacity.

Take:

- shear strength on bolts (Ps) = 375 N/mm^2
- bearing strength (P_{bb}) = 1000 N/mm^2
- tension strength P_t = 560 N/mm^2

(10 marks)

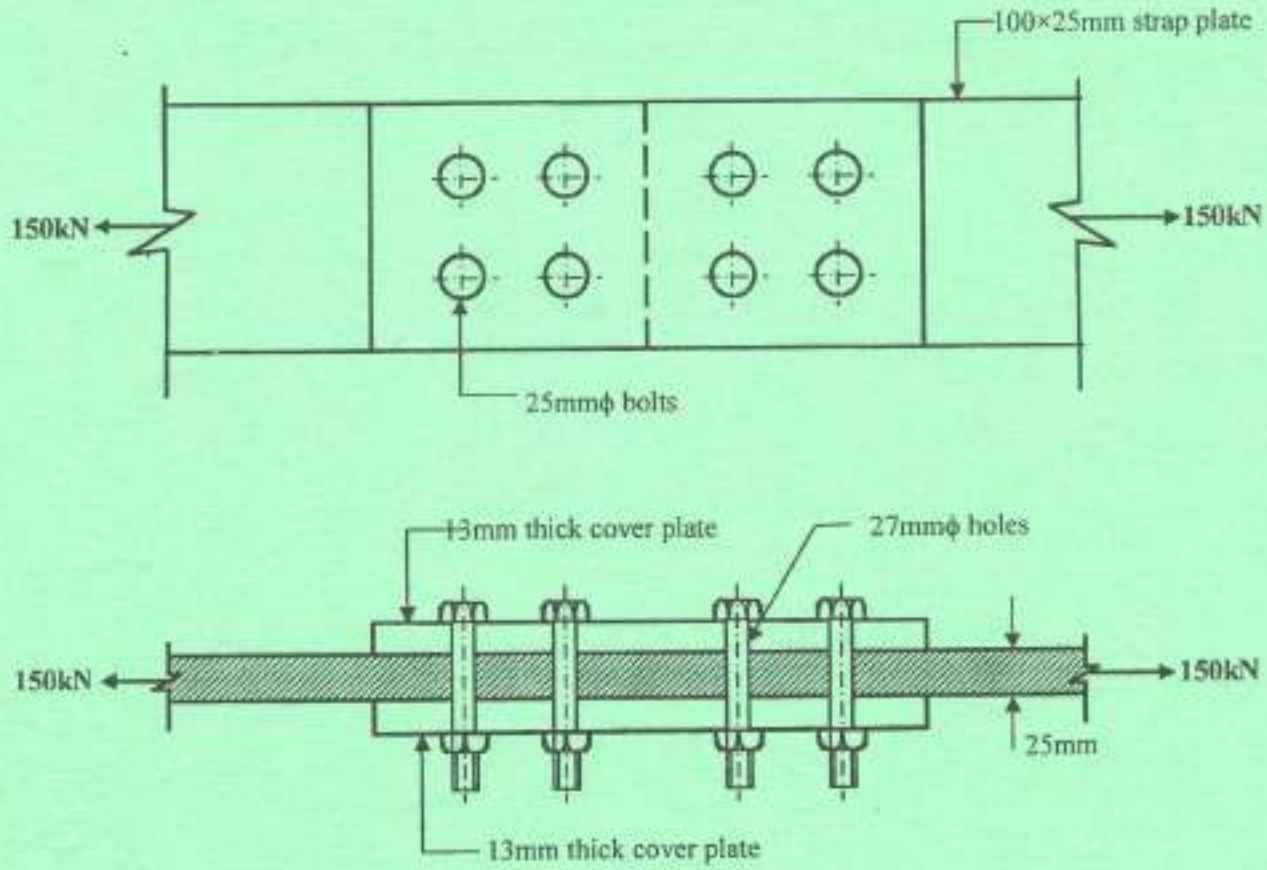


Fig. 7

(b) State **three** advantages of welded connections over bolted connections. (3 marks)

(c) Find the length of side fillet welds required for the connection shown in figure 8. The capacity of 6 mm fillet weld = 924 N/mm run. (7 marks)

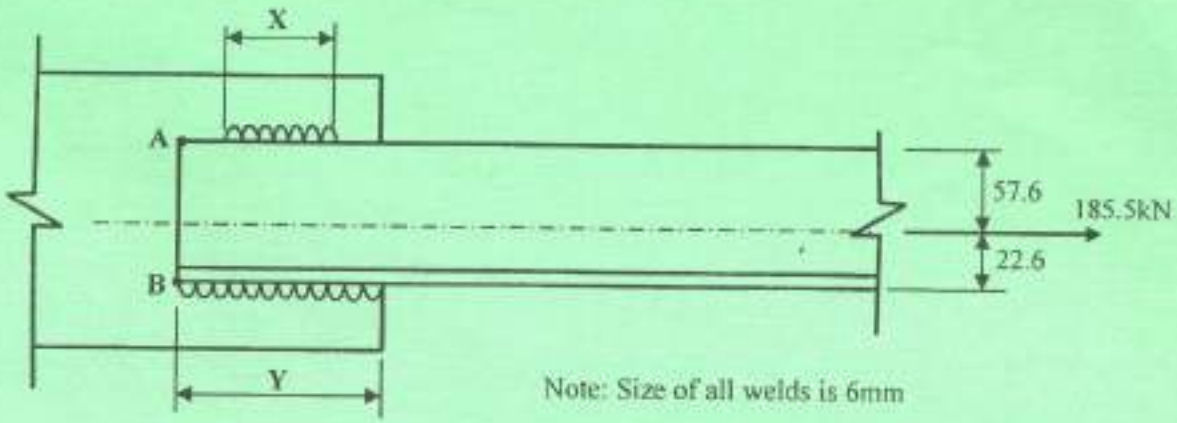
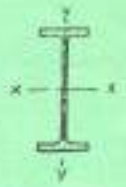


Fig. 8

Modification factor K_{12} for compression members

$E/\sigma_{0.2}$	Value of K_{12}																		
	Values of slenderness ratio $\lambda = L_e/i$																		
	≤ 5	5	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	250
	Equivalent L_e/b (for rectangular sections)																		
	< 1.4	1.4	2.9	5.8	8.7	11.6	14.5	17.3	20.2	23.1	26.0	28.9	34.7	40.5	46.2	52.0	57.8	63.6	69.4	72.3
400	1.000	0.975	0.951	0.896	0.827	0.735	0.621	0.506	0.408	0.330	0.271	0.225	0.162	0.121	0.094	0.075	0.061	0.051	0.043	0.040
500	1.000	0.975	0.951	0.899	0.837	0.759	0.664	0.562	0.466	0.385	0.320	0.269	0.195	0.148	0.115	0.092	0.076	0.063	0.053	0.049
600	1.000	0.975	0.951	0.901	0.843	0.774	0.692	0.601	0.511	0.430	0.363	0.307	0.226	0.172	0.135	0.109	0.089	0.074	0.063	0.058
700	1.000	0.975	0.951	0.902	0.848	0.784	0.711	0.629	0.545	0.467	0.399	0.341	0.254	0.195	0.154	0.124	0.102	0.085	0.072	0.067
800	1.000	0.975	0.952	0.903	0.851	0.792	0.724	0.649	0.572	0.497	0.430	0.371	0.280	0.217	0.172	0.139	0.115	0.096	0.082	0.076
900	1.000	0.976	0.952	0.904	0.853	0.797	0.734	0.665	0.593	0.522	0.458	0.397	0.304	0.237	0.188	0.153	0.127	0.106	0.091	0.084
1000	1.000	0.976	0.952	0.904	0.855	0.801	0.742	0.677	0.609	0.542	0.478	0.420	0.325	0.255	0.204	0.167	0.138	0.116	0.099	0.092
1100	1.000	0.976	0.952	0.905	0.856	0.804	0.748	0.687	0.623	0.559	0.497	0.440	0.344	0.272	0.219	0.179	0.149	0.126	0.107	0.100
1200	1.000	0.976	0.952	0.905	0.857	0.807	0.753	0.695	0.634	0.573	0.513	0.457	0.362	0.288	0.233	0.192	0.160	0.135	0.116	0.107
1300	1.000	0.976	0.952	0.905	0.858	0.809	0.757	0.701	0.643	0.584	0.527	0.472	0.378	0.303	0.247	0.203	0.170	0.144	0.123	0.115
1400	1.000	0.976	0.952	0.906	0.859	0.811	0.760	0.707	0.651	0.595	0.539	0.486	0.392	0.317	0.259	0.214	0.180	0.153	0.131	0.122
1500	1.000	0.976	0.952	0.906	0.860	0.813	0.763	0.712	0.658	0.603	0.550	0.498	0.405	0.330	0.271	0.225	0.189	0.161	0.138	0.129
1600	1.000	0.976	0.952	0.906	0.861	0.814	0.766	0.716	0.664	0.611	0.559	0.508	0.417	0.342	0.282	0.235	0.198	0.169	0.145	0.135
1700	1.000	0.976	0.952	0.906	0.861	0.815	0.768	0.719	0.669	0.618	0.567	0.518	0.428	0.353	0.292	0.245	0.207	0.177	0.152	0.142
1800	1.000	0.976	0.952	0.906	0.862	0.816	0.770	0.722	0.673	0.624	0.574	0.526	0.438	0.363	0.302	0.254	0.215	0.184	0.159	0.148
1900	1.000	0.976	0.952	0.907	0.862	0.817	0.772	0.725	0.677	0.629	0.581	0.534	0.447	0.373	0.312	0.262	0.223	0.191	0.165	0.154
2000	1.000	0.976	0.952	0.907	0.863	0.818	0.773	0.728	0.681	0.634	0.587	0.541	0.455	0.382	0.320	0.271	0.230	0.198	0.172	0.160

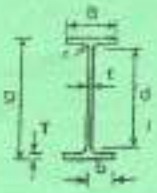
UNIVERSAL BEAMS

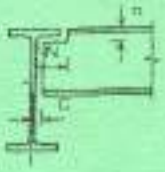


PROPERTIES

Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area of Section
	Axis x-x cm^4	Axis y-y cm^4	Axis x-x cm	Axis y-y cm	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^3	Axis y-y cm^3	u	x	H dm^6	J cm^4	A cm^2
457 × 191 × 98	45700	2350	19.1	4.33	1960	246	2230	379	0.882	25.7	1.18	121	125
457 × 191 × 89	41000	2090	19.0	4.29	1770	218	2010	338	0.879	28.3	1.04	90.7	114
457 × 191 × 82	37100	1870	18.8	4.23	1610	196	1830	304	0.879	30.8	0.922	69.2	104
457 × 191 × 74	33300	1670	18.8	4.20	1460	176	1650	272	0.877	33.8	0.818	51.8	94.8
457 × 191 × 67	29400	1450	18.5	4.12	1300	153	1470	237	0.872	37.9	0.705	37.1	85.5
457 × 152 × 82	36800	1190	18.7	3.37	1570	153	1810	240	0.871	27.4	0.591	89.2	105
457 × 152 × 74	32700	1050	18.6	3.33	1410	136	1630	213	0.873	30.2	0.518	66.9	94.5
457 × 152 × 67	29900	913	18.4	3.27	1260	119	1450	187	0.868	33.6	0.446	47.2	85.6
457 × 152 × 60	25500	795	18.3	3.23	1120	104	1290	163	0.868	37.5	0.387	33.8	75.9
457 × 152 × 52	21400	645	17.9	3.11	950	84.6	1100	133	0.859	43.8	0.311	21.4	66.6
406 × 178 × 74	27300	1550	17.0	4.04	1320	172	1500	267	0.882	27.6	0.608	62.8	94.5
406 × 178 × 67	24300	1370	16.9	3.99	1190	153	1350	237	0.880	30.5	0.533	46.1	85.5
406 × 178 × 60	21600	1200	16.8	3.97	1060	135	1200	209	0.880	33.8	0.466	33.3	76.5
406 × 178 × 54	18700	1020	16.5	3.85	930	115	1060	178	0.871	38.3	0.392	23.1	69.0
406 × 140 × 46	15700	536	16.4	3.00	778	75.7	888	118	0.872	39.0	0.207	19.0	58.6
406 × 140 × 39	12500	410	15.9	2.87	629	57.8	724	90.8	0.858	47.5	0.155	10.7	49.7
356 × 171 × 67	19500	1360	15.1	3.99	1070	157	1210	243	0.886	24.4	0.412	55.7	85.5
356 × 171 × 57	16000	1110	14.9	3.91	896	129	1010	199	0.882	28.8	0.330	33.4	72.6
356 × 171 × 51	14100	968	14.8	3.88	795	113	895	174	0.881	32.1	0.269	23.8	64.9
356 × 171 × 45	12100	811	14.5	3.76	687	94.8	775	147	0.874	36.8	0.237	15.8	57.3
356 × 127 × 39	10200	358	14.3	2.68	576	56.8	659	89.1	0.871	35.2	0.105	15.1	49.8
356 × 127 × 33	8250	280	14.0	2.58	473	44.7	543	70.3	0.863	42.2	0.081	8.79	42.1
305 × 165 × 54	11700	1060	13.0	3.93	754	127	846	196	0.889	23.6	0.234	34.8	68.8
305 × 165 × 46	9900	896	13.0	3.90	646	108	720	166	0.891	27.1	0.195	22.2	58.7
305 × 165 × 40	8500	764	12.9	3.86	560	92.6	623	142	0.889	31.0	0.164	14.7	51.3
305 × 127 × 48	9580	461	12.5	2.74	616	73.6	711	116	0.874	23.3	0.102	31.8	61.2
305 × 127 × 42	8200	389	12.4	2.70	534	62.6	614	98.4	0.872	26.6	0.0846	21.1	53.4
305 × 127 × 37	7170	336	12.3	2.67	471	54.5	539	85.4	0.871	29.7	0.0725	14.8	47.2
305 × 102 × 33	8500	194	12.5	2.15	416	37.9	481	60.0	0.867	31.6	0.0442	12.2	41.8
305 × 102 × 28	5370	155	12.2	2.09	348	30.5	403	48.5	0.869	37.4	0.0349	7.40	35.9
305 × 102 × 25	4460	123	11.9	1.97	292	24.2	342	38.8	0.848	43.4	0.0273	4.77	31.6
254 × 146 × 43	8540	677	10.9	3.52	504	92.0	568	141	0.890	21.2	0.103	23.9	54.8
254 × 146 × 37	5540	571	10.8	3.46	433	78.0	483	119	0.889	24.4	0.0857	15.3	47.2
254 × 146 × 31	4410	448	10.5	3.36	351	61.3	393	94.1	0.879	29.6	0.0660	8.55	39.7
254 × 102 × 28	4010	179	10.5	2.22	308	34.9	353	54.8	0.874	27.5	0.0280	9.57	36.1
254 × 102 × 25	3420	149	10.3	2.15	266	29.2	306	46.0	0.867	31.4	0.0230	6.42	32.0
254 × 102 × 22	2840	119	10.1	2.09	224	23.5	259	37.3	0.858	36.3	0.0182	4.15	28.0
203 × 133 × 30	2900	385	8.71	3.17	280	57.5	314	88.2	0.861	21.5	0.0374	10.3	38.2
203 × 133 × 25	2340	308	8.56	3.10	230	46.2	258	70.9	0.877	25.6	0.0294	5.95	32.0
203 × 102 × 23	2110	164	8.46	2.36	207	32.2	234	49.8	0.868	22.5	0.0154	7.02	29.4
178 × 102 × 19	1360	137	7.48	2.37	153	27.0	171	41.6	0.886	22.5	0.00987	4.41	24.3
152 × 89 × 16	834	89.8	6.41	2.10	109	20.2	123	31.2	0.889	19.6	0.00470	3.56	20.3
127 × 76 × 13	473	55.7	5.35	1.84	74.6	14.7	84.2	22.8	0.896	16.3	0.00199	2.85	16.5

UNIVERSAL BEAMS





DIMENSIONS

Section Designation	Mass per Metre	Depth of Section	Width of Section	Thickness		Root Radius	Depth between Fillets	Ratios for Local Buckling		Dimensions for Detailing			Surface Area	
				Web	Flange			Flange	Web	End Clearance	Notch		Per Metre	Per Tonne
	kg/m	D mm	B mm	t mm	T mm	r mm	d mm	b/T	d/t	C mm	N mm	n mm	m²	m²
457 × 191 × 98	98.3	467.2	192.8	11.4	19.6	10.2	407.6	4.92	35.8	8	102	30	1.67	16.9
457 × 191 × 89	89.3	463.4	191.9	10.5	17.7	10.2	407.6	5.42	38.8	7	102	28	1.66	18.5
457 × 191 × 82	82.0	460.0	191.3	9.9	16.0	10.2	407.6	5.98	41.2	7	102	28	1.65	20.1
457 × 191 × 74	74.3	457.0	190.4	9.0	14.5	10.2	407.6	6.57	45.3	7	102	26	1.64	22.1
457 × 191 × 67	67.1	453.4	189.9	8.5	12.7	10.2	407.6	7.48	48.0	6	102	24	1.63	24.3
457 × 152 × 82	82.1	465.8	155.3	10.5	18.9	10.2	407.6	4.11	38.8	7	84	30	1.51	18.4
457 × 152 × 74	74.2	462.0	154.4	9.6	17.0	10.2	407.6	4.54	42.5	7	84	28	1.50	20.3
457 × 152 × 67	67.2	458.0	153.8	9.0	15.0	10.2	407.6	5.13	45.3	7	84	26	1.50	22.3
457 × 152 × 60	59.8	454.6	152.9	8.1	13.3	10.2	407.6	5.75	50.3	6	84	24	1.49	24.9
457 × 152 × 52	52.3	449.8	152.4	7.6	10.9	10.2	407.6	6.99	53.6	6	84	22	1.48	28.2
406 × 178 × 74	74.2	412.8	179.5	9.5	16.0	10.2	360.4	5.61	37.9	7	96	26	1.51	20.3
406 × 178 × 67	67.1	409.4	178.8	8.8	14.3	10.2	360.4	6.25	41.0	6	96	26	1.50	22.3
406 × 178 × 60	60.1	406.4	177.9	7.9	12.8	10.2	360.4	6.95	45.6	6	96	24	1.49	24.8
406 × 178 × 54	54.1	402.6	177.7	7.7	10.9	10.2	360.4	8.15	46.8	6	96	22	1.48	27.4
406 × 140 × 46	46.0	403.2	142.2	6.8	11.2	10.2	360.4	6.35	53.0	5	78	22	1.34	29.2
406 × 140 × 39	39.0	398.0	141.8	6.4	8.6	10.2	360.4	8.24	56.3	5	78	20	1.33	34.2
356 × 171 × 67	67.1	363.4	173.2	9.1	15.7	10.2	311.6	5.52	34.2	7	94	26	1.38	20.6
356 × 171 × 57	57.0	358.0	172.2	8.1	13.0	10.2	311.6	6.62	38.5	6	94	24	1.37	24.1
356 × 171 × 51	51.0	355.0	171.5	7.4	11.5	10.2	311.6	7.46	42.1	6	94	22	1.36	26.7
356 × 171 × 45	45.0	351.4	171.1	7.0	9.7	10.2	311.6	8.82	44.5	6	94	20	1.36	30.1
356 × 127 × 39	39.1	353.4	126.0	6.6	10.7	10.2	311.6	5.89	47.2	5	70	22	1.18	30.2
356 × 127 × 33	33.1	349.0	125.4	6.0	8.5	10.2	311.6	7.38	51.9	5	70	20	1.17	35.4
305 × 165 × 54	54.0	310.4	166.9	7.9	13.7	8.9	265.2	6.09	33.6	6	90	24	1.26	23.3
305 × 165 × 46	46.1	306.6	165.7	6.7	11.8	8.9	265.2	7.02	39.6	5	90	22	1.25	27.1
305 × 165 × 40	40.3	303.4	165.0	6.0	10.2	8.9	265.2	8.09	44.2	5	90	20	1.24	30.8
305 × 127 × 48	48.1	311.0	125.3	9.0	14.0	8.9	265.2	4.47	29.5	7	70	24	1.09	22.7
305 × 127 × 42	41.9	307.2	124.3	8.0	12.1	8.9	265.2	5.14	33.1	6	70	22	1.08	25.8
305 × 127 × 37	37.0	304.4	123.4	7.1	10.7	8.9	265.2	5.77	37.4	6	70	20	1.07	29.0
305 × 102 × 33	32.8	312.7	102.4	6.6	10.8	7.6	275.9	4.74	41.8	5	58	20	1.01	30.8
305 × 102 × 28	28.2	308.7	101.8	6.0	8.8	7.6	275.9	5.78	46.0	5	58	18	1.00	35.4
305 × 102 × 25	24.8	305.1	101.6	5.8	7.0	7.6	275.9	7.26	47.8	5	58	16	0.992	40.0
254 × 146 × 43	43.0	259.6	147.3	7.2	12.7	7.6	219.0	5.80	30.4	6	82	22	1.06	25.1
254 × 146 × 37	37.0	256.0	146.4	6.3	10.9	7.6	219.0	6.72	34.8	5	82	20	1.07	29.0
254 × 146 × 31	31.1	251.4	146.1	6.0	8.6	7.6	219.0	8.49	36.5	5	82	18	1.06	34.2
254 × 102 × 28	28.3	260.4	102.2	6.3	10.0	7.6	225.2	5.11	35.7	5	58	18	0.904	31.9
254 × 102 × 25	25.2	257.2	101.9	6.0	8.4	7.6	225.2	6.07	37.5	5	58	16	0.897	35.6
254 × 102 × 22	22.0	254.0	101.6	5.7	6.8	7.6	225.2	7.47	39.5	5	58	16	0.890	40.5
203 × 133 × 30	30.0	206.8	133.9	6.4	9.6	7.6	172.4	6.97	26.9	5	74	18	0.823	30.8
203 × 133 × 25	25.1	203.2	133.2	5.7	7.8	7.6	172.4	8.54	30.2	5	74	18	0.815	36.4
203 × 102 × 23	23.1	203.2	101.8	5.4	9.3	7.6	169.4	5.47	31.4	5	60	18	0.760	34.2
178 × 102 × 19	19.0	177.8	101.2	4.8	7.9	7.6	146.8	6.41	30.6	4	60	16	0.739	38.9
152 × 89 × 16	16.0	152.4	88.7	4.5	7.7	7.6	121.8	5.76	27.1	4	54	16	0.638	39.8
127 × 76 × 13	13.0	127.0	76.0	4.0	7.6	7.6	96.8	5.00	24.1	4	46	16	0.537	41.3

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